Nonindigenous Aquatic and Selected Terrestrial Species of Florida

Status, Pathway and Time of Introduction, Present Distribution, and Significant Ecological and Economic Effects

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NATIONAL BIOLOGICAL ~~SURVEY~~ SERVICE

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MEMORANDUM

To: Victor Ramey, IFAS, University of Florida

From: Center Director, SBSC

Subject: Publication of McCann report on Aquatic Nonindigenous Species of Florida

Dr. McCann has prepared a very good compilation of information on aquatic nonindigenous species of Florida. The Florida report has gone through an in house peer review process for publication.

Due to budget cuts we will not be able to publish it in house. Anyone who can publish this is free to do so.

[signature]

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Preface

Under the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990 (Public Law 101-646, 104 STAT. 4671, 16 U.S.C. 4701-4741 approved Nov. 29, 1990), the Aquatic Nuisance Species Task Force was instructed to conduct biological studies of the identification, pathways, and significant effects of the introduced nonindigenous aquatic species in the United States. This, a literature review, is one of the two biological studies that the task force initiated and funded in 1993.

We concentrated on the nonindigenous aquatic species of Florida that were revealed by a literature review during September 1993-January 1994. Limited additional 1995 references were added to the text during the review and editoring stages. Some information is on high-profile nonaquatic species. When experts were available, unpublished information about some groups of species was also obtained. However, resources were not available to gather new or unpublished information on all species. Recent published reviews were available of fishes (Courtenay et al. 1984, 1986, 1991), plants (Schardt and Schmitz 1990), and insects (Frank and McCoy 1992, 1993). We depended on the reviews and are indebted to W. R. Courtenay Jr., J. H. Frank, and D. C. Schmitz for assistance. No effort was made to include data on insects that immigrated (migrated on their own accord or were unintentionally introduced by humans) into Florida before 1970 because much of the information is scattered, not well documented, open to speculation, and beyond the scope of this study. Gathering and updating information on most of the other groups was impossible because of shortness of time and lack of sufficient resources.

We hope that the updating of the information on the status of nonindigenous species in Florida will be continued and that similar documents will be prepared for other states. Knowledge of the pathways of introduction is critical for the development of methods to stop the introduction and establishment of nonindigenous nuisance species while allowing the wise use of beneficial nonindigenous species.

Abstract

A literature review of the nonindigenous aquatic species introduced into Florida determined that at least 19 plant, 6 mollusk, 38 insect (including species that were imported as biological control agents), 83 fish, 2 amphibian, 1 reptile, 3 bird, 1 mammal, and 1 crab species and an unknown number of pathogens and parasites have been introduced into Florida. Nineteen species of exotic aquatic plants are established in Florida. Hydrilla (*Hydrilla verticilata*), water hyacinth (*Eichhornia crassipes*), water lettuce (*Pistia stratiotes*), and alligator weed (*Alternanthera philoxeroides*) are the major problem species, requiring significant annual expenditures for control. The Asian Clam (*Corbicula*) is among the 6 species of freshwater mollusks that were introduced and are established in Florida. There have been 12 migrations or unintentional introductions of aquatic insects into Florida and 27 importations of insects for evaluation as biological control agents of aquatic nuisance species. Of these, 14 species have been released and 4 are still under evaluation. Twenty-three exotic tropical fish species and 1 temperate exotic fish species have become established. The populations of 11 are expanding, and populations of 12 are locally established. The blue tilapia (*Tilapia aurea*), walking catfish (*Clarias batrachus*), black acara (*Cichlasoma bimaculatum*), and blackchin tilapia (*Tilopia melanopleura*) are the most widely spread exotic fish species. The marine toad (*Bufo marinus*), and Cuban treefrog (*Osteopilus septentrionalis*), spectacled caiman (*Caiman crocodilus*), muscovy duck (*Cairina moschata*), and the nutria (*Myocastor coypus*) were released or escaped and became established.

The culture of tropical, exotic plants and animals supports a large aquaculture industry in Florida, which has historically been responsible for the release of many species into the wild. However, the rate of introductions through this pathway has been reduced in recent years. The harmful and beneficial ecological and economic effects of these introductions are not well documented.

The major pathways of unofficial introductions of fishes include escape or release from fish farms, intentional release of species to support established populations for a sport or commercial fishery, and disposal of unwanted pet aquarium fishes. Only two fish species, the peacock cichlid (*Cichla ocellaris*) and the speckled pavon (*Cichla temensis*), were studied before being officially released by the Florida Game and Fresh Water Fish Commission. A sport fishery for the peacock cichlid has developed. The introduction of exotic pathogens and parasites by the fish-culture industry in Florida is also poorly documented. There is no evidence that these pathogens have harmed wild, free-ranging, native fish species.

Key words: Nonidigenous, Exotic, Aquatic, Plants, Fish, Animals, Pathogens, Florida.

This report is primarily about the introductions of nonindigenous aquatic species into the state of Florida, about their status, pathways and times of introduction, and about their economic and environmental effects on the native flora and fauna. Our research was limited to a literature review and to updates from experts on some species.

Our report is about one of two biological studies that were funded by the task force under the Nonindigenous Species Prevention and Control Act of 1990. The information on the significant economic and ecological effects of the various species sets priorities for future research and for the development of prevention and control of nuisance species and may serve as a basis for future discussions in a national workshop for the reduction or elimination of new introductions of injurious species.

Definitions of Terms[1]

Aquatic Species. All animals and plants, including pathogens or parasites of aquatic animals or plants, that are dependent on aquatic ecosystems for at least a portion of their life cycles.

Alien. Synonymous with "exotic," a species that is not native to the continental United States.

Established species. A species with one or several reproducing, self-sustaining populations in open ecosystems.

Ecosystem. A community of organisms and their physical environment that interact as an ecological unit; it includes human environments and elements of the infrastructure such as climate, geographic latitude, altitude, and soil type.

Exotic. An organism or species that is not native to the continental United States; synonymous with "alien."

Immigration. The move--including the unintentional introduction by humans--of an individual, group, or species into a geographical area.

Impact-any change to an ecosysten either natural or made by humans, either harmful or beneficial.

Importation -the act of bringing an organism from a foreign place or country into another country.

Introduction. The release or escape of a nonindigenous species into a geographical region or into an ecosystem where it did not previously exist.

Nonindigenous. A species or other viable biological material that is not native to an ecosystem or to a geographical region; includes exotic and transplanted species.

Nuisance species. A species potentially injurious to humans, fish, or wildlife or their habitats, or to the interests of agriculture, horticulture or forestry in the United States. Any species that threatens the diversity or abundance of native species or the ecological stability of the infected ecosystem or interfers with commercial, agricultural, aquacultural, or recreational activities.

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[1]Definitions were formulated with consultation of texts by Lincoln et al. (1982), Shafland and Lewis (1984), Frank and McCoy (1990), and U.S. Interagency Nuisance Species Task Force (1992).

Pathway. The means by which species are transported into a geographical region or into an ecosystem.

Pest species. Term synonymous with nuisance species.

Species. A group of organisms that is formally recognized as distinct from other groups; also a taxon of the rank of species, i.e., a category below genus.

Transplants. Individuals of native species of North America that since European colonization were introduced into ecosystems outside their historic ranges.

Introductions and Survival of Nonindigenous Species in Freshwater Systems

Problems from nonindigenous species are probably more serious in Florida than elsewhere in the United States. Special features of the state, such as the subtropical climate, the major ports of entry for nonindigenous species, the burgeoning pet trade, the expanding tropical fish and ornamental-plant industries, the high rates of human immigration, the increasing urbanization, and the extensive environmental manipulations have contributed greatly to this problem (United States Congress 1993). Florida is famous for its mild climate, abundant waterways, beaches, and natural attractions and for its versatility for freshwater and commercial fishing and wildlife habitat (Johnson and Montalbano 1984). Southern Florida, consisting of approximately 9,065 km^2, is the part of the state with most of the nonindigenous species and is one of the largest complexes of preserved ecosystems in the eastern United States--including Everglades National Park, the Cypress National Preserve, the Loxahatchee National Wildlife Refuge, and the Fakahatchee Strand Preserve.

Florida is infested with approximately 925 aggressive, nonindigenous plants--most of which were deliberately introduced (Doren and Whiteaker 1991). Many taxonomic classes in Florida contain at least one nonindigenous species. More specifically, the state of Florida lays claim to 63 percent of the nonindigenous bird species (American Ornithologists Union 1983), the largest number of established nonindigenous amphibian and reptilian species (Wilson and Porras 1983), and 25% of nonindigenous plants and land mammals. Overall, approximately 15% of Florida's flora, 16% of its fishes, 42% of its reptiles, 22% of its amphibians, 23% of its mammals, and 5% of its birds are naturalized nonindigenous species (Ewel 1986).

Because of their negative impacts on fishing and water sports, degradation of wildlife habitat, reduction of biological diversity, and alteration of natural ecosystems, some nonindigenous species cause severe problems for the ecology, economy, and resource management in the state. Persisting immigrations of insects and plant pathogens (Frank and McCoy 1992) and continuing range expansion of already established nonindigenous species are anticipated to harm agriculture, natural resources, and human health (Myers and Ewel 1990). Neill (1957) discussed the historical biogeography of Florida.

Disturbed areas such as construction sites, abandoned farm land, drained or stressed wetlands, roadsides, and canals and ditches are most notable where nonindigenous species often displace indigenous forms, alter ecosystem dynamics, and eventually become established. Whether nonindigenous species established themselves by outcompeting and displacing indigenous species in disturbed and undisturbed areas or in mainly colonized disturbed habitats that are no longer primary sites for indigenous species is debated. Colonization of undisturbed areas is typically difficult for many nonindigenous species, but this is inconsequential because most areas of Florida are disturbed to some extent (Ewel 1986; Myers and Ewel 1990). Gleason (1984) discussed the environments of southern Florida in relation to urbanization.

Other conditions such as Florida's subtropical climate and lengthy growing season, plentiful freshwater resources, numerous plant and fish industries, large pet trade, international ports of entry, and ever-expanding tourist industry facilitate the introduction and establishment of nonindigenous species (Shafland 1991). Davis (1943) discussed the natural features of Florida in relation to the vegetation of the state.

Subtropical Climate

Most of Florida--from the panhandle to Lake Okeechobee--is a continuously hot, humid subtropical climatic zone, and the rest of the state may be described as the only tropical savanna--the Everglades--in the United States (Council of Environmental Quality 1989). The climate in the Everglades alternates between wet and dry seasons. Florida's maximum average temperature range is between 17.2 and 27.8° C (Winsberg 1990). The lower winter temperatures of northern Florida and especially of south-central Florida (4.4° C and lower) probably limited the dispersal of many nonindigenous species (Shafland and Pestrak 1982; Wilson and Porras 1983). However, with an average rainfall of 135 cms, Florida is one of the wettest states and thereby favors establishment of tropical nonindigenous species. Because Florida is close to the equator and the weather is tempered by large bodies of water that surround the peninsula, this subtropical climate not only appeals to tourists but provides the necessary climate for industries in the ornamental and aquarium plant trade (United States Congress 1993). Furthermore, Florida is subject to many tropical weather storms that disturb the system and aid the spread of nonindigenous species (e.g., Hurricane Andrew in 1992).

Pathways of Introduction

Most evidence of the pathways of introductions of exotic species is circumstantial and based on the opinion of the individual who first discovered that the species was released. Usually, the date and site of an introduction are questionable but may sometimes be estimated by locating the center of the present range, the relative abundance of the species throughout its range, and the rate of the species' expansion. Many species may exist in an area for many years in small, token populations that suddenly expand rapidly for poorly understood reasons. It is also possible that after many unsuccessful introductions the species may finally become established and flourish.

Introductions are either planned, incidental, accidental, or unintentional or caused by a natural disaster. Several attempts have been made to identify the possible pathways of introduction of nonindigenous species (Carlton 1989,1990,1992a,c,d,e; Mills et al. 1993). Intentional introductions are either preceded by research and by careful consideration of the suitability of life history traits of the species to the environment of the receiving waters or releases on the spur of the moment with little consideration for the welfare of the species or the receiving environment (e.g., aquarium dumps). Carefully planned introductions are rare.

The American Fisheries Society (1973) developed a position statement about the intentional introduction of exotic aquatic organisms by governmental agencies. The reasons for intentional introductions of nonindigenous species are (1) establishment of wild populations for recreation or for later commercial harvest; (2) establishment of a forage fish population; (3) use as biological control agents for nuisance plants and insects (Avault et al. 1968); (4) recreational hunting and trapping; (5) disposal of unwanted pets or unprofitable animals or avoidance of prosecution; (6) landscaping, soil stabilization, or commercial harvest; and (7) bait. The incidental introductions are caused by (1) escapes from holding facilities (federal, state, private) such as fish farms, hatcheries, pet dealers, and research facilities because of poor designs of facilities, employee error, or operational mismanagement of the facility; (2) releases from natural disaster such as flooding, hurricanes, earthquakes, etc.; (3) escape of specimens from display pools, aquariums, gardens, zoos, etc.; (4) natural dispersal; (5) movement by predators, and (6) ballast-water discharges. The use of nonindigenous species for bait, recreational fishing, commercial crops, aquaculture, landscaping, and soil stabilization almost always guarantees establishment in new areas--especially if its release could result in profit.

Many plants are introduced for aesthetic or ecological reasons. For example, botanist David Fairchild imported large quantities of nonindigenous plants into Florida in the 1800s and early 1900s (Sailer 1983). Since that time, the two most cataclysmic, intentional terrestrial-plant introductions are melaleuca (*Melaleuca quinquenervia*), a tree introduced for its ability to dry out the swamps of southern Florida, and Brazilian pepper (*Schinus terebinthifolius*), a tree noted for its ornamental value. Both species are spreading rapidly through southern Florida. Hydrilla (*Hydrilla verticillata*) and water hyacinth (*Eichhornia crassipes*) are two examples of nonindigenous aquatic plants that currently cause considerable ecological and economic damages. Another pathway of introduction is the indirect importation of plant pathogens and other species that occur on or around foodstuffs and plants (Denmark and Porter 1973). Although routes of entry for many species have been identified, the exact pathways of introductions of most nonindigenous plants and some animals into the state are unknown.

Theoretically, all undesirable introductions could be avoided if the proper precautions were taken before the species are imported into the area. Many believe that, if the professionals in charge of the resources fully recognize and appreciate the problems by the introduction of exotic species and take the necessary precautions, the number of nuisance introductions could be significantly reduced (McCann 1984). The current debate between those for and those against new introductions relates to the necessary level of precaution that slows the introduction of harmful species without hindering the use of beneficial species. Another issue is a failure by some individuals to separate the act of importation from the act of introduction. In this respect, whether the nonindigenous species is an exotic species (from another country) or a transplanted species (from another part of the same country) makes little difference to the impact on the receiving ecosystem. A good example of the latter is the impact of the transplanted brown darter (*Etheostoma edwini*) that was introduced as a baitfish on the endangered Okaloosa darter, *E. okaloosae*, (Burkhead and Williams 1990). The change from the introduction does not depend on the origin of the species but on the characteristics of the species in relation to the characteristics of the receiving ecosystem.

Industries that Import Nonindigenous Species

Many industries are directly or indirectly responsible for the introduction of harmful nonindigenous species into Florida. Each year, more than $1 billion of woody ornamental plants (for landscaping and shade) and $170 million of tropical fishes and aquarium plants continue to be imported into Florida (United States Congress 1993). Most of Florida's 19 established nonindigenous fish species came from aquarium-fish culture facilities (Courtenay and Stauffer 1990). The aquarium-plant trade introduced many nonindigenous plant species and released hydrilla into canals near Tampa in the 1950's and later into Miami canals and into the Crystal River (Joyce 1990). The existence of nonindigenous birds, reptiles, and mammals in Florida is due in part to pet wholesalers-merchants and to individual pet owners (Owre 1973; Toops and Dilley 1986). Many insects were primarily introduced to control nuisance plants (Frank and McCoy 1993).

Human Population Growth

With a human population of 12.9 million in 1990--a 32.8 percent increase since 1980--Florida is one of the nation's fastest growing states (U.S. Department of Commerce 1990). This rapidly expanding population has increased the demand for more development and for supplies of water and thus altered most of the natural ecosystems of southern Florida. As a result, the disturbed areas--urban, suburban, and rural--are now paramount sites for introduction and establishment of nonindigenous plants and animals.

Human Interaction with Pests

Humans are worldwide spreaders of nonindigenous species. Humans not only spread their own pathogens but also those of wild and domesticated animals and plants (Bates 1956). Many plants and animals that were deliberately and accidentally introduced by humans would not have become established or naturalized if humans had not already changed the environment and stressed the native species before the introductions (Mooney and Drake 1987). Ewel (1986) described the ecology of Southern Florida and how humans changed it. In general, plant and animal populations of Florida once consisted of a population depauperate of species because the climate is tropical, because the climate limits migration and colonization of flora and fauna from northern land masses, and because the surrounding waters isolate Florida and prevent migration from the south. Most introduced nonindigenous species in southern Florida that are now considered nuisance species were present before government agencies gained control of these lands (Ewel 1986). Ecologist are now only beginning to recognize how vulnerable the land is to colonization by nonindigenous species.

Nonindigenous Diseases and Parasites in Freshwater Systems

Nonindigenous Diseases of Plants

The distinction of nonindigenous from native pathogens of plants is difficult (G. E. Buckingham, Research Entomologist, Biological Control Laboratory, U.S. Department of Agriculture, Gainesville, Florida, personal communication). Only if the pathogen is recovered from the plants when the shipping container is opened, importation of the pathogen can be determined. Many reported pathogens were identified only to genus and most genera are common worldwide. In Florida, the list of pathogens includes many on common nonindigenous plants like waterhyacinth, hydrilla, alligator weed, and others that are well established in the field and thus susceptible to native Florida pathogens. Alfieri et al. (1994) identified eight imported nonindigenous aquatic plant species in four families on which pathogens have been reported (Table 1). Those pathogens are supposedly nonindigenous.

Nonindigenous Diseases and Parasites of Fishes

The well-established custom of moving desirable species to new locations--for example, European horses and chickens to North America; American rainbow trout to Europe, South America, Africa, Australia, and New Zealand; and so on--will continue. The advantages of such transfers probably outweigh the disadvantages (Hoffman and Schubert 1984). However, some diseases and pests have accompanied such transfers. Therefore, exotics must be examined by a fish parasitologist to avoid the future transfer of problem species.

The diseases of the native fauna of the United States including nonindigenous diseases were addressed by two major international symposia: The Symposium on Diseases of Fish and Shellfishes (Snieszko 1970) and The Symposium on Wildlife Diseases (Page 1975). The proceedings summarized the status and the effects of worldwide nonindigenous diseases on fishes and wildlife (Bogel and Abdussalam 1976). Since then, new information has been published (Sindermann 1990a,b). Dobson and May (1986) discussed the patterns of invasions by pathogens and parasites.

A summary of the introductions and transfers of parasites and bacterial and viral pathogens by finfishes was completed by Ganzhorn et al. (1992). Not only fishes or eggs may be infected, but the water and the containers may also be contaminated and serve as vehicles for the introduction of pathogens. The chance of establishment of the pathogens depends on the biology of the organisms, the fate of the shipment, and the presence or absence of appropriate hosts. The detection of a pathogen for the first time in a specific geographic location does not necessarily indicate a recent introduction but a major outbreak or increased surveillance. Illegal or undocumented movement of an organism or a natural migration frequently complicates attempts to determine the source of a pathogen in a new geographical area.

Many infectious diseases of fishes are caused by bacterial pathogens (Ganzhorn et al. 1992). Some pathogens exist in a carrier state and may therefore easily be transferred to new geographic areas despite fish-disease surveillance. In the carrier state, the bacteria exist in the host without any detectable pathology and at concentrations that are below the detection level of routine examinations. In addition, some host species and intermediate hosts may not be routinely inspected for fish diseases (Ganzhorn et al. 1992).

Imported viruses may have severe impacts on intensively cultured fishes because viral fish diseases are often untreatable. Some viruses can survive for extended times outside their hosts, some can exist in a carrier state or as latent infections and are not easily detected, and some can be vertically transmitted from progeny by eggs from infected parents (Ganzhorn et al. 1992). Only recently were techniques developed to detect and identify viruses.

Many introduced diseases have been transferred around the world, and their origins are difficult, if not impossible to determine (Granzhorn et al. 1992). The probability of establishment decreases with the complexity of the life cycle of a pathogen.

Several attempts to list the internationally transferred fish parasites have been made (Malevitskaya 1958a,b; Reichenback-Klinke 1961; Kulakovskaya and Krotas 1961b; Hoffman 1967; Hoffman 1970; Bauer and Strelkov 1972; Volovik et al. 1974; Bauer and Hoffman 1976; Gratzek et al. 1976, 1978; Hoffman 1981a), but the records are probably incomplete (Hoffman and Schubert 1984). To identify the established species of nonindigenous pathogens in Florida, we contacted several fish diagnosticians who are familiar with fish diseases in Florida. However, we were unable to determine from Hoffman (1967) and Hoffman and Schubert (1984) which nonindigenous species are presently in Florida. Most, if not all pathologists identify the pathogens to only genus level, which suffices to recommend suitable treatment but not to determine whether the genus is nonindigenous or native. This is particular true of genera with worldwide distributions. Some diagnosticians felt that many species listed by Hoffman (1967) were in fact indigenous to the United States. Some expressed concern that identifying the nonindigenous pathogens in Florida results in more regulations for Florida's aquaculture industry by irresponsible regulatory agencies whose personnel do not understand diseases or epidemiology. However, most basically agreed that many warmwater fish diseases elsewhere in the United States had at one time or another appeared in Florida, especially, when the fishes were under stress. The diagnosticians generally agreed that any pathogen that is host specific to an exotic species is probably also exotic. Some agreed that some pathogens that now occur in other countries may have been transported with exported fishes from the United States. The lack of a national system to prevent the movement of infected warmwater fishes between regions of this country--such as exists for coldwater fishes--is partly responsible for the spread of the pathogens (Hoffman 1970). Many pathogens do not appear until the fishes are under stress from handling, crowding, poor nutrition, or poor water quality (personal observation).

A 1977 survey of 46 comprehensive necropsies of pet fishes in Florida revealed 59% of all fishes carried pathogenic bacteria, 44% had ecologically related diseases, 35% carried protozoan, 28% carried trematodea, 13% carried nematodea, 2% carried dinoflagellates, 2% carried hirundinea, 2% carried crustacea, 2% carried insecta, and 2% had hereditary abdomalities (Meryman 1978). More than 95% of the new infectious fish diseases in Florida are found in newly imported shipment of fish (Meryman 1978). Meryman (1978:234) stated that "The leniency of United States fish health inspections and inadequate research funding has caused a lack of information on diseases in the Florida pet fish industry."

Hoffman and Schubert (1984) pointed out that significant damage to wild fishes from any parasite is usually difficult to demonstrate, but the number of parasites tends to increase and parasites become pathogenic when the host fishes are placed in intensive culture or in confined areas (crowded) such as aquariums or tanks or are transferred to other countries where they are not already present. Host-specific, nonindigenous parasites will probably not become a problem for other species in the country in which they are newly introduced (Hoffman and Schubert 1984). However, parasites such as protozoa (other than blood inhabitants), monogeneans, leeches, and parasitic crustacea that require no intermediate hosts could continue to exist in the exotic species and become a problem if cultured intensively. In their countries of origin, most parasites, however, are adequately controlled Hoffman and Schubert (1984). Parasites that need alternate hosts (trematodes, cestodes, nematodes, acanthocephalans) probably do not survive if the alternate host is not present in the new country. Many non-host-specific parasites have already been transferred to other countries (Hoffman and Schubert 1984). Some are dangerous and should always be eliminated from all shipments.

Gratzek (1980) presented an overview of the diseases of ornamental fishes. He reported that most (60%) aquarist who discontinue keeping fishes do so because the fishes die. He identified common problems with keeping ornamental fishes and stated that the treatment of diseased fishes is the most common problem. Each important disease and parasite of cultured fishes was illustrated and described to aid the aquarist with identification. Aldridge and Shireman (1987) discussed the common diseases and parasites of cultured fishes in Florida and provided information sources for the identification and treatment of common fish diseases.

Based on Hoffman (1970) and Hoffman and Schubert (1984), the introduced nonindigenous pathogen species in the United States are protozoans (12), trematodes: monogenea (24), trematodes: digenea (2), cestodes (1), nematodes (2), copepodes (2), acanthocephalians (1), and isopodes (2). Many have become parasites of indigenous fishes and are now in fishes in Florida. The following information about the nonindigenous pathogens in the United States was taken from Hoffman (1970) and Hoffman and Schubert (1984). Species that are marked with an asterisk are believed to have been introduced into Florida because the pathogen is host specific to introduced nonindigenous fishes in Florida or the biology of the species is similar to that of already established other species or was recently imported (Table 2). Published information on the continued presence of many of these species in Florida is not available. Many pathogens were first discovered when an outbreak occurred, and clear evidence that a pathogen was recently introduced is also not available. Many times the pathogen is only identified to a taxonomic level, frequently to only genus level, to facility an appropriate treatment or control--if one exists. Because one genus may contain indigenous and nonindigenous species to the United States, determination of the status of a pathogen as native or indigenous is difficult. Published details on introductions of the subsequently described species is rarely available.

Protozoa

Dermocystidium koi Hoshina and Sahara 1950. This parasite was in the skin of the common carp (*Cyprinus carpio;* including Koi carp) and is native to Japan. This parasite has also been in common carp from Korea and in Koi carp in the United States (Migaki et al. 1981).

Ichthyophthirius multifiliis Fouquet 1876. This parasite probably originated in Asia (Hoffman 1970, 1981a) and, because of the lack of host specificity, has been transferred by many fishes throughout the temperature zone. This species is not only a serious problem in hatcheries and in fish farms but is also a major problem in pet stores and in aquariums. It costs thousands of dollars each year for treatment of affected fishes and destroys large numbers of fishes. Economically, this is the most destructive freshwater- fish parasite and its transfer should be denied to places where it is now absent (Hoffman and Schubert 1984). This species is on fishes in Florida.

**Mitraspora cyprini* Fujita 1912 (Hofferellus; *Sphaerospora cyprini*). This parasite causes kidney enlargement and death of goldfishes in Japan (Ahmed 1973, 1974). It has been reported from carps from the Amur River (Bykhovskaya-Pavlovskaya et al. 1962) and from goldfishes from the United States (Hoffman 1981a, 1981b).

Myxosoma cerebralis (Plehn 1904). This species is restricted to the Family Salmonidae and is not believed to be in fishes in Florida.

**Oodinium pillularis*. The origin of this species is unknown, but it is believed to be nonindigenous to the United States (Hoffman 1970). It is cosmopolitan and in many fish species (Reichenbach-Klinke 1961).

**Pleistophora hyphessobryconis* Schąperclaus 1941. This species is a destructive muscle parasite of ornamental fishes including goldfishes (Dykova and Lom 1980). Most reports are from Europe, but in the United States it has been seen in *Metynnis* sp. from Brazil (Hoffman and Schubert 1984) and *Paracheirodon innesi* from South America (Hoffman and Schubert 1984).

**Protopalina symphysodonis* Foissner, Schubert, and Wilbert 1979. This species was shipped from Bangkok to Europe and into the United States. Small numbers of it are in the intestines of adult *Symphysodon*, but often many are in fry and seemingly kill them (Hoffman and Schubert 1984).

**Sphaerospora carassii* Kudo 1919. This species is a gill pathogen of goldfishes, common carp, and grass carp in Europe (Molnar 1979). It has recently been found in goldfishes in the United States (Hoffman and Schubert 1984).

**Spironucleus elegans* Lavier 1936. This species is a close relative of *Hexamita* spp.

and in the intestines of many ornamental fishes, particularly in South American cichlids (Family Cichlidae) . It often kills fry of *Pterophyllum* and *Symphysodon*. It readily invades tissues when *Capillaria pterophylli*, which damages intestinal mucosa, is present. *Spironucleus elegans* is often seen in Europe and North America and probably worldwide (Molnar 1982).

**Trichodina reticulata* Hirschmann and Partsch 1955. This parasite of goldfishes was described from Europe but probably originated in Asia (Hoffman 1970). It has been on goldfishes in Arkansas (Hoffman and Schubert 1984), Alabama, Mississippi, Louisiana, Georgia, Kentucky, South Carolina (Wellborn 1967), and Pennsylvania (Lom and Hoffman 1964).

**Trichodina subtilis* Lom 1959. This parasite was on the gills of goldfishes and other fishes in Eurasia (Lom and Haldar 1977) and in the United States (Lom and Hoffman 1964; Hoffman 1978).

**Trichodinella epizootica* (Raabe 1950, Sramek-Husek 1953). This species was probably moved from Asia to Europe on the gills of goldfishes (Hoffman 1970) and other fishes (Lom 1970; Lom and Haldar 1977; Hoffman 1978) and to the United States (Lom and Hoffman 1964; Hoffman and Schubert 1984). This dangerous parasite has seemingly become widely distributed (Hoffman and Schubert 1984).

Some protozoans, *Ichthyophthirius multifiliis*, *Ichtyobodo necatrix*, *Chilodonella cyprini*, *C. hexasticha*, and certain trichodinids are among the most damaging parasites of fishes and should never be transferred. Possibly equally dangerous new species will be found during transfer of exotics. However, because of the many completed shipments of exotic fishes, the appearance of comparable new problems is unlikely (Hoffman and Schubert 1984)

Monogenea (gill and skin flukes)

Many monogenetic trematodes have been transferred with their hosts (Hoffman 1970; Bauer and Hoffman 1976). They are easily transferred because no intermediate host is necessary. Some destroy their hosts, but most are specific for one species of fish or for two or more closely related species. Nevertheless, transfers to new locations are undesirable (Hoffman and Schubert 1984). Because of high host specificity, most Monogenea do not spread to other fish species when they are introduced with their hosts into a new habitat. But they may become more dangerous to their hosts in the new surroundings (Hoffman and Schubert 1984). Monogenea of food fishes have also been transferred to many countries, mostly in the temperate zone--Asia, Europe, and North America-- where fish culture has increased. Such transfers were reviewed by Hoffman (1970) and Bauer and Hoffman (1976). Monogenea of ornamental fishes have been transferred throughout the world. They usually do not attack other fishes, but transfer should be avoided because the parasites of many tropical fishes have not been thoroughly studied (Hoffman and Schubert 1984). The number of parasites that were introduced into the United States is unknown. Hoffman (1970) listed nine species that are known to have been transferred: *Anacanthorus anacanthorus*, *Dactylogyrus anchoratus*, *D. vastator*, *D. wegeneri*, *Gyrodactylus bullatarudis*, *G. elegans*, *Urocleidoides reticulatus*, *Urocleidus crescentis*, and *U. orthus*.

**Anacanthorus anacanthorus*, *A. brazielensis* and *A. neotropicalis* have been on the gills of the redbreasted piranha (*Serrasalmus nattereri*), which was introduced into the United States from South America (Mizelle and Price 1965).

Anacanthorus brevis (Mizelle and Kritsky 1969a). This species was taken from the gills of *Brycon melanopterus*. It was transferred from Brazil to the United States (Hoffman and Schubert 1984).

Archidiplectanum archidiplectanum (Mizelle and Kritsky 1969b). This species was taken from the gills of *Gnathonemus petersi*. It was transferred from western Africa to the United States (Hoffman and Schubert 1984).

**Cichlidogyrus* sp.This parasite was on the gills of *Tilapia* sp. and was transferred from Africa to United States in 1960 on *T. mossambica* (Hoffman 1970).

Cleidodiscus amazonensis, *C. piranhus,* and *C. serrasalmus* This parasite was on the gills of the redbreasted piranha that were transferred from South America to United States (Mizele and Price 1965).

**Dactylogyrus anchoratus* Dujardin 1845; Wegener 1857. This parasite was on goldfishes. It probably originated in Asia and was transferred to the United States (Price and Mizelle 1964).

**Dactylogyrus extensus* Mueller and Van Cleave 1932. This parasite was on the gills of common carp. It has been transferred from Europe to the United States and Israel (Paperna 1964).

Dactylogyrus vastator Nybelin 1924. This species was on the gills of goldfishes. It probably originated in Asia (Price and Mizelle 1964).

**Dactylogyrus wegeneri* Kulwiec 1927. This parasite was on goldfishes and was probably transferred from Europe or Asia (Price and Mizelle 1964).

Dactylogyrus minutus. This parasite of the common carp is well known in Europe and in Central Asia and has been found in the United States (Hoffman and Schubert 1984).

Dactylogyrus baueri and *D. formosus.* Both parasites are on the gills of goldfishes and were transferred from Japan to the United States (Rogers 1967).

**Gyrodactylus cyprini* (Diarova 1964). This species is a parasite of the common carp and is well known in Europe and Central Asia. It occurs in the United States (Rogers 1968).

**Gyrodactylus elegans*. This species is a parasite of the goldfish, probably originated in Asia, and then transferred to Europe and to the United States (Malmberg 1962).

Heteronocleidus gracilis was on the gills of *Colisa labiosa* (Mizelle and Kritsky 1969b) and probably transferred from India to California (Hoffman and Schubert 1984). There is no record of it in Florida.

Longihaptor longihaptor was on gills of *Cichla ocellaris* (Mizelle and Kritsky 1969a) and was transferred from Brazil to the United States (Hoffman and Schubert 1984).

**Pseudacolpenteron pavlovskyi* is a parasite of the common carp and was transferred to Israel and the United States (Hoffman and Schubert 1984).

**Trianchoratus acleithrium* Price and Berry 1966. This parasite was taken from the gills of *Helostoma rudolfi* and was imported from Malaysia into the United States (Mizelle and Kritsky 1969a).

**Urocleidoides amazonensis* (Mizelle and Kritsky 1969a) was on the gills of *Phractocephalus hemiolopterus* and was transferred from Brazil to the United States (Hoffman and Schubert 1984).

Urocleidoides catus (Mizelle and Kritsky 1969a). This parasite was on the gills of *Phractocephalus hemiolopterus* and was transferred from Brazil to the United States (Hoffman and Schubert 1984).

Urocleidoides megorchis (Mizelle and Kritsky 1969a) attacks the gills of *Sorubim lima* and was transferred from South America to the United States (Hoffman and Schubert 1984).

Urocleidoides reticulatus Mizelle and Price 1964. This parasite was on a guppy (*Lebistes reticulatus)* and was transferred from Trinidad to California (Mizelle and Price 1965).

**Urocleidoides robustus*. This parasite was on the gills of *Symphysodon discus* (Mizelle and Kritsky 1969a) and transferred from Brazil to the United States.

Urocleidus crescentis and *U. orthus*. These parasites were on the gills of redbreasted piranha and were transferred from South America to the United States (Mizelle and Price 1965).

Trematoda, Digenea

Manter (1963) believed that the intestinal trematode *Crepidostomum farionis* of salmonids was transferred from Europe to North America in trout and became established (Hoffman and Schubert 1984). Because this pathogen is restricted to salmonids, it is not established in Florida.

Bolbophorus confusus. This Eurasian strigeid trematode probably came to the United States in a stray pelican, its natural final host (Hoffman 1970). Hoffman and Schubert (1984) found it in fathead minnows (*Pimephales promelas*) that were shipped from South Dakota to Arkansas. This species has not been seen in Arkansas since its reported introduction and may not have become established. No record of this species in Florida could be found, but fathead minnows are frequently shipped into Florida from Arkansas as bait, and the trematode could have been introduced into the state.

Cryptocotyle lingua. This species has been in coastal marine fishes in the United States. It was probably carried by European snails on ships from Europe to the East Coast of the United States about 100 years ago (Sindermann and Farrin 1962).

Cestoda

Cestodes require at least one and often two intermediate hosts. Although this requirement complicates relocation of parasite species, some have been transferred.

**Bothriocephalus opsarichthydis* (*B. acheilognathi*, *B. gowkengensis*). This pseudophyllaeid cestode was introduced into the United States with the importation of grass carp and acquired a new host, the common carp. The common carp is infected between the ages of 2 months and 3 years because it feeds on microcrustaceans, the intermediate host of the parasite (Hoffman and Schubert 1984). Since its initial introduction, the cestode has been reported in cultured bait minnows--the golden shiner (*Notemigonus crysoleucas*) and the fathead minnow (*Pimephales promelas*)-- in North America. Later Hoffman (Fish Farming Experimental Station, U.S. Fish and Wildlife Service, Stuttgart, Ark., unpublished data) found it in mosquitofishes (*Gambusia affinis*; Hoffman and Schubert 1984). It presumably traveled by air shipments in grass carp from Asia. Since then, it has been in mosquito fishes in North Carolina and in California. W. Rogers at Auburn University (Hoffman and Schubert 1984) found *B. opsarichthydis* in channel catfishes, but it is rarely in a nonplankton feeder. Recently, Hoffman and Schubert (1984) found it in an American endangered fish, the Colorado squawfish (*Ptychocheilus lucius*), from a fish hatchery in New Mexico.

Nematoda

**Philometra sanguinea* (*P. carassii*). This parasite is a specific parasite of goldfishes and infects the blood vessels of fins (Vismania and Nikulina 1968). It was presumably transferred from Japan to North America by fish hobbyists (Hoffman 1970).

**Camallanus cotti.* This species, originally described from fishes in Japan (Fujita 1927), became established in ornamental fish culture and turned up in Malaysia, Europe, the United States, and Australia (Stumpp 1975).

Copepoda and Branchiura, Parasitic

**Argulus japonicus* Thiele 1900 Linnaeus. This branchiuran has been transferred to Africa (Fryer 1960), Ceylon (Kirtisinghe 1964), Israel (Paperna 1964), New Zealand (Hine 1975), and North America (Cressey 1978). Although seemingly lacking host specificity, it is usually on goldfishes and on common carp. It also occurs in Japan and China (Yamaguti 1963).

**Lernaea cyprinacea* Linnaeus 1758. This devastating copepod has been reported from many species of freshwater fishes and from frog and salamander tadpoles in Africa, Asia, Europe, Israel, Japan, Eurasia, and the United States. In the [former] U.S.S.R., it is known as *Lernaea elegans* and as a host-specific parasite of goldfishes; however, most parasitologists know it as *L. cyprinacea.* It probably originated in Asia and spread with the goldfish trade (Hoffman 1970).

Isopoda

Artystone trysibia. This species was imported from Colombia, South America, into the United States in *Corydoras*. It burrows into fishes and lives in the wound hole (Hoffman and Schubert 1984).

**Lironeca symmetrica* (often reported as *Livoneca*). This species was imported on ornamental fishes from South America to the United States. It has become an established parasite and damages many exotic fishes (Herwig 1976).

Acanthocephala

**Polyacanthorhynchus kenyensis* Schmidt and Canaris, 1967. Juvenile forms of this parasite have been in the liver of *Micropterus salmoides* and *Tilapia* sp. This species was probably transferred from South America to North America (Schmidt and Canaris 1967).

Nonindigenous Diseases of Humans

Some diseases, including parasites, of marine species can be transferred to humans. Sindermann (1990a) concluded that the principal public-health problems from diseased marine fishes are the ingestion of larval worms (nematodes, cestodes, and trematodes) and the handling of raw marine fishes. The latter can impart microbial, chronic granulomatous lesions that are caused by mycobacteria, erysipelas, and other inflammatory lesions of the skin and septicemias from infection of superficial wounds by vibrios and other bacterial genera.

Adams et al. (1970), Black et al. (1971), Kelly (1976), and Wilson (1976) reported that the bacterium *Mycobacterium marinum* was transmitted from fishes to humans from marine aquariums; whether this disease is nonindigenous to Florida is not known.

Janssen (1970) summarized the literature on fishes as potential vectors of human bacterial diseases. Reichenbach-Klinke and Elkan (1965) stated that transmittal of fungal or viral diseases from fishes to humans has not been demonstrated. However, they emphasized that little investigation has been conducted on this topic. The transmittal of bacterial diseases from fishes to humans and vice versa is discussed. Bullock (1964) showed the close relationship of bacterial organisms of diseases in fishes and in humans, especially in the genera *Aeronomas*, *Pseudomonas*, and *Vibrio*. Some human diseases can be traced to swimming pools, aquariums, or tropical fish tanks (Oppenheimer 1962 and Middlebrook 1965). Brunner (1949) called attention to the role of fishes as actual and potential vectors of many human diseases.

Wells et al. (1973) stated that 300,000 of the estimated two million annual cases of human salmonellosis in the United States were probably contracted from pet turtles. Pet turtles carry the disease, which multiplies in dirty water in the turtle bowl or in the shipping bogs. The association of the bacterial species with turtles has been of suggested considerable significance to public health (McCoy and Seidler 1973). For this reason, the United States Congress enacted legislation that prohibits the interstate shipment of turtles harboring *Salmonella* and *Shigella*.

In the early 1970's, despite the attention given to the terrapins, little consideration had been given to the role of other aquarium species as vectors of potential pathogens for humans (Wells et al. 1973). Little attention had been given to the ornamental fishes, although large numbers of them are imported into North America from areas of the world where sanitation is often inadequate and where numerous diseases of humans are endemic. Many of these fishes are offered for sale to the public. An estimated 20 million household aquaria are in the United States (Axelrod 1973). In addition, aquaria with ornamental fishes are often in public school classrooms, medical and dental offices, eating establishments, department stores, and nursing homes and even in hospital wards. The presence of potentially pathogenic microorganisms in these aquaria presents a risk to public health. Janssen and Meyers (1968) discussed the infection of fishes with human pathogens.

Trust and Bartlett (1974) monitored water with ornamental fishes from retail stores and found that the aquarium water contained significant numbers of a wide variety of bacteria. These bacteria probably originated from the fishes and often include coliforms and fecal coliform counts that were significantly higher than allowed for recreational and bathing waters in the United States and Canada. They found that 75% or more of the samples contained *Citrobacter*, *Escherichia*, *Pseudomonas,* and *Vibro,* and *Aeromonas*, *Alcaligenes*, *Enterobacter*, *Flavobacterium*, and *Streptococcus* were isolated from 45 to 65% of the samples. The concentration and type of bacteria were similar to those in waters with small pet green turtles (McCoy and Seidler 1973; Wells et al. 1973). However, Shotts and Gratzek (1984) pointed out that some of the bacteria belonging to the genus *Citrobacter* can be confused with bacteria causing human salmonellosis in this country. Some of the organisms were potential pathogens of humans. *Klebsiella pneumonia* and *Pseudomonas aeruginosa* isolated were also from the samples that Trust and Bartlett (1974) examined. Both are potential pathogens of humans and can be of considerable clinical significance (Weistreich and Lechtman 1973).

Trust and Bartlett (1974) pointed out that the bacteria that are shipped with fishes are provided with a liquid menstruum with added nutrients in the form of fish feed, surfaces for colonization, heated water, and aeration, which are perfect conditions for the culture of the pathogens. A wide variety of bacterial species capable of causing disease in humans are able to grow on commercial fish diets as the sole source of nutrients (Trust and Money 1972). Moreover, some of these fish diets also contain potential pathogens of humans (Trust and Money 1972). Other studies revealed that human pathogens such as *Vibrio cholerae*, *V. parahaemolyticus*, *Erysipelothrix rhusiopathiae*, and *Leptospira icterohemorrhagiae* can survive and multiply in the gut, mucus, and tissues of fishes (Janssen 1970).

The etiological agents of eye, ear, nose, and throat, gastrointestinal, and genito-urinary infections in humans that could be fish or water borne are rarely identified accurately and more rarely traced to their sources (Janssen 1970). Janssen (1970) stated that the relationship of bacteria in aquaria with clinical conditions in humans is worthy of investigation by public health officials, especially because so little consideration and research have been devoted to the possibility of fishes and aquaria as vectors of human pathogens. He suggested, for example, the incidences of enteric infections in clerks who are involved in the sale of aquarium species may be worthy of study. The current sale of ornamental fishes represents a unique situation in which the public can purchase a mixed bacterial broth with as many as 10^7 cells/ml that may include potential pathogens. The establishment and enforcement of regulations that are similar to those for the control of turtle-borne disease are needed (Janssen 1970).

After Trust and Bartlett (1974) reported the results of their studies of the diseases and parasites from aquarium fishes and the fishes' transport water in Canada, the Pet Industry Joint Advisory Council of the United States funded a 3-year study to determine the existence of a similar problem in the United States, the magnitude of the problem, and the potential import of new exotic tropical disease or parasite species that could be health hazards to humans (Shotts & Gratzek 1984).

As part of the study that the Pet Industry Joint Advisory Council of the United States funded (Gratzek et al. 1976; Shotts et al.1976), samples of blood, slurry, and shipping water from 77 bags of fishes in 16 shipments from Hong Kong, Taiwan, Singapore, and Bangkok were examined. The examinations revealed that 61% of the samples contained fishes with some type of parasite (Table 3). Gill flukes were the most common type of parasites. Intestinal examinations revealed 12.5% were infected with nematodes or acanthocephalans in the intestines or in surrounding tissues, indicating that the fishes probably were intermediate hosts. Bacteremias were in 51 bags and represented 11 genera of bacteria. The most common were *Pseudomonas, Aeromonas, Proteus, Citrobater, Enterobacter,* and *Escherichia*. Two species of other bacteria, *Salmonella arizona* and *Mycobacterium* spp., were found. The latter is universal in water. The virus isolate (*Acanthophthalmus* sp.) was in some kuhli loaches (Family Cobitidae). The investigators concluded that the parasite load from Southeast Asia was less than expected. They did not consider the finding of *Salmonella* significant.

Shotts et al. (1976) and Gratzek et al.(1978) concluded that, because no mycoplasmas were in any of the fish tissues or water samples from Southeast Asia, the organisms are not considered a serious threat or source of contamination in Southeast Asian aquarium fishes and that their transportation in shipping water is of negligible significance to human health in the fish industry. Shotts et al. (1976:735) further noted the flora in the bags did "not differ significantly from those present in fish under natural conditions, or in pond-raised food fish." They felt that neither the fishes nor the transport water were a source of disease to humans because no widespread outbreaks had ever been associated with aquaria. Shotts and Gretzeh (1984:230) concluded "Common hygiene practice should minimize the exchange or the existing bacterial flora between the pet and the owner."

Shotts and Gratzek (1984) described a 3-year study that the Pet Industry Joint Advisory Council funded to determine the potential ecological impact of the introduction of fishes or their transportation water from South America and Southeast Asia on the health of humans, domestic animals, and native game and fish species. A sample of fishes from Florida was also sent to their laboratory in Georgia for evaluation and for a comparison of the frequency and type of diseases and parasites in domestically shipped fishes with foreign shipped fishes.

Shotts et al. (1976) found that 69% of the bags contained fishes with bacteremias (Table 3). When tissue suspensions of fishes were examined, 18 genera of bacteria were noted. Fourteen genera were associated with the shipping water. In each case, the two predominating organisms were *Pseudomonas* sp. (not *aeruginosa*) and *Aeromonas hydrophila* complex. Other organisms were *Citrobacter*, *Proteus*, *Escherichia*, *Micrococcus*, *Mycobacterium*, and *Flavobacterium*. Mycoplasmas were not recovered.

The presence of *Escherichia coli* indicated that the water with the fishes was contaminated with animal or human wastes. Samples from Florida contained the least evidence of contamination, even though the domestic fish farmers were told not to treat their fishes before shipment. The results from this study are related to the type of culturing in different parts of the world. Fishes from Southeast Asia are raised in intense culture for maximum yield in the smallest possible space and as economically as possible. In contrast, fish culture in Florida is a selective management approach--fishes are raised in ponds. Most of the South American fishes are usually captured in the wild (Shotts and Gratzek 1984). The bacteria frequencies reflect the culture techniques. The cited studies revealed that the parasites were common in cultivated food fishes or in ornamental species.

Shotts and Gratzek (1984) found that the methods for shipping and handling the fishes affected the results of the tests. The fishes from Southeast Asia and South America had experienced several transfer points where dead fishes were discarded from the shipment. The fishes probably died from diseases, parasites, and stress of shipping and handling. Most fishes in Florida were not treated before being shipped. Treatment of the fishes before shipping can reduce diseases and parasites.

The South American fishes were frequently from wild populations and 98% of them in the bags were infested with monogenetic trematodes, metacercariae of digenetic trematodes, plerocercoid stages of cestodes, and nematodes. Treatment before shipment would reduce the pathogen load.

Conroy et al. (1981) found more parasite species such as leeches (*Lemea)* and the isopod *Lironeca* (common parasites in tropical fishes in the United States) than Shotts and Gratzek (1984). However, fishes that Conroy et al. (1981) examined were caught in the wild and were not treated before examination. Shotts and Gratzek (1984) concluded that there was no major difference between the species in foreign sources and species from domestic sources. Some organisms, however, could severely debilitate tropical fishes. Shotts and Gretzek (1984:230) did not consider that the "microorganisms already present in this country via aquarium fishes presents a source of potential health hazard to humans, domestic species or indigenous wild animals or fish in the United States" and concluded their report with the statement "while there are 'exotic' aquarium fishes, there do not appear to be 'exotic' aquarium fish parasites." From the same series of studies, Shotts et al. (1976:735) stated that "It would be presumptuous to assume from our findings that aquarium fish, or their transport water, present a source of potential disease to humans, especially as no widespread outbreaks of human disease have been directly associated with aquaria." However, the confirmed presence of the bacteria *Mycobacterium* in salt-water aquaria confirms a threat to aquarists.

The subject of diseases in the pet trade, in general, puts the industry in a different position. Representatives of the pet-fish industry are frequently reluctant to talk about problems with diseases for fear that it will result in additional regulations. Privately, they however admit that diseases of their stocks during confinement in close conditions, during either culture, transportation, or holding are a serious problem.

Ganzhorn et al. (1992) pointed out a pathogen usually is studied when mortality becomes heavy during the culture of fishes and when the disease is a bacterium or virus and the exact identification of the organism is in doubt. Attempts to detect diseases in the absence of clinical problems is difficult because the disease organism is usually present in small numbers and difficult to recover, especially if the organism is a carrier of the disease. In the absence of symptoms in the fishes, the organisms may be present in small numbers and may be difficulty to find. During or immediately before a disease outbreak, the numbers of the organisms increase rapidly and the organisms can be more easily found. Mild cases of a disease are usually not detected but are only noticed when the population explodes. Most detection techniques that are routinely used only identify the organisms to genus level. Identification to species is time consuming and requires an expert in the field of identification of that group. Identification to species level is not needed to prescribe a treatment.

Our literature searches revealed no evidence of an infection of a human by freshwater aquarium fishes in Florida. Saltwater aquariums have been implicated as a vector in infections of humans with the bacteria *Mycobacterium marinum* (Adams et al. 1970, Black et al. 1971, Kelly 1976, and Wilson 1976).

Twice during routine sampling in 1991, toxigenic *Vibrio cholerae* 01, resembling the Latin American strain that had earlier caused an epidemic cholera outbreak in Central America, was recovered from seafoods from closed oyster beds in Mobile Bay, Alabama (McCarthy et al. 1992). Nonendemic pathogenic species can be inadvertently introduced into a region when ballast water or sediments of bulk-cargo vessels are discharged. Vessels that entered the Mobile Bay from Central America may have carried *V. cholerae* in their ballast water, bilge water, or sewage tanks. Toxigenic *V. cholerae* was taken from the ballast, bilge, and sewage of three of the foreign vessels in the harbor (McCarthy et al. 1992). The last port of calls of the vessels in the harbor had included Brazil, Columbia, and Chile. Exchange of ballast water on the high seas could have reduced some of the potential spread of this disease and other diseases and organisms, but the exchange of ballast water on the high sea is only part of a prevention of the spread of nonindigenous organisms by shipping.

In November 1979, five cases of non-O group 1 (non-O1) *V. cholerae* gastroentertis occurred in the panhandle of Florida (Wilson et al. 1981). The source of this outbreak was traced to the consumption of raw oysters from the Oyster and Apalachicola Bay in Florida. Oyster and water samples from the bay revealed the disease organism. Because the two infected sites were in separate locations, the authors believed that the source was human fecal material from sewage that was washed into the areas by heavy rains or that the heavy rains changed the ecological environment to favor the growth of the *V. cholerae* organism. The initial origin of the organism was not identified.

We could not determine the source of the outbreaks of cholera that took place in the early development of this country, but it is believed that the strain of *V. cholerae* in these cases resulted from the introduction of a more virulent form from South America because of the timing of the outbreak with an outbreak in South America and the nature of the organism (Wilson et al. 1981). The strain was considered different from the toxigenic strain that is endemic to the estuaries of the northern Gulf Coast; it lacks haemolysin and the VcA-3 vibriophage, and it has a different chromosomal restriction pattern (McCarthy et al. 1992).

Nonindigenous Aquatic and Semi-Aquatic Plants in Freshwater Systems

Nonindigenous Aquatic Plants

Aquatic and wetland plants are important components of the lakes, ponds, and streams of Florida. The state has an abundance of freshwater and salt water ecosystems that encompass more than 1,012,500 surface hectares. Recreation includes boating, fishing, water skiing, and hunting in the freshwaters of the state. Aquatic plants form an important link between the base of the foodweb and the higher forms of plant and animal lives. Aquatic plants provide protection and spawning and feeding habitats for aquatic insects, mammals, waterfowl, and fishes (Tarver et al. 1986). The important role of aquatic plants in nutritional regulation of eutrophic and oligotrophic waters was described in the literature in recent years (Sheremen and Haller 1980, Confield et al. 1983).

Pieterse (1990a,b) and Pieterse and Murphy (1990a) discussed the ecology and management of nuisance aquatic plants. Cook (1990) described the origin, autoecology, and spread of most plants that are considered worldwide pests. Of the more than 700 aquatic plants in the world, fewer than 20 are considered major pests or weeds. The term "weed" may be defined as a plant that is undesirable in one area but beneficial in other areas. The negative effects of excessive plant growth can be direct or indirect. Direct harmful effects include impeding the movement of water, hindering navigation, interfering with hydroelectric facilities, increasing sedimentation, decreasing human-food production in aquatic habitats (crops and fisheries), and adversely affecting recreation such as swimming, waterskiing, and fishing. The indirect negative effects include loss of water by evapotranspiration and increase of health hazards by the development of vectors of human diseases such as malaria and schistosomiasis (bilharzia; Pieterse 1990a). Holm et al. (1969) and Holm and Yeo (1980) discussed many of the international problems caused by the failure to control nuisance aquatic plants.

Whereas Klose (1950) estimated that at least 180,000 nonindigenous plant were introduced into the United States prior to 1950, Bates (1964) estimated that 200,000 exotic plants have been brought into the United States in the past few decades. Ripley (1975) estimated that as many as 1,800 exotic plant species have escaped into the nation's ecosystems and that a large portion of these species have become naturalized (Morton 1976; Austin 1978). Many were imported into the United States through Miami, Florida (Austin 1978). Florida has been particularly susceptible to exotic-plant invasions because of its semitropical climate and abundance of aquatic habitats. Florida is also home to a large exotic aquarium and ornamental foliage-plant industry that imports millions of non-native plants each year and cultures native and exotic species for export.

McLane (1969) and Long (1974) described the early history--which started in the late 1920's--of the introduction of nonindigenous aquatic plants into Florida by the aquatic plant industry. During that time, stocking open waters of the state of Florida with nonindigenous plants was common practice. The purpose of most of the stocking of Florida's waterways with nonindigenous plants was to create wild populations for later harvest and sale. Because this activity is now illegal and because the industry realized that additional introductions could lead to more regulations, the rate of new introductions of plants was reduced in recent years (Schmitz et al. 1991).

The first attempts to count the number of plants in Florida was by Small (1933, 1938). He recognized 3,356 seed-plant and 133 fern species. More recent studies revealed that Florida is inhabited by approximately 3,450 species of plants, as many as 925 of which are considered exotic (Ward 1990).

Freshwater ecosystems in Florida were probably the first in the United States that experienced invasions by nonindigenous vegetation (Schmitz et al. 1993). Austin (1978) discussed the early introduction of many of today's worst pest species such as the kudzu-vine (*Pueraria thunbergiana*), Brazilian peppertree (*Schinus terebinthifolius*), melaleuca (*Melaleuca quinquenervia*), Australian pine (*Casuarina* spp.), sugar-cane (*Socchorum officinarum*) and oranges (*Citrus aurantium* and *Citrus sinensis*) by well-meaning individuals. Among those who promoted the importation and planting of nonindigenous plants was John C. Gifford, a forester at the University of Miami, bank official, nurseryman, and land-development company entrepreneur (Austin 1978), and Dr. Henry Nehrling, a well-known scholar and horticulturist (Nehrling 1944).

More recently, Tarver et al. (1986) compiled an identification manual with descriptions, habitats, and values to wildlife of common native, naturalized, and noxious nonindigenous aquatic and wetland plant species of Florida. Presently, statewide surveys of aquatic plants are conducted every other year to determine the status of nuisance plants and to identify new introductions (Schardt 1980, 1986, 1988; Schardt and Nall 1989). Nineteen nonindigenous plant species were reported in Florida's public waters during 1990 (Schardt and Schmitz 1990). This placed Florida into second or third place behind Hawaii and perhaps California (Westman 1990) in the number of introduced plant species.

Of the 925 exotic terrestrial and aquatic plants in Florida, approximately 33 are considered highly invasive (Exotic Pest Plant Council 1993). The 20 nonindigenous aquatic plant species established in Florida (Table 4) include invasive species such as hydrilla (*Hydrilla verticillata*), waterlettuce (*Pistia stratiotes*), alligatorweed (*Alternanthera philoxeroides*), torpedograss (*Panicum repens*), and waterhyacinth (*Eichhornia crassipes*); the latter species has the reputation of being the world's worst aquatic weed (Cook 1990). The remaining plants are nuisances, which cause occasional problems or seem to be innocuous in Florida's navigable rivers and public lakes. Although the 1990 survey (Schardt and Schmitz 1990) dealt only with the natural waters of the state, the additional species are also invasive in ditches or in flood-control canals. The surveys did not include the nonindigenous plants established in drainage systems and in other created water bodies.

Most Florida residents who spend any time near water in Florida are well aware of the state's problems with aquatic nuisance plants. However, many residents of the state are unaware of the magnitude of the Florida aquatic-plant industry. The cumulative 1992-93 database of the Bureau of Aquatic Plant Management, Tallahassee, Florida, now under the

Florida Department of Environmental Protection, contained the names and addresses of all known entities in the collection, culture, sale, research, or restoration of aquatic plants and listed 1,051 entries. In 1991, the Aquaculture Program of the Florida Department of Agriculture and Consumer Services, Tallahassee, Florida, produced the Florida Aquatic Plant Locator (Aquaculture Program 1991). The locator is a list of sources of Florida aquatic plants for the aquarium, garden pool, and wetland restoration, for mitigation, and for human consumption. The locator listed 31 wholesalers and 90 retail dealers of aquarium plants; and 67 wholesalers and 62 retail dealers of aquatic plants for garden pools. In addition, wholesalers and retail dealers that specialize in aquatic plants for restoration (91), exporters (8), aquatic plant installers (42), maintenance services (41), and landscape architects who specialize in designing the indoor and outdoor facilities with aquatic plants (8) were listed. Joyce (1990) discussed the potential uses of aquatic nuisance plants for biofertilizers, compost, animal foods, human drugs, human foods, paper and fibre production, ornamentation, waste water treatment, and biogas production. Most uses are presently limited in scope or still under study. Rataj and Horeman (1977) discussed the identification, cultivation, and ecology of the plants that are most frequently used in aquariums.

Plants are considered nonindigenous to Florida if information suggests they were not present in the state before the colonization of the continent by Europeans. Only few exotic aquatic plants are suspected to have been accidentally released in Florida, usually from the discharge of ship ballast (Schardt and Schmitz 1990). These introductions included waterlettuce (*Pistia stratiotes*), salvinia (*Salvinia minima*) and alligatorweed (*Alternanthera philoxeroides*; Schardt and Schmitz 1990).

Horticultural interests have been paramount in the invasion of Florida by exotic plants. Foy et al.(1983) summarized the history and impacts of exotic plants and the introduction of pests on North American aquaculture. Waterhyacinth (*Eichhornia crassipes*) was introduced because of its showy flower. Brazilian pepper (*Schinus terebinthifolius*) was intentionally planted throughout southern Florida to display its brilliant red berries and evergreen foliage. The advent of airfreight and the return of military personnel that were stationed across the globe during World War II precipitated a boom in the aquarium industry. McLane (1969) described the relation of the aquatic plant business with the introduction of exotic aquatic plants in Florida and potential problems in the late 1960's. Most plants can quickly be transported to anywhere in the world. Some were subsequently cultivated in public waters of Florida to provide a ready source of plants. Nonindigenous plants in Florida that were introduced by the aquarium trade include limnophila (*Limnophila sessiliflora*), hygrophila (*Hygrophila polysperma*), and the state's worst aquatic weed, hydrilla (*Hydrilla verticillata*). Regardless of the reason for an introduction, none of the plants was screened or investigated for its potential harm to the receiving aquatic ecosystems before its introduction into the open waters of the state (Schardt and Schmitz 1990).

Most plant species were deliberately imported into Florida almost exclusively for agricultural or horticultural purposes. Many emersed exotic plants were spread in the early twentieth century to support agricultural interests. In search for better cattle forage that could withstand the wet climate of southern Florida, grasses such as paragrass (*Brachiaria mutica*), napier grass (*Pennisetum purpureum*), and the invasive torpedograss (*Panicum repens*) were introduced. Melaleuca (*Melaleuca quinquenervia*) was deliberately planted in the Everglades to dry these wetlands and make them suitable for agriculture (Schardt and Schmitz 1990).

Austin (1978) discussed the effects of some nonindigenous plants on southeastern Florida. Williams (1980) reported the number of introduced plants and the increased efforts to stop further introductions. He also pointed out that with even limited studies the undesirability of the introduced plants and the toxicity of some of these plants to humans and other animals could have been determined. The aquatic-plant industry is now sensitive to further unplanned introductions and diligent about containing nonindigenous plants.

Possession of the 24 plant species that are considered pest species is prohibited in Florida (Anonymous 1993). Routine examination of importation and nurseries facilitated the identification and destruction of exotic problem species such as *Salvinia molesta*, *Eichhornia azurea* (rooted waterhyacinth), and the male genotype of hydrilla. None of these species has yet become established. The introduction of any of these species into waterways of Florida is prohibited (Schardt and Schmitz 1990).

The state of Florida is considered to have one of the best organized aquatic plant programs (surveys, inspections, control, law enforcement, legislation, and documentation; Steward 1990). As part of this program, the Bureau of Aquatic Plant Management of the Florida Department of Environmental Protection has for 12 years conducted an annual survey of the state waterways to provide early warning of new introductions, determine the most critical control problems, obtain funding for control, and assess the success of control in earlier years.

A plant's invasive capacity is determined by physiological factors such as rapid growth rate, multiple reproductive strategies, and tolerance to a broad range of environmental parameters. The conditions of the site into which a plant is introduced also determines the plant's degree of invasiveness (Westman 1990). If endemic plants are stressed or removed or if natural controls of an nonindigenous plant such as predators, diseases, or other limiting environmental conditions are not present, the nonindigenous plant may have a distinct advantage over endemic species (Schardt and Schmitz 1990).

The nonindigenous plants with the greatest potential for invasion are the floating and submersed species because they can harm nearly all of Florida's shallow waters (Schardt and Schmitz 1990). From 1980 through 1991, more than $98 million were spent for the control of waterhyacinth, waterlettuce, and hydrilla in Florida public waters (Schmitz et al. 1993). State records show that the management of all other plants--native and exotic plants--cost less than 5% of that sum (Schardt and Schmitz 1990).

The advantage of using biological control agents to manage nuisance aquatic plants is significant. "Advantage of using effective, safe organisms to manage aquatic weeks biologically include (1) longevity of the method once it is established; (2) constant feeding activities against the growing weed; (3) low longterm costs; (4) high effectiveness in some plants; and (5) in the case of fish, the potential for conversion of the week to a useful protein product (fish flesh)" (Sutton and Vandiver 1986:2).

Morton (1976) summarized the spread of many ornamental and fruit-bearing plant species in Florida and the environmental and ecological problems it created. She stated (p. 348), "The great increase in our naturalized flora is attributable mainly to the escape from cultivation of trees, shrubs, vines, and other plants deliberately imported as ornamentals or as sources of food, timber, fibre or forage." Schmitz et al. (1991) reported the history and efforts to prevent new introductions of exotic invasive aquatic and wetland plants. Gunderson (1983) described the distribution and effect of nonindigenous woody plants in the Big Cypress National Preserve and the influences of fire, hurricanes, frost, and anthropogenic disturbance on the establishment of such plants.

Chemical or mechanical methods were traditionally used to control nuisance-plant populations. More recently, biological control was developed. Frank and McCoy (1993) listed the nuisance aquatic or semi-aquatic nonindigenous plants that were identified as targets for biological control. They are waterlettuce (*Pistia stratiotes* L., Arales:Araceae); alligatorweed (*Alternanthera philoxeroides* (Martius) Grisebach, Caryophyllales:Amaranthaceae); Eurasian watermilfoil (*Myriophyllum spicatum* L.,Haloragales:Haloragaceae); hydrilla (*Hydrilla verticillata* (Lf.) Royle, Hydrocharitales:Hydrocharitaceae); waterhyacinth (*Eichhornia crassipes* (Martius) Solms, Lilliales:Pontederiaceae); melaleuca (*Melaleuca quinquenervia* (Cavanilles) S.T. Blake, Myrtales:Myrtaceae); and Brazilian Peppertree (*Schinus terebinthifolius* Raddi, Sapindales:Anacardiaceae).

Biological control agents are also considered for the control of limnophila (*Limnophila sessiflora*), hygrophila (*Hygrophila polysperma*), water morning glory (*Ipomoea aquatica*), and parrotfeather (*Myriophyllum aquaticum*) (Buckingham and Habeck 1990). The time, resources, and cost of finding, evaluating, and testing a biological control agent and obtaining approval for its release into the field are considerable. Cost estimates for biological controls of the mentioned plants could not be obtained.

The following descriptions of nonindigenous plants of Florida are from Schardt and Schmitz (1990), Schmitz et al. (1991), and Schmitz et al. (1993). Information, especially on plant control agents and on significant effects on the environment and on the economy, was added. The distributional maps of plants (Figs. 2-19) were taken by computer scan from Schardt and Schmitz (1990).

Hydrilla (*Hydrilla verticillata*)(L.F.) Presl.

Hydrilla (Fig. 2) was introduced into Florida by the aquarium trade under the common name Indian star-vine from Sri Lanka (Southeast Asia) in the early 1950's (Schmitz 1990). A tropical fish and plant farmer from St. Louis, Missouri, imported from Ceylon (now Sri Lanka) what he thought was another species of *Anacharis* and sent six small bundles of this plant species to another farmer in the Tampa Bay area. This farmer, who wished to remain anonymous, was not impressed with the color and overall appearance of this new plant and dumped the six bundles into a canal in back of his business near Cypress Street, Tampa. A few months later, the farmer noticed that this new species grew very well in the canal and decided to market it under the common name Indian star-vine (Schmitz et al. 1991). The first farmer in southern Florida who received Indian star-vines resided near Old Cutler Road in southern Miami. A former employee of this farm stated that the Indian star-vine was cultured and sold when she started her job there in 1955. Although another former employee denied the deliberate planting of this species in the creek, he verified its establishment by 1959 (Schmitz et al. 1991).

By the mid-1960's, severe problems with this species throughout the state were reported. Hydrilla has been the reported most abundant submersed aquatic plant in Florida's public waters since 1983. In 1990, it was found in 187 lakes and rivers or 23,085 ha. Hydrilla is in more than 40% of Florida's public waters and appears in more waters each year. Nineteen new infestations were identified at boat ramps in 1990. This invasive plant grows in water that can be from several inches to 10.7 meters deep. It does not sexually reproduce in Florida where only the female plant occurs. However, a monoecious male was recently introduced into the Potomac River. The introduction of such a male into Florida would create genetic diversification and a more aggressive hydrilla population, especially in the colder waters of northern Florida (Schmitz et al. 1993; Conant et al. 1984). Blackburn et al. (1969) compared hydrilla with similarly appearing species such as American elodea (*Elodea canadensis*). Langeland (1990a) discussed the life history and general problems with hydrilla in Florida.

The most important vector of dispersal to new waters seems to be the transportation of fragments by boat trailers. A single node is sufficient to propagate an entire plant (Haller 1978). Once established, boat traffic continues to enhance dispersal by fragmenting plants. Detached stem fragments readily develop into new plants that attach themselves to the hydrosoil by unbranched adventitious roots (Cook and Luond 1982). Germination usually occurs in spring and summer but also year-round in southern Florida waterways (Sutton and Portier 1985). Other forms of reproduction include the formation of axillary buds and subterranean tubers. Tubers are important to managers because they penetrate the substrate by several centimeters (Joyce et al. 1980). Hydrilla is resistant to control with conventional methods because tubers may resprout long after control operations are terminated (Bruner and Batterson 1984).

Because hydrilla grows rapidly and is competitive, populations usually exceed beneficial levels and adversely affect aquatic systems. Dense hydrilla mats form at the water's surface and accelerate the filling of water bodies, cause wide fluctuations in the amount of dissolved oxygen, pH, and temperature (Bowes et al. 1979), reduce plant and animal diversity (Barnett and Schneider 1974), and stunt sport-fish populations (Colle and Shireman 1980). Water flow in flood-control canals and rivers may also be restricted. Access to a water body may become limited and preclude water recreation and associated income for local businesses (Colle et al. 1987). Colle et al. (1987) discussed the influence of hydrilla on harvestable sport-fish populations, angler use, and angler expenditures at Orange Lake, Florida, in relation to the cost of controlling the plant. Another study of the effects of hydrilla in lakes Harris and Griffin in Lake County, Florida, revealed the costs and loss of activities on a lake that is overpopulated with this species (Milon et al.1986). The researchers discussed the effect of this plant on the economy of the area.

Hydrilla may be controlled variously. The current recommendation is control with the triploid grass carp (*Ctenopharyngodon idella*). Leslie et al.(1987) summarized the problems with their use to control vegetation and its impacts on the ecology of the water body.

Mechanical controls are slow, short term, and expensive and, because they fragment plants, increase the spread and establishment of the species and frequently cause algal blooms. They are not recommended except for small areas (Center et al. 1991; Shireman and Haller 1980, Canfield et al. 1983, Leslie et al. 1987). Several herbicides including diquat, endothal, and copper provide acceptable small-scale control. Slow, partial eradication must be used on serious infestations because mass destruction of the dense vegetation for a short time may deplete the dissolved oxygen in the water and kill fishes. Fluridone may provide large-scale control of hydrilla with reasonable selectivity and long-term control.

The release in Florida of four host-specific insects that feed on hydrilla were approved by the U.S. Department of Agriculture, but the effectiveness of the agents is as yet undetermined (Bennett and Buckingham 1991; G. E. Buckingham, Research Entomologist, Biological Control Laboratory, U.S. Department of Agriculture, Gainesville, Florida, personal communication). Sterile triploid grass carp provide excellent control but are not specific to hydrilla (Clugston and Shireman 1987, Thayer et al. 1990) and are inappropriate for most rivers and natural lakes where submersed native vegetation is a valuable component of the system (Center et al. 1991). The cost of control in Florida approached $50 million in federal and state funds during the 1980's (Schmitz et al. 1991).

Schmitz et al.(1993) summarized the literature on the significant effects of heavy populations of aquatic weeds on fishes and their habitats. Because of its ability to adapt to low light levels, hydrilla can displace native aquatic vegetation in Florida lakes and rivers (Bowes et al. 1977). In August 1987, approximately 1,618 ha of the 11,332-ha lake Istokpoga in south-central Florida was covered with hydrilla (Schardt and Schmitz 1990). By December 1988, this plant species covered nearly 8,000 ha (Schmitz et al. 1993).

Excessive growth of hydrilla in many lakes has been attributed to increased eutrophication (Canfield et al. 1983). Canfield et al. (1983) reported that the effects of hydrilla on lake-water chemistry, water clarity, and planktonic chlorophyll are related to the percentage of the lake's volume that is infested with hydrilla and to macrophyte standing crop. The lake's pH, conductivity, or total nitrogen concentrations did not change with changes in hydrilla levels. The magnitude of any change in the water quality of a lake depends on the abundance of aquatic macrophytes and the lakes's trophic status (Confield et al. 1983). Large reductions in macrophyte coverage, therefore, may cause unacceptable changes in phytoplankton biomass and in water clarity in some but not all lakes. The major reason for the changes hydrilla imparts on a lake's ecosystem is due to the dense shade the plant creates (Schmitz et al. 1993). Heavy infestations of hydrilla in Florida lakes have decreased zooplankton abundance and increased the number of species (Schmitz and Osborne 1984; Richard et al. 1985; Schmitz et al. 1993). Case histories comparisons of the use of grass carp in a number of Florida lakes were recently made Colle and Shireman 1995; Leslie et al. 1995; Hestand, Thompson, and Mallison 1995; Mallison, Hestand, and Thompson 1995; Van Dyke 1995; Jaggers 1995; Eggeman 1995). The results depended on many factors including degree of infestation, size of lake, and type of vegetation.

Hydrilla begins to harm fish populations when its coverage eliminates open-water feeding and spawning areas. The almost total coverage by hydrilla may significantly reduce bluegill (*Lepomis macrochirus*), redear (*Lepomis microlophus*), and black crappie (*Pomoxis nigromaculatus*) fisheries (Shireman et al. 1983). Populations of these species become skewed to smaller individuals because of insufficient predation (Colle et al. 1985). As the vegetation increases forage, smaller game fishes gain more cover and protection from predators and increase in numbers. The smaller game species are too small and provide no recreational fishing. On the other hand, Colle and Shireman (1980) believed that the complete elimination of hydrilla and other macrophytes may be detrimental to sport-fish communities. Hydrilla cover in excess of 30% resulted in low condition (fatness) of the larger (>250 mm TL) largemouth bass (*Micropterus salmoides*). Until cover exceeded 50%, smaller bass had high condition factors.

Many factors determine the response of a water body to attempted reductions of nuisance vegetation with grass carp). In Florida, the removal of nuisance vegetation from lakes has been attempted, for example, from Deer Point Lake (Van Dyke et al. 1984), from the Lake Conway Chain (Lazor 1983), and from several smaller lakes such as Lake Baldwin (Shireman and Maceina 1981) and Lake Wales (Shireman 1976). Leslie et al.(1987) summarized the history and management of the use of grass carp to control nuisance aquatic plants.

Montegut et al.(1976) found that waterfowl heavily fed on hydrilla in Lake Wales. Johnson and Montalbano (1987) also found that hydrilla is important habitat for ducks (Anatinae), coots (*Fulica americana*), and common moorhens (*Gallinula chloropus*) and supports the highest species density. Because of the extensive loss and degradation of wetlands in Florida since the turn of the century (Fernald and Patton 1984), managers noted increased use of hydrilla-infested habitats by waterfowl. Aquatic vegetation is a major food item for waterfowl (Hardin et al. 1984; Kerwin and Webb 1971). Chamberlain (1960) and Johnson (1987) discussed Florida's waterfowl populations and their habitats and management.

Torpedograss, Bullettgrass, Quackgrass (*Panicum repens*)L.

Torpedograss (Fig. 3) was first described by Linnaeus in Europe in 1762 (Tarver 1979). It is now found in Asia, Africa, Australia, and in South and North America. It was first collected in North America near Mobile, Alabama, in 1876 (Hodges and Jones 1950). The first report of torpedograss in Florida was in the wet prairies of the lower Kissimmee Valley in the early 1920's (Kretchman 1962). By 1926, seeds of this species were also imported and distributed by the U. S. Department of Agriculture for planting in cattle pastures throughout the southern states (Tarver 1979). Torpedograss was planted in every southern Florida county and in several central and northern locations (Hodges and Jones 1950) because it was well suited to wet prairies on which cattle are grazed in those areas. Ironically, it was later determined that torpedograss is not a good cattle feed. Other grasses are equal or better feed and do not have the potential of creating serious weed problems. Torpedograss also frequently spreads into adjoining lands (Hodges and Jones 1950). This invasive grass can grow in water that is as deep as 1.8 m and in habitats from wetlands to dry fields.

Torpedograss was found most often in the southern part of the state where it was the sixth most abundant aquatic plant during surveys of plants in public lakes and navigable rivers in 1990 (Schardt and Schmitz 1990). It was reported in 281 sites and covered nearly 5,062 ha. Reproduction is primarily by vegetative means; seed production is not known in the United States (Wilcut et al. 1988). Rhizomes, which can extend several meters from the parent plant (Holm et al. 1977), are not vulnerable to mechanical or herbicidal control. Cutting rhizomes and stems produces numerous small pieces, each of which can produce a new plant (Chandrasena and Peiris 1989).

Torpedograss is of little value to fisheries and is seldom used by waterfowl or songbirds (Tarver et al. 1986). It quickly invades disturbed areas and may overwhelm and replace native aquatic and terrestrial plants. Plant and animal diversities are therefore reduced. Torpedograss is now considered a serious problem along the lower coastal plain in Alabama, in Mississippi, and in a large part of Florida (Wilcut et al. 1988). The above-ground portions of torpedograss can be controlled with herbicides (Peng and Twu 1979); however, herbicides are not easily translocated to the starch-laden rhizomes. Torpedograss can thus withstand herbicides; it regrows after the lethal effects dissipate. Biological controls of torpedograss are not known at this time. Aquatic growths of torpedograss in flood-control systems are most often managed with the herbicide glyphosate. As many as 4,860 ha may be controlled at an annual cost of more than two million dollars in Florida. During 1990, approximately 40.5 ha of torpedograss were controlled in navigable rivers and in public lakes for a cost of about $20,000 (Schardt and Schmitz 1990).

Waterlettuce (*Pistia stratiotes*)L.

Waterlettuce (Fig. 4) is one of the most widely distributed hydrophytes that occurs on all continents except in Europe and in Antarctica (Giliett el al. 1968; Stoddard 1989). The most commonly accepted pathway of this species into the United States is in ballast water in ships from South America. Waterlettuce was first reported in Florida by John and William Bartram in 1765 (Bartram 1942). This led many to believe waterlettuce was native to North America. The origin of this species is still speculative; however, the absence of coevolved herbivorous insects is the strongest evidence of an exotic origin (Dray et al. 1988). Cordo et al.(1981) suggested that waterlettuce may be native to South America because of the abundance of regionally native insects associated with waterlettuce.

Waterlettuce poses many of the same environmental and economic problems as waterhyacinth, namely, loss of habitat, flood control, and unrestricted navigation (Sharma 1984). Dense mats deplete oxygen in underlying water and in sediments by blocking the air-water interface, by respiration of the roots, and by the decay of dead plants (Attionu 1976).

Waterlettuce reproduces by propagation and by seeds (Schardt and Schmitz 1990). Seed production is important in this species because seeds can remain dormant for months and withstand drought and freezing.

The abundance of waterlettuce is low statewide; its status was reduced from the ninth most abundant plant in public waters in 1982 (1,359 ha) to 41st in 1990 (684 ha; Schardt and Schmitz 1990). Although waterlettuce was found in 128 public water bodies, it is considered under control throughout the state except in some lakes in central Florida. Control is conducted primarily with the herbicide diquat; mechanical harvesters are occasionally used. The search for biological controls of waterlettuce began nearly 30 years ago, and practical application in Florida started in 1987. Distribution of *Neohydronomus affinis*, a weevil, in Argentina during the middle 1970's began in Florida in April 1987. Aquatic plant managers recently began statewide dispersal of another insect, a moth *(Namangana pectinicornis*).

Seedlings are a particularly significant source of reinfestation of waterways in which waterlettuce was earlier reduced by control or by extreme cold weather (Schmitz et al 1993).

Waterhyacinth generally displaces waterlettuce (Chadwick and Obeid 1966; Bond and Roberts 1978; Tucker and DeBusk 1981; Sutton 1983; Agami and Reddy 1990). Consequently, large floating islands of waterlettuce in the mid- to late- eighteenth century in Florida (Stuckey and Les 1984) became less prevalent with the spread of waterhyacinth (Schardt and Schmitz 1990). Control of waterhyacinth may be followed by increasing populations of waterlettuce.

Evapotranspiration by waterlettuce may exceed evaporation over open water as much as tenfold (Sharma 1984). However, the question of whether these higher evapotranspiration rates affect regional hydrologic cycles remains unanswered. Like waterhyacinth, waterlettuce populations also can bioaccumulate considerable amounts of heavy metals (Sridahar 1986).

The root system of waterlettuce increases siltation, which changed the benthic substrates, making it unsuitable for nesting sites for fishes (Beumer 1980) or as habitat for many macroinvertebrates (Roback 1974). Increased siltation from waterlettuce mats has never been measured in Florida's flowing waters. The effect of waterlettuce on native plant communities also has been poorly documented. The greatest harm from this species is its destruction of native species by excessive shading.

Waterhyacinth and waterlettuce harbor the amphipod *Hyalla azteca* (Dray et al. 1988). The importance of these amphipods in the ecosystems has not been studied. A study of the fauna associated with mats of waterlettuce in Florida failed to reveal any that were significant control agents of the plant (Dray et al. 1988).

Alligatorweed (*Altemanthera philoxeroides* (Mart.) Griseb.)

The first known description of alligatorweed from plants obtained in Brazil (Fig. 5) was published in 1926 (Zeiger 1967). This emersed, rooted species seemingly entered the United States before 1987 as an accidental release from the ballast of sailing ships in Mobile, Alabama (Zieger 1967). Schardt and Schmitz (1990) recorded an unsubstantiated report of alligatorweed in Florida in 1894 (Weldon 1960).

Although alligatorweed was recognized for its potential threat to the waterways of the United States as early as 1901, its weedy nature was not realized until the advent of organic herbicides in 1945 (Coulson 1977). When reductions of the competition from the more aggressive floating waterhyacinth was initiated, herbicide-resistant alligatorweed quickly spread into drainage canals and along shorelines of rivers and lakes. More than 1,215 ha of alligatorweed were in public waters by the mid-1960's (Zieger 1967). This invasive plant grows primarily as an emersed aquatic plant but also can thrive in wet or dry soils. The hollow stems grow to 15 m and allow plants to form dense floating mats that extend far into water bodies. These mats reduce or eliminate native plants, are impenetrable to motor boats, and restrict water movement. Alligatorweed was in 243 public waters in 1990, covered 510 ha of water, and ranked 46th in abundance of all aquatic plant species (Schardt and Schmitz 1990).

Salvinia, Water Fern, Water Spangles (*Salvinia minima*) Baker.

This plant (Fig. 6) does not reproduce by seed in the United States (U.S. Congress

1965; Kay and Haller 1982) but readily spreads by fragmentation or by floating mats that break loose and reattach elsewhere (Schardt and Schmitz 1990).

A complete review and evaluation of the biological control of this species was conducted (Coulson 1977). Searches for potential biological controls were begun in South America during 1960. Research revealed the identification and release of three host-specific insects (Zeiger 1967; see the insect section of this report for more details). In 1964, several host-specific biological control agents were released in the United States to manage alligatorweed and have generally been effective in the reduction of this weed's aggressiveness. These host-specific insects and plant pathogens increased leaf mortality, decreased plant size, and reduced overall population expansion. This biological weed control remains the most successful to date in Florida because alligatorweed only occasionally requires emergency control. Insects, usually the alligatorweed flea beetle (*Agasicles hygrophila*), are transported from existing colonies elsewhere to create new infestations. Control is usually achieved within a few months (Schardt and Schmitz 1990).

Salvinia is native to the region from southern Mexico through Central and into South America (Weatherby 1937). In Florida, it was first collected in the St. Johns River during 1928 (Long and Lakela 1976). The exact nature of its entry into the state is unknown but may have been through the discharge of spore-contaminated ship ballast at the Port of Jacksonville (Schmitz et al. 1991) or from discarded aquaria. Rataj and Horeman (1977) among others list this species as the most convenient and acceptable salvinia species for aquaria. This species has long been used as an ornamental and as a shade and habitat provider for pools and aquatic gardens. It is one of the more widely dispersed plants in Florida waters and present in 208 of the surveyed public lakes and rivers in 1990. With more than 506 reported hectares, it ranks 47th in abundance of observed aquatic plants (Schardt and Schmitz 1990).

Salvinia can be a nuisance floating plant that grows best in warm, quiet, often nutrient-enriched waters. Its buoyant, horizontal stems spread out on the surface of the water. Reproduction is sexual and asexual, and the fragmentation of stems prevails in spreading the plant (Cook and Gut 1971). This plant grows extremely fast and is capable of doubling its size in approximately 3.5 days (Gaudet 1973). This is even faster growth than the closely related *S. molesta,* which is one of the world's worst weeds (Nelson 1984). Problems with salvinia in Florida are usually confined to drainage systems and are few in lakes and rivers. This species is controlled most often with the herbicide diquat. Mechanical controls are ineffective (Schardt and Schmitz 1990). Thomas and Room (1986) discussed the taxonomy and control of *Salvinia molesta.*

Eurasian Watermilfoil (*Myriophyllum spicatum*)L.

Eurasian watermilfoil (Fig. 7) was first described by Linnaeus in 1753 from specimens collected in Europe. Its origin is Europe, Asia, and North Africa. The estimated date of its arrival in North America considerably varies from as early as 1814 (Grace and Wetzel 1978) to the late 1800's in the Chesapeake Bay (Holm et al. 1977) to as recently as the early 1940's (Couch and Nelson 1986) in the District of Columbia. These discrepancies may be in part due to the similarity between *M. spicatum* and *M. sibiricum* (= *M. exalbescens*), a native of North America (Smith and Barko 1990). Shortly after Bertholdt

(1958) published an article promoting this species for aquarium hobbyists, Eurasian watermilfoil spread quickly across the country. In temperate North America, Eurasian watermilfoil is a serious problem weed in 34 of the United States and in three Canadian provinces. The first infestations in Florida began with deliberate planting by aquarium plant collectors in 1964 in the Crystal and Homosassa rivers (Blackburn and Weldon 1967).

Reproduction of this submersed species is sexual and asexual. It is competitive, particularly in disturbed freshwater. Rapid colonization through fragment dispersal, accelerated growth in spring, and profuse, light-limiting branching and matting at the water surface allow milfoil to dominate or replace native plant species (Smith and Barko 1990). In Florida, however, hydrilla seems to be better adapted to the environment and displaces milfoil, except in brackish waters where Eurasian watermilfoil has a greater salt tolerance (Tiller 1982). Eleven Eurasian watermilfoil populations covered 499 ha in 1990 and ranked 48th in abundance of aquatic plant species. All but one population were in the brackish waters of northern Gulf Coast rivers (Schardt and Schmitz 1990).

Management of this species in Florida is uncommon because Eurasian watermilfoil only occasionally presents problems (Schardt and Schmitz 1990). Grass carp have been used for control of this species in Deer Point Lake, Florida, a potable water reservoir, at great expense to native vegetation because milfoil is not a preferred food by waterfowl. Florschutz (1972) discussed the importance of Eurasian watermilfoil as a food for waterfowl.

Waterhyacinth (*Eichhornia crassipes*; Mart.) Solms.

Waterhyacinth (Fig. 8) is commonly believed to have been introduced from its native South America into the United States at the World's Industrial and Cotton Centennial Exposition of 1884-1885 in New Orleans, Louisiana. It may have been cultivated by a New Orleans horticulturist in the 1860's (Tabita and Woods 1962). A visitor of the exposition in New Orleans in 1884 took several of the plants (Penfound and Earle 1948) to his farm a few kilometers north of Palatka (Tabita and Woods 1962). Perhaps intrigued by the showy lavender flower, the plants were placed in a lawn fountain on the banks of the St. Johns River near Palatka. The plants rapidly multiplied and filled the pond, and excess plants were discarded into the St. Johns River (Anonymous. 1896). By 1896, the plants had spread throughout most of the basin, assisted by cattlemen who introduced water hyacinths from basin to basin because they thought the species would make good cattle feed (United States Congress 1957). By 1893, waterhyacinth was already becoming a nuisance by hindering navigation on the St. John's River (Buker 1982). By 1898, the plant population had increased to the point that steamboats and other vessels were unable to reach docks or pass through navigation openings in bridges or narrow points in the river (Anonymous 1896; Joyce 1991). The introduction of waterhyacinth into Florida waters was an economic and ecological disaster soon after it was introduced. By the late 1950's, the waterhyacinth populations occupied more than an estimated 51,000 ha of Florida's waterways (United States Congress 1965). A 1959 inventory revealed more than 51,030 ha of waterhyacinth in Florida lakes and rivers.

This floating invasive species is probably the most prolific plant species in Florida lakes, rivers, and canals. It was reported in 254 public waters in 1990. Reproduction is by budding and by seeds that germinate after periods of drying and reflooding (Parija 1934).

Growth rates exceed dry biomass production of any terrestrial, saltwater, or freshwater vascular macrophyte (Wolverton and McDonald 1978). Doubling times of 6-18 days have been reported (Mitchell 1976). Environmental harm from large waterhyacinth populations is degraded water quality and drastic changes in plant and animal communities. Light and oxygen diffusion are severely curtailed by the floating plant (Gopal 1987), and water movement can be reduced by 40-95% (Bogart 1949).

Mechanical controls are used where herbicides are inappropriate but have proved too expensive and too slow to keep pace with waterhyacinth growth on a large scale. Several methods such as log booms and barriers, conveyor belts and grapples, toxic sodium arsenite, crusher-boats, blighted worms, and herbicides have been used to eradicate waterhyacinth. None of these methods is practical on a large scale. When waterhyacinth populations decreased after herbicide applications, alligator weed expanded (Schmitz et al 1993).

A computer simulation model was developed to help control personnel determine the best method of control for this species (Akbay et al. 1988). Four biological control agents for this species have been dispersed in Florida (see insect section for details). Although they may stress waterhyacinth, they do not seem to control or prevent further spread of this rapidly growing pest. The herbicides 2,4-D and diquat are effective controls of waterhyacinth; however, only aggressive management reduced waterhyacinth in public waters from the third most abundant aquatic plant n 1982 to 50th in 1990 (Schardt and Schmitz 1990).

In Florida, evapotranspiration rates are higher of waterhyacinth communities than of adjacent open water and ranged from 3.7 to 6.0 (Timmer and Weldon 1967; Rogers and Davis 1972; Reddy and Tucker 1983). Whether large waterhyacinth infestations can affect regional hydrologic cycles in Florida has not been reported (Schmitz et al. 1993).

Center and Spencer (1981) reported that the leaves of the plant represent 60-70% of waterhyacinth plant biomass, and the leaf turnover rate can range from 60 to 70%/month (Schmitz et al. 1993). The decomposition of the plants, if a large biomass of the plants are killed at once, can use up all the oxygen in the water. The resulting anoxia from such detritus can enhance the release of phosphorus into the water during decomposition. The additional detrital load that is generated by dense waterhyacinth mats is believed to burden these systems with additional nutrient loadings. Consequently, because of the rapid growth rate and high evapotranspiration rate of waterhyacinth, populations of this plant species can be a depository for heavy metals and probably for toxic organic compounds, which may pose some risk for the Florida populations of the West Indian manatee (*Trichechus manatus*), an endangered, herbivorous aquatic species (Schmitz et al 1993). Further study is needed to determine overall ecological effects of waterhyacinth invasions on the dynamics of plankton communities (Schmitz et al 1993).

The roots at the edges of waterhyacinth mats support many invertebrates (O'Hara 1967; Schram et al. 1987). At least seven fish species are associated with waterhyacinth habitat in Florida (Hansen et al. 1971). In contrast, spawning areas for fishes are reduced by waterhyacinth mats, and their dead masses shade out benthic communities and can nearly block the diffusion of oxygen through the water-atmosphere interface. Low oxygen concentrations underneath waterhyacinth mats can kill fishes (Timmer and Weldon 1967). Drifting mats of waterhyacinth often smother beds of submersed vegetation and overwhelm marginal plants that are important to waterfowl (Tabita and Woods 1962; Chesnut and Barman 1974). The Florida Everglades Kite (*Rostrhamus sociabilis*) is endangered because, in part, of the invasions of its habitat by waterhyacinth. Sykes (1987) discussed the feeding habits of the kite in Florida. Large expanses of waterhyacinth uproot emergent vegetation and impede the bird's location of the apple snail (*Pomacea paludosa*), its most important food item (Griffen 1989). In Louisiana, waterhyacinth completely eliminated resident fish populations in small lakes (Gowanloch 1945).

Anchored Waterhyacinth (*Eichhornia azurea*).

This species, a federally designated noxious weed and a close relative to water hyacinth, was seized at a private residence in Florida after it was learned the species was obtained from a mail-order aquatic-plant nursery in Ohio (Schmitz et al.1993). Information indicating that this species was introduced into the open waters of Florida seemingly does not exist.

Taro (*Colocasia esculenta*; L.) Schott.

Taro (Fig. 9) in the Americas is from French Tropical Africa and was brought in as a staple food crop by slaves. Its origin is in India and in Southern Asia. It was an important food source in the Nile Valley (Begley 1979). The variety of the most familiar taro in Florida was introduced by the U.S. Department of Agriculture in 1910 as a substitute for potatoes that did not grow well in the moist soils of the Southeast (Greenwell 1947). As recently as 1982, experiments to grow taro for food or fuel in the Everglades Agricultural Area were partially funded by the South Florida Water Management District (Shih and Snyder 1984). Taro was in 183 public waters during 1990, covered 371 ha, and ranked 51st in abundance of all reported aquatic plants (Schardt and Schmitz 1990).

Taro can grow in a wide range of sites from dry uplands to wetlands with soils that remain saturated for prolonged periods (de la Pena 1983). It is emersed along moist, shaded lake and river shorelines and tolerates intense sunlight to deep shade. Reproduction is primarily vegetative. Seed production is thought to be uncommon, and seeds and seedlings have low viability (Nyman and Arditti 1985). Taro displays allelopathic characteristics (Perdales and Dingal 1988) and contains a toxin (calcium oxalate crystals) that can deliver a mild sting or even a severe rash (Greenwell 1947). Cooking before ingestion eliminates much of the irritation (Schardt and Schmitz 1990).

Although it is a nuisance species, problems by taro are uncommon and are usually associated with environmental concerns rather than human activities. Taro can grow densely along lake and river margins where it crowds out native vegetation. Mechanical harvesting or mowing does not control taro because regrowth from the corms is quick. Repeated treatments with 2,4-D or 2,4-D and glyphosate provide acceptable temporary results; however, physical removal of the corms is required for eradication from aquatic sites (Schardt and Schmitz 1990).

Paragrass, Californiagrass (*Brachiaria mutica*; Forsk.) Stapf.

The genus Brachiaria (Fig. 10) contains about 90 species, most of which are in tropical Africa and six are semi-aquatic to aquatic (Cook et al. 1974). Paragrass is an aquatic grass that is present throughout the world's tropics and subtropics where it inhabits wet soils along shorelines and sometimes floating mats (Handley and Ekern 1981). A native of Africa, it has been distributed into both hemispheres as a highly palatable pasture fodder (Vicente-Chandler et al. 1974) but now causes problems in drainage ditches and agricultural fields. Paragrass may have been introduced into Florida in the late 1870's (Austin 1978) as a forage grass (Godfrey and Wooten 1979) and is now common in the southern through central regions. During the 1990 survey, 174 paragrass populations covered 262 ha in public lakes and rivers and ranked 59th in abundance of all recorded aquatic plant species (Schardt and Schmitz 1990).

Paragrass can quickly reach a height of 1.8 m with roots to about the same depth. The hollow, floating stems can extend as far as 6 m across slowly flowing fresh or brackish water (Sainty and Jacobs 1981). Paragrass is an aggressive competitor that can displace most agricultural crops and other shoreline emergent plants. Its competitive advantage is not only its rapid growth and high productivity but its allelopathic nature (Chang-Hung 1977) of producing substances that inhibit growth and germination of other plants. Reproduction is sexual and asexual, although seed production seems to be of lesser importance (Bown et al. 1966). Floating stolons readily become detached and reestablish themselves from roots that develop at the nodes (Sainty and Jacobs 1981).

Paragrass was used in southeastern Florida for camouflage around military installations in World War II (Austin 1978). Its rapid, dense, and monocultural growth has been used in Hawaii to remove nitrogen from domestic effluent (Handley and Ekern 1981).

In Florida, paragrass only occasionally creates problems at access points or other disturbed areas in public lakes and rivers, but it is a serious weed problem in drainage systems. Biological controls are unknown in Florida, and mechanical controls are mowing and excavation. Herbicides are frequently used, and glyphosate provides the most satisfactory results (Schardt and Schmitz 1990).

Water Nymph (*Najas ancistrocarpa*) Magnus.

This diminutive submersed exotic naiad (Fig. 11) is rare even in its native Japan. It is in ponds and quiet lakes (Schardt and Schmitz 1990). Data on the introduction of water nymph into the United States are scarce. It is currently in only some locations in southern Georgia and northern Florida (Godfrey and Wooten 1979). The water nymph was reported in one public water in 1990 where it covered about 2 ha. In Florida, this species has not caused problems, and records do not reveal control of this plant.

Egeria, Anacharis (*Egeria densa*) Planch.

Egeria (Fig. 12) is one of two species of the genus that are native to the cool subtropical or warm temperate regions of South America--southeastern Brazil, Uruguay, and

Argentina (Cook et al. 1974).

Egeria was sold as a rapid growing and attractive oxygenator plant for ponds and aquaria as long ago as 1915 (Countryman 1970). It remains one of the most universally used and distributed aquarium plants. Oxygenator plants were also widely used to control mosquito larvae. Cook and Urmi-Konig (1984) speculated that egeria was planted for malaria eradication. It is widespread in the United States; the most abundant populations appear in the eastern states between latitudes 33°N and 35°N (Cook and Urmi-Konig 1984). In 1990, 22 populations were detected in Florida public waters where it covered 37 ha. Egeria ranked 83rd in abundance of all aquatic plants (Schardt and Schmitz 1990).

In its home range, egeria prefers quiet or slowly moving, shallow waters that are somewhat acidic and enriched. It is less tolerant of high temperatures than hydrilla, and its preferred range is 16-18°C (Barko et al. 1980). In Florida, egeria is most abundant in rivers and springs, perhaps because temperatures remain within egeria's tolerance limits throughout most of the year (Schardt and Schmitz 1990). In some water bodies, egeria is a nuisance.

Vegetative fragments, particularly those with double nodes, readily root and develop new shoots (Getsinger and Dillon 1984). Egeria is a buoyant plant, and most of its biomass is produced near the water surface where the plant can interfere with human activities; however, egeria only occasionally causes problems in Florida waters (Schardt and Schmitz 1990). Problematic populations are usually controlled with herbicides or occasionally with sterile grass carp. Egeria is not preferred but is readily consumed by grass carp; however, rivers and spring runs are usually not appropriate release sites for herbivorous fishes. Herbicides for the control of egeria include diquat and copper and are only marginally successful in flowing water, and therefore the plants are usually left alone or harvested (Schardt and Schmitz 1990).

Hygrophila, Hygro (*Hygrophila polysperma*; Nees) T. Anderson.

Hygrophila (Fig. 13) of India (Rataj and Horeman 1977) and of the East Indies (Les and Wunderlin 1981) was imported into Ohio near the end of World War II by an aquarium nursery (Reams 1953). Hygrophila was imported into Florida during the early 1950's, and several waterways were deliberately stocked by aquarium plant collectors. It was collected in Lee County in 1979 (Les and Wunderlin 1981). Hygrophila is still a popular and widely distributed aquarium plant, but, because of its potential as a weed, the Department of Natural Resources prohibited its sale in Florida. Hygrophila was first noticed in the wild near Tampa in 1965 but was not correctly identified until 1977 (Les and Wunderlin 1981). Its similar appearance to alligatorweed may have delayed its proper identification. Hygrophila is now in many flood-control canals of southern Florida and was in 12 rivers and public lakes in 1990 where it covered 30 ha and ranked 87th in abundance of aquatic plant species (Schardt and Schmitz 1990).

Hygrophila has terrestrial and aquatic growth forms that survive in shallow acidic waters to wet soils. Reproduction is sexual and asexual, although seed production seems to be rare in Florida (Spencer and Bowes 1985). Because much of its biomass is concentrated at or near the water surface, this species can be a problematic weed. Unlike hydrilla, establishment of this species in deeper-than-2-m water is very slow. Hygrophila seems to grow more robustly in enriched waters (Schmitz and Nall 1984) and in flowing waters (Van Dijk et al. 1986).

Control of hygrophila is difficult. Harvesters fragment plants and increase distribution, and grass carp have a low preference for hygrophila. Registered herbicides including diquat, endothal, and fluridone, provide marginal control. Hygrophila's resistance to herbicides and biological controls provides a competitive advantage over hydrilla that can be controlled by several methods. As hydrilla is brought under statewide control, hygrophila may emerge as a greater pest in Florida waters. More than $250,000 in federal and state funds were spent on the control of hygrophila in flood-control canal systems during the 1980's (Schmitz et al. 1991).

Parrot-Feather (*Myriophyllum aquaticum*; Vell.) Verdc.

This member of the milfoil family (Fig. 14) is generally thought to be native to South America (Nelson and Couch 1985), although its origin is sometimes assigned to Brazil (Fernald 1950). Parrot-feather is named for the feather-like appearance of its gray-green, almost iridescent leaves.

Aquarists were responsible for introducing this plant worldwide (Nelson and Couch 1985) for an indoor and outdoor ornamental (Sutton 1985). Parrot-feather began appearing in the United States in the late 1800's and was first reported in Florida in 1906. Its subtropical origin is reflected by its distribution in the southern United States and along the West Coast. Many temperate introductions survived for short periods but did not persist (Nelson and Couch 1985).

Parrot-feather is relatively uncommon in Florida. It grows sporadically throughout the state, most often in enriched or degraded canals and ditches in southern Florida. Forty-eight of the public lakes and rivers surveyed in 1990 were hosts to a total of 19 ha of parrot-feather, which ranked 93rd in abundance of all aquatic plants. This submerged milfoil has emersed stems and grows in a variety of habitats from muddy soils to 1.8-m deep water (Schardt and Schmitz 1990).

Parrot-feather is listed as a problem weed in some parts of the world but is for the most part nonproblematic in Florida (Schardt and Schmitz 1990). Some experts consider this plant more beneficial than harmful in some environments (Sutton 1985). The herbicide 2,4-D (liquid and granular formulations) applied to young, growing plants provides the best control. Fewer than 2 ha are controlled each year in rivers and along lake shores in Florida (Schardt and Schmitz 1990).

Limnophila, Ambulia (*Limnophila sessiliflora*; Vahl) Blume.

This plant (Fig. 15) is native to Southeast Asia and to India (Schardt and Schmitz 1990). It was seemingly imported into Florida by the aquarium industry during the 1950's (Mahler 1980). It was first reported growing wild in Glades County (Long and Lakela 1971) and is now established in 10 public waters throughout the state (Schardt and Schmitz 1990). A review of this species was prepared by Gilbert (1984).

Limnophila produces a standing crop that is similar to the crop of hydrilla (Spencer and Bowes 1985) because most of its biomass is near the water surface where it can interfere with navigation and recreation (Schardt and Schmitz 1990). However, limnophila does not seem to colonize well in deeper-than-3-m water (Spencer and Bowes 1985) and prefers the quiet, shallow, and slightly acidic waters of lakes, rivers, and marshes (Mahler 1980). It can be submersed or emersed.

Reproduction of this species is sexual and asexual. The 10 limnophila populations reported in 1990 covered 19 ha of public waters. Limnophila only occasionally causes problems; an average of 2 ha--mostly in drainage canals--are controlled each year (Schardt and Schmitz 1990). Triploid grass carp reject limnophila, perhaps because of a toxin in the stem tissue (Mahler 1980).

Water Sprite, Water Hornfern, Oriental Waterfern (*Ceratopteris thalictroides*; L.) Brongn.

Water sprite (Fig. 16) is a native of tropical East Asia and Australia (Muhlberg 1982; Sainty and Jacobs 1981). It was first cultivated as an ornamental in England in 1834 and remains widely popular for aquaria and outdoor gardens. All parts except the roots are edible (Sainty and Jacobs 1981). Two species of *Ceratopteris* occur in Florida; *C. pteridoides* and *C. thalictroides*. *Ceratopteris pteridoides* is presumed native to the state, whereas *C. thalictroides* has a much wider distribution and may be introduced (Schardt and Schmitz 1990). Circumstances surrounding the entry of water sprite into Florida are unclear; however, it was first reported in southwestern Florida in 1878 (Small 1931).

Water sprite is floating, submersed, or emersed; the two latter forms are usually rooted to muddy soils. This delicate fern is in static or slowly moving, acidic (pH 5.0-6.5), and soft waters (Rataj and Horeman 1977). Reproduction is by spores that germinate readily on muddy soils (Rataj and Horeman 1977).

The two species of water sprite were in 28 waters where they covered 11 ha and ranked 100th in abundance of aquatic plants recorded in public waters during 1990. They rarely cause water-use problems (Schardt and Schmitz 1990). Both species are usually innocuous.

Napier Grass, Elephant Grass (*Pennisetum purpureum*) Schumach.

Napier grass or elephant grass (Fig. 17) is semi-aquatic and native to the warm climates of Africa but is now common worldwide between latitudes 23 N and 23 S (Holm et al. 1977). It is extensively grown for forage in Central America (Gould 1968) and for this purpose was introduced in Texas and in southern Florida (Schardt and Schmitz 1990).

Napier grass is now established throughout southern Florida, especially along canal and ditch banks and in other disturbed areas. It is less common in central to northern Florida because it is susceptible to freezes. Napier grass populations were in 13 public lakes and rivers during 1990, covered 9 ha, and ranked 102nd in abundance of all observed aquatic species (Schardt and Schmitz 1990).

Napier grass is a large, upright perennial that grows to a height of approximately 4 m (Godfrey and Wooten 1979). It is a rapid colonizer of disturbed areas and prospers in a broad range of conditions. It tolerates periods of inundation and drought and fire, although it grows best in rich, well-drained soils (Schardt and Schmitz 1990). It is a forage plant of considerable importance in some parts of the world (Bajaj and Dhanju 1980) but also one of the world's worst weeds (Holm et al. 1977). Dense, impenetrable forests can quickly form after Napier grass gains a foothold. Napier grass is rarely a problem along lake and river shores but causes difficulties for flood control, especially in southern Florida. Plants block access to waterways, reduce water flow, and can overgrow pumping stations. Biological controls for napier grass are unknown in Florida. Mowers and draglines are used for mechanical control. The herbicide glyphosate provides acceptable control in aquatic sites (Schardt and Schmitz 1990).

Watercress (*Nasturtium officinale*) R. BR.

Watercress (Fig. 18) is native to Europe and Northern Asia (Schardt and Schmitz 1990) and has a long history as a medicinal plant. It was used until the nineteenth century to prevent scurvy. Rollins (1978) stated that watercress was introduced into Florida at least by the early 1800's and probably much earlier. The watercresses have been prized herbs for salads or as green vegetables in Europe for centuries. They provide rich sources of iron, iodine, and vitamins A, B, and C (Anonymous 1976). Their introduction into North America and subsequent spread to Florida may be related to the use of watercresses as a food crop, although they are also cultivated to some extent for display in aquaria and aquatic gardens (Schardt and Schmitz 1990).

Watercress was reported at 12 sites during 1990, covered 5 ha of Florida public waters, and ranked 107th in abundance of recorded aquatic plant species (Schardt and Schmitz 1990). Watercress is a plant of temperate latitudes and consequently in Florida grows best in cool spring runs or in sluggish brooks (Godfrey and Wooten 1981). Managers regard watercress as innocuous.

Water Spinach (*Ipomoea aquatica*) Forsk.

The first historical record of water spinach (Fig. 19) is of its cultivation as a vegetable during the Chin Dynasty about 300 A.D. (Edie and HO 1969). Its native origin is Southeast Asia and India. Its introduction into Florida is unclear; however, Ochse (1951) reported that water spinach grows well in winter and summer in the Everglades. Water spinach is popular among persons of Asian descent in Florida. The species has become Florida's most problematic non-naturalized noxious weed species. The species is cultivated as an edible vegetable by Asian immigrants for personal use and for sale in oriental food markets throughout the United States. It is a vine-like species that can grow in a wide range of habitats and is quite aggressive in Florida's water bodies because of its prolific growth rate. The Florida Department of Natural Resources seized seeds and harvested plants from Oriental food stores and destroyed many water-spinach infestations in southern and central Florida drainage ditches and ponds. Many believe that establishment of the species in Florida is only a matter of time. Most occurrences of water spinach in the wild are deliberate plantings. They are usually confined to ditches and pond shores; however, water spinach has been discovered in two public lakes, West Lake Tohopekaliga and Lake Maggiorie (Schardt and Schmitz 1990).

Water spinach is a perennial trailing herb of muddy stream banks and freshwater ponds and marshes. It is confined to the tropics and subtropics because it is susceptible to frosts and does not grow well where mean temperatures are below 23.9°C (Edie and Ho 1969). It usually grows prostrate but can climb and cover emergent vegetation.

Although water spinach had not been in public lakes or rivers until 1990, its possession in Florida has been prohibited since 1973. The greatest management concern is its adaptation for growth in areas of periodic drying and flooding such as the Everglades. This concern is heightened because water spinach is a climbing vine that can grow to 10 cm/day. Furthermore, attempts to control water spinach with registered aquatic herbicides were only temporary. Diuron provided acceptable control in dry ditches but also controlled most other adjacent plants, which is unacceptable in areas such as the Everglades (Schardt and Schmitz 1990). Because of its prolific growth, this species can invade moist cultivated areas, such as rice and sugar cane fields, and other areas with varying water levels, such as the Everglades, drainage canals, and ditches. A single plant of Chinese water spinach may grow taller than 21 m and can branch profusely. Harvesting by humans and wildlife creates fragmentation (Schardt and Schmitz 1990).

Nonindigenous Semi-Aquatic Plants

Melaleuca, Cajeput Tree (*Melaleuca quinquenervia*)(Cau.) S.T. Blake.

Melaleuca is native to Australia, New Guinea, and New Caledonia (Balciunas and Center 1991) and was first planted at two coastal locations in Florida from seeds that were imported from Melbourne, Australia, in the early 1900's: near Davie in Broward County and near Estero in Lee County (Morton 1966). Melaleuca was originally imported for its swamp-drying abilities (Morton 1976). During the early 1930's, a private individual spread melaleuca by airplane to dry up the Everglades wetland system (Austin 1978). A melaleuca forest has an evapotranspiration rate approximately four times that of native sawgrass. Since 1960, the range of this invasive species has increased greatly. By 1980, it had infested nearly 202,500 ha or 6% of the total land area of southern Florida (Balciunas and Center 1991). This included more than 101,250 ha or nearly 13% of all wetland areas (Cost and Carver 1981). Recent estimates suggested that the area of infestation has increased by at least 50% since the 1980 study (Villano 1988). Thayer et al. (1990) estimated that the current population is only at 10% of its potential spread. A dense stand of melaleuca is along the edge of Lake Okeechobee as a result of a planting by the U. S. Army Corps of Engineers in 1940-41 to protect levees (Meskimen 1962). An accurate determination of the present range of melaleuca does not exist in part because of its fast rate of spread and in part because of the lack of a full realization of the magnitude of the problem (Hofstetter 1991). The recently established Exotic Pest Plant Council in Florida may assist with the development of goals and coordination of multi-agency efforts to control the spread of this species.

Melaleuca is characterized in Florida by a rapid growth rate, efficient reproduction, and the ability to invade a wide variety of habitats (Meskimen 1962). This exotic tree grows along roadsides, on ditchbanks, in mesic prairies, in sawgrass marshes, and on lake shorelines. When established, trees form dense stands that are nearly impenetrable (Center and Dray 1986). More than 4,000 trees/ha is not uncommon in melaleuca forests. Although small mammals seem to use these forests, species diversity in wet prairie-marsh ecosystems with dense monocultures of melaleuca decreases by 60-80% (Austin 1978, Woodall 1978, Mazzotti et al. 1981). Schortemeyer et al.(1981) reported that only 10% of the bird species in melaleuca stands actually fed there and only 1.5% of their activity involved nesting in these trees. Wildlife experts fear the exclusion of native vegetation by melaleuca will reduce deer abundance in the endangered Florida panther's (*Felis concolor coryi*) limited range (Grow 1984). Melaleuca is feared to replace some of the area that is occupied by the native pond cypress *Taxodium distichum var. nutans* that had expanded into many areas of southern Florida because of lack of competition from other native plants (Myers 1983).

The effect of melaleuca on native populations can be evaluated by determining the benefit and losses from development of a method that completely eradicates the malaleuca (Turner 1984). Information on the economic impact from the elimination of melaleuca was compiled (Diamond et al. 1991) as part of an effort to measure the economic impact if the species is placed on the Florida Prohibited Aquatic Plant List. Such considerations include its impacts on Hendry County that is still using the species in its landscaping plan, on public health (skin and respiratory allergic reactions), on the residents and tourist trade, and on the displacement of native species. Opinions about the effects of the loss of the trees on beekeeping and on honey production and the pollination of the vegetable crops remain divided; however, no harm was anticipated from the use of the species for woodchip and mulch. Benefits of removal included the long-term protection of regional water tables, maintenance of tourism at the current minimum worth of $4.2 million in direct receipts and as much as $145 million/year in regional expenditures, reduced expenditures for allergy treatment by $0.5- 2.0 million, and reduced eradication expenses of $370--$2,079/ha (Diamond et al. 1991).

Good methods for the control of this species are not available. However, the range of this plant is limited, and prospects for the identification of a biological control agent are good because no native species is closely related to melaleuca (Balciunas and Center 1991). Fire does not kill melaleuca trees, which is almost perfectly adapted to fire. It has a thick, spongy bark that insulates the cambium. The outer layers of bark are flaky and burn vigorously. The leaves and small branches are killed, but dormant lateral buds on the trunk germinate within weeks (Ewel 1986). Moreover, burning causes massive seed release and germination. A burned melaleuca can release millions of seeds that are dispersed short distances by wind and water (Ewel 1986).

Melaleuca becomes established more readily on sand than on marl but can survive on any disturbed soil in southern Florida. It tolerates extended flooding, moderate drought, and some salinity (Ewel 1986). The limited mobility of the seed probably confined the invasion of melaleuca thus far. Resource managers should concentrate on eliminating seed sources nearest the pine-cypress ecotones into which melaleuca is preadapted to spread, rather than expending resources on pockets of melaleucas near other, less susceptible habitats (Ewel 1986).

The melaleuca seedlings in test plots had lower than 50% survivorship in five of the eight communities where it was experimentally planted. Survivors grew best in two disturbed ecosystems (a severely burned pine-cypress ecotone and a drained forest) and in one undisturbed community (a dwarf cypress forest; Myers 1984). Melaleuca is capable of invading the zone between pine (*Pinus* spp.) and cypress (*Taxodium distichum*) forests in southern Florida and of displacing the cypresses (Ewel 1986). The probability of selecting the right combination of environmental conditions for the increases of established melaleuca seedlings increases with time and with the number of dispersed propagules (Ewel 1986).

Thayer et al. (1990) in their Melaleuca Management Plan reported that the major potential threat by this species is its harm to southern Florida's water supply. This is ironic because the principal reason for its original introduction was the drying up the Everglades (Thayer et al. 1990). The control and management of this species on federal lands in southern Florida is expensive in time and resources (Doren 1991). The cost of controlling melaleuca in three major areas (the Big Cypress National Preserve, the East Everglades, and the Loxahatchee National Wildlife Refuge) is significant (Burkhead 1991; Maffei 1991; Molnar et al. 1991). Cochran (1992) applied a benefit-cost analysis to the introduction of melaleuca and determined that the eradication of melaleuca would greatly benefit the state's economy.

The most successful control of melaleuca is pulling by hand and injecting or girdling the trunks and injecting the herbicide imazapyr. Basal soil treatments with the herbicides hexazinone or tebuthioron have provided effective control with little damage to surrounding vegetation; however, none of these herbicides is presently fully registered for use in standing water (Schardt and Schmitz 1990). An assessment of the methodology and efficiency of the eradication of melaleuca with herbicides was recently conducted in Florida (Trimmer and Teague 1991). A combination of herbicidal, mechanical, and environmental controls are proposed for trees, seedlings, and seed germination. Cassani (1986) discussed the arthropods that may be used as potential control agents and Center and Balciunas (1988) discussed the role of insects in the management of melaleuca.

A weevil, *Oxyops vitiosa*, was imported from Australia and is in quarantine in Gainesville, Florida, as a biological control agent of melaleuca. The evaluation and clearance of this insect could take from 9 months to 6 years (Leist 1993). If it passes all tests, it may be released in 1994.

Brazilian Pepper, Florida Holly (*Schinus terebinthifolius*) Raddi.

Brazilian pepper is indigenous to the coast of tropical Brazil, Paraguay, and Argentina (Ewel 1986). It was present in Florida in the early 1840's (Barkley 1944) and was re-introduced into Florida in 1898 (Morton 1978). This plant was once sold as a landscape ornamental because it produced dense masses of scarlet berries.

In its natural habitat, Brazilian pepper is a sparse species and never dominates the landscape as it does in southern Florida. It is emersed along ditchbanks and pinelands. Good estimates of the Brazilian pepper population size in Florida are not available, but Bennett and Habeck (1991) reported that this species now infests thousands of hectares in southern and central Florida, in the Florida Keys, and on other islands off the eastern and western coasts of the state.

Generally, Brazilian pepper infestations are in disturbed areas (Ewel et al. 1982). However, because Brazilian pepper is now so widespread, areas of low disturbance such as the pinelands in Dade County were invaded by this species (Schardt and Schmitz 1990). Brazilian pepper is capable of surviving a broad range of hydrologic conditions but prefers well-drained sites (Ewel 1978). Typically, dense monospecific stands of Brazilian pepper form within a few years after trees invade an area. This often creates a dense canopy and eliminates almost all of an herbaceous understory (Ewel 1978). Survival of Brazilian pepper seedlings is unusually high, even of mature forest trees, and is 66-100% (Ewel 1986). The tenacity of Brazilian pepper seedlings impairs competition by native vegetation. Moreover, Brazilian pepper seems to be allelopathic, suppressing the growth of other plants (Bennett et al. 1988).

Multiple burnings are needed to control Brazilian pepper. Applications of the herbicide triclopyr on foliage and bark have provided selective control of Brazilian pepper when mixed with native willows (*Salicacea*), myriles (*Myricaceae*), and maples (*Aceraceae*). Imazapyr also provides satisfactory control but is not as selective (Schardt and Schmitz 1990). When this species burns (as it frequently does when it is colonized in open pinelands), the above-ground parts are killed, but the tree promptly resprouts from the base (Thayer et al. 1990).

Like melaleuca, Brazilian pepper grows in a broad range of sites from mangroves (*Rhizophora mangle*) to pinelands (*Pinus* spp.) in southern Florida. It thrives on disturbed soils and in habitats that are created by drainage and farming (Ewel 1986). Naturalized species often develop mutualistic interactions with indigenous species. The Brazilian pepper, for example, provides food for native organisms that pollinate its flowers and disperse its seeds (Ewel 1986). Most dispersal is effected by the huge flocks of robins (*Turdus migratorius*) that periodically but not annually congregate in southern Florida during the winter. Introduced species such as the red-whiskered bulbul (*Pycnonotus jocosus*) also disperse the seeds (Owre 1973). During the late winter months when seeds of this species are normally dispersed, the native trees are dormant. This exploitation of a different time of reproduction may explain the success of this species in southern Florida. The conflicts of interest in this species between the apiarists and the landscapers, who use a closely related tree as an ornamental, and the biological control personnel, who want to introduce a control agent that preys on both species are reviewed by Bennett and Habeck (1991).

Australian Pine, Beefwood, Swamp She-Oak *(Casuarina equisetifolia)* L. ex J.R. and G. Forst., (*C. gluaca*) Sieb. exk Spreng, (C. *cunninghamiana*) Miq.

Several species of Australian pine were introduced into Florida before 1920 (Morton 1980). The three species of Australian pine in Florida are *Casuarina equisetifolia*, *C. glauca*, and *C. cunninghamiana*. Hybridization of these species is extensive and complicates identification (Schardt and Schmitz 1990). The tree is an emersed hardwood, native to Australia and Malaysia, and occurs along rocky coasts, dunes, sand bars, and islands.

The Australian pine was primarily planted to form windbreaks along coastal areas. The trees can reach 35-m heights. Published surveys or estimates of area in Florida that were invaded by Australian pine were not available; however, the species is abundant in southern Florida and extends as far north as Gainesville. Australian pine occurs in 30 of Florida's state parks (Schardt and Schmitz 1990).

Australian pines grow at a rate of 1.0 to 1.5 m a year. This fast growth rate has created problems for utility companies in southern Florida because of interference with power and telephone transmission lines. In southern and central Florida, Australian pines typically produce dense stands and form thick carpets of needles on the ground that prohibit the growth of native vegetation. In dune communities, Australian pine's dense shade and leaf litter retard the growth of native coastal vegetation (Schardt and Schmitz 1990).

Dense monospecific stands of Australian pine crowd out native vegetation in coastal areas and affect the cotton rat (*Sigmodon hispidus*), marsh rabbit (*Sylvilagus palustris*), and gopher turtle (*Gopherus polyphemus*; (Morton 1980). The trees also usurp the nesting places of loggerhead turtles (*Caretta caretta caretta*) and green sea turtles (*Chelonia mydas mydas*) and American crocodiles (*Crocodylus acutus*) on sandy beaches above the high-tide line (Schardt and Schmitz 1990).

The herbicides tebuthioron or hexazinone are used for control in nonaquatic sites. Imazapyr applied to girdled trees provides some control of mature trees. Small trees can be controlled with the herbicide tryclopyr or with a combination of 2,4-D and dicamba. Cutting does not provide acceptable control because regrowth from root sprouts is quick (Schardt and Schmitz 1990).

Catclaw Mimosa, Giant Sensitive Plant (*Mimosa pellita)* formally *M. pigra.*

The mimosa is indigenous to tropical Central and South America. It may have been introduced into North America as a botanical curiosity because its leaves fold on touch. There is some evidence that it was introduced into Florida as early as in 1926 (Fairchild 1944). Three small populations of this exotic plant species are in Florida now: near Sebring adjacent to the Loxahatchee River along the Martin-Palm Beach County borders and near the mouth of the St. Lucie River in Martin County. The infestation near the Loxahatchee River dates back to 1953 (Hall 1985). The extensive canals and wetlands of southern Florida are similar to habitats that have been invaded by catclaw mimosa elsewhere. It is an emersed plant along river banks, ditchbanks, and wetlands (Nall et al. 1986). Many scientists believe that this species rivals the ability of melaleuca to invade the Everglades wetland systems (Schardt and Schmitz 1990).

In Australia where the catclaw mimosa was introduced in the late 1800's (Miller and Lonsdale 1987), a largely intact natural swamp forest in a floodplain is now covered by dense monospecific stands of catclaw mimosa (Lonsdale et al. 1989). Braithwaite et al.(1989) reported that fewer birds and lizards, less herbaceous vegetation, and fewer tree seedlings were in catclaw mimosa stands than in surrounding native plant communities. Catclaw mimosa is an invasive plant and has recently been placed on the Federal Noxious Weed List (White 1984).

Eradication of catclaw mimosa in three sites was conducted by the Department of Natural Resources (Schardt and Schmitz 1990). Because single plants are sparsely dispersed among tall, native vegetation, selective eradication is difficult. Even seedlings resist hand pulling because the roots quickly anchor deeply into soils. Control has been attempted with only registered herbicides for use in aquatic sites because the sites are often wet. Eradication has been successful with foliar applications of glyphosate, 2,4-D or a combination of 2,4-D and dicamba. Regrowth from seeds is quick, and seeds seem to be viable for several years; therefore, treatments are routinely applied to control new growth and to prevent flowering and the formation of new seed beds (Schardt and Schmitz 1990).

In 1986, biologists of the Florida Department of Natural Resources collected seeds of *Mimosa pigra* from a wetland in Florida. Later, beetles emerged from these seeds and were identified as *Acanthoscelides quadridentatus* (Coleoptera: Bruchidae; Center and Kipker 1991). The previous range of this beetle was Texas, Mexico, Guatemala, Belize, Honduras, El Salvador, Nicaragua, Costa Rico, Panama, and South America (Johnson 1983). Some studies have been initiated to determine whether this beetle could be used as a biological control agent for the mimosa.

Significant Effects By Nonindigenous Aquatic Plants

Research by the U.S. Fish and Wildlife Service (Gallagher and Haller 1990) revealed that waterhyacinth and alligatorweed were detrimental not only to navigation but to fishes and wildlife. In the larger water bodies, drifting mats of plants tore up and shaded beds of native submersed plants that decreased dissolved oxygen in the water, provided breeding grounds for disease vectors, (e.g., mosquitoes), reduced spawning areas for fishes, reduced habitat and food sources for waterfowl, and lowered angling success. In response to this concern, the Florida Game and Freshwater Fish Commission initiated limited herbicide spraying in 1952 with funds from the Dingell-Johnson Federal Aid to Fisheries (Joyce 1991).

The removal of populations of plants can have significant consequences that depend on the extent and speed of the removal (Thayer et al. 1990). The killing of large amounts of aquatic vegetation can significantly affect the ecosystem, especially if the killed plants are left to decay in the water. This is especially true if the percentage of the biomass to total volume of the lake is great (Thayer et al. 1990). If so, the decomposing plant material can use up all dissolved oxygen in the water and kill fishes. The ecological changes in a water body as the vegetation is slowly removed reveal the changes that must have occurred in the ecosystem as the vegetation originally increased. The major concern is that improper control methods can remove all or most vegetation and reduce the ecosystem's ability to support native fish species. Excessive removal of plants can also affect birds and terrestrial animals that use aquatic habitats.

The food preferences of grass carp frequently do not match the needs for aquatic-plant control by the managers for a particular water body. Target plant species may rank lower in preference by grass carp than the more valuable plants, and management of the undesirable plants takes place only after the more valuable plants are consumed. Sometimes, the removal of rooted aquatic plants by the grass carp triggers the flow of carbon and energy through the plankton populations and creates an algae bloom (Hichling 1966; Michewichewicz et al. 1972; Canfield et al. 1983). Stanley (1972) and others found that the proper level of stocking water bodies with grass carp can increase the yield of native fishes. Leslie et al. (1987) determined how much vegetation should be removed for a specific level of control.

Taylor et al. (1984) discussed the results of evaluations of the use of grass carp to control aquatic--usually nonindigenous--nuisance plants. Canfield et al. (1983) discussed the possible effects on ponds in Florida from the removal of hydrilla with grass carp. We were unable to find any evidence that the grass carp are established in Florida. Additional information on the ability of this species to control aquatic vegetation is discribed later under the section entitled "Biological Agents other than Insects". Bain (1993) developed a set of guidelines for managers for the gathering of basic data to assess the significant effects of grass carp on large systems. He concluded that the effects would increase in relation to the percentage of the affected vegetation and that maximum changes would be related to complete removal of the vegetation. Fine tuning of the level of removal by grass carp has been difficult (Shireman and Haller 1982). Either the stocking is inadequate to remove much of the vegetation in a given timeframe or the stocking rate exceeds the desirable level of control and all vegetation is removed (Shireman et al. 1980, 1991). The U.S. Army Corps of Engineers (Theriot and Decell 1978) attempted to develop a computer model to predict the correct size of grass carp stock for Florida's Lake Conway. A population of female grass carp was released into Lake Conway in 1977 (Theriot and Decell 1978; Lazor 1983). A comprehensive study to measure the effect of the hydrilla reduction on the flora and fauna in the lake was initiated.

Introductions of grass carp as weed control agents can be advantageous. They are less expensive than mechanical removals, chemical applications, water level manipulations, or other biological agents (Shireman and Smith 1983), and the results usually last longer than results from other methods (Decell 1975; Rottmann 1977). Chemical treatment may be faster, but slower removal of the vegetation by grass carp avoids depletion of oxygen from the decomposition of dead plants, which may cause fish kills (Thayer et al. 1990). Native biological control agents have also been evaluated (Leslie et al. 1987). Native nematodes attack hydrilla in Florida (Esser et al. 1985; Gerber and Smart 1987), but no exhaustive surveys for nematodes have been made in the native range of hydrilla (Buckingham and Habeck 1990).

The present method for appropriate levels of weed control in Florida is the treatment of infested areas with an herbicide to return the weed to an acceptable level (Shireman et al. 1980, 1991). Applications of herbicide are followed with lighter stockings with grass carp to control regrowth of the nuisance plants. Shireman et al. (1980, 1991) discussed the problems from stocking with too many grass carp.

Nonbiological Control of Nuisance Plants

The history and development of aquatic-weed control in the United States was summarized by Gallagher and Haller (1990) and Schmitz et al. (1993). Selection from the many methods for the control of nuisance plants are by plant species, the environment of the plant, the required results, and restrictions. Mechanical control provides immediate, tangible results, especially when the plants are removed from the water body. Because of its high cost, mechanical control is usually practical in only small areas like marinas, swimming areas, and fishing trails or where other methods are unfeasible or undesirable. Rapid growth by some aquatic nuisance plants often necessitates repeated mechanical control during a single growing season (Center et al. 1991).

In Florida, control of aquatic nuisance vegetation is funded by the U.S. Army Corps of Engineers for federal navigation; funded jointly by the corps and the Florida Department of Environmental Protection for navigation on other public waters; and funded by the state for flood control on small lakes, canals, and ditches and for drainage and mosquito control (Nelson and Dupes 1988). Some nuisance-plant control is also done by private individuals or organizations.

The first large machines for mechanical control of aquatic plants were designed and built for the U.S. Army Corps of Engineers in 1900 (Center et al. 1991). The machines (Kenny) crushed vegetation like waterhyacinths and discharged them back into the water. In 1937, the Kenny was invented that crushed 81 ha of waterhyacinths per month. In the 1940's, saw boats (large, flat boats with cutting devices on the front, which cut weeds below the surface; saw boats were followed by a barge that was equipped with a conveyor belt that lifted the cut vegetation and piled it; the cut vegetation was later taken to shore and unloaded to rot on the dry land) were used to cut submersed plants that were also left to decompose in the water (Center et al. 1991). The selection of a machine for weed control depends on the plant species, type of disposal, availability of funds, and management objectives for the water body. No one system is universally effective (Center et al. 1991).

Removing aquatic plants from the water simultaneously removes nutrients from aquatic ecosystems (Shireman et al. 1979). However, because aquatic plants are composed of 90% to 95% water, the quantity of the removed nutrients is low in relation to the harvested mass of plant material (Center et al. 1991).

Drawdowns alter the composition of aquatic vegetation but do not always produce desirable changes, and the responses of various aquatic plant species to drawdowns vary widely and sometimes unpredictably (Thayer et al. 1990). For instance, submersed aquatic plants respond variably to drawdown, whereas emergent plants readily tolerate them (Center et al. 1991).

Sometimes, various materials such as black plastic and specially manufactured semipermeable benthic barriers can be used to deprive plants of sunlight or to prevent rooted aquatic plants from growing. However, gases that are produced from the decaying vegetation on pond bottoms accumulate under the accumulated,nonpermeable bottom covers and sometimes cause them to float to the surface (Center et al. 1991). Some specially made materials are gas-permeable, but even these eventually become clogged by debris and microorganisms and then also trap gases. However, new materials that are currently tested may be resistant to colonization by microorganisms. Securely anchoring heavy material to the bottom can sometimes hinder plant growth in ornamental ponds or in swimming areas, but the material is normally expensive (Center et al 1991).

During 1944-46, evaluations of a newly discovered herbicide, 2,4-D, as a control agent for waterhyacinth was initiated by the U.S. Department of Agriculture, the Jacksonville District of the U.S. Army Corps of Engineers, and the Everglades Experiment Station of the University of Florida (Joyce 1991). The herbicide 2,4-D proved effective and economical and was not toxic to fishes, cattle, or humans. Various agencies began ground and aerial applications of 2,4-D in 1947, which marked the beginning of the modern age of scientific aquatic-plant management. For the first time in decades, many miles of infested streams were open to navigation, and as time passed, the control operations shifted back into feeder areas (small isolated concentrations of waterhyacinth that periodically, especially in times of flood, release viable plants into areas where the plants had been removed) as the aquatic weeds became less of a threat to navigation and other uses of open water (Joyce 1991).

Biological Control Agents Other Than Insects

The use of plant pathogens for the biological control of aquatic weeds has many advantages. Suspensions of spores can be readily formulated and applied to the weed like a herbicide. In theory, the plant pathogens could then reproduce and become selfsustaining. If so, this approach encompasses the best advantages of biological and herbicidal controls. However, pathogens tend to be environmentally sensitive and can be rendered ineffective by extreme temperature or humidity (Center et al. 1991). Restrictions of the importation of plant pathogens from abroad tend to prohibit the use of biological controls and limit the scope to native pathogens.

Fungi

Cerospora rodmani. In 1971, the association of a native fungus, *Cerospora rodmanni,* with a widespread decline of water hyacinth in the Rodman Reservoir, a large impoundment of water near Orange Springs, Florida, was discovered (Conway 1976a,b). The fungus is host specific to hyacinths and caused root rot and small spots on the margin of the leaf. The spots later expand and eventually cause the leaves to wither and die. The field tests revealed a high virulence of the fungus on waterhyacinths and severe damage to the plant. Tests in the greenhouse and in the field indicated that the fungus adversely affected the water hyacinth. Because it is native to Florida, no adverse effects on commerce or on the environment are expected (Conway and Freeman 1977). Although it has been formulated as a mycoherbicide, the fungus has not been effective for the control of waterhyacinths, and research is continuing (Center et al. 1991).

Snails

However, interest in the use of snails as biological control agents has waned, probably because of the environmental risk of the purposeful propagation of prolific, generalized herbivores and because snails are intermediate hosts for certain fish parasites (Center et al. 1991; Gallaghen and Haller 1990).

Marisa cornuarietis is a large freshwater snail that was accidentally introduced into Florida. It feeds on a variety of plant species including coontail (*Ceratophyllum demersum*), southern naiad (*Najas guadalupensis*), Illinois pondweed (*Potamogeton illinoensis*), salvinia (*Salvinia rotundifolia*), and hydrilla (*Hydrilla verticillata*). Large numbers of this snail may control weeds in small, confined water bodies, but their effective use as control agents is limited (Center et al. 1991; Blackburn et al. 1971b).

Another small snail, *Pomacea australis*, has been used experimentally and at one time was thought to be a promising biological control agent of plants.

Freshwater fishes

Some freshwater fishes consume large quantities of aquatic vegetation (Avault et al. 1968). The common carp (*Cyprinus carpio*), goldfish (*Carassius auratus*), Chinese grass carp or white amur (*Ctenopharyngodon idella*), tilapia (*Tilapia* sp.), and silver dollar fish (*Metynnia* sp.) are used for control of aquatic vegetation in many areas of the world. The latter two genera are sensitive to cold weather and, in colder climates, must be overwintered in temperature-control tanks.

The triploid Asian grass carp (*Ctenopharyngodon idella*) has been used in Florida and elsewhere for the control of aquatic weeds. However, this carp is not host-specific (Schmitz et al. 1993). (For more information about the use of the grass carp as a biological control agent, see the section about nonindigenous fish species.)

Diseases, viruses, fungi, bacteria, and nematodes

Diseases, viruses, fungi, bacteria, and nematodes have received little attention in research into biocontrol of aquatic weeds. Two diseases are the cause of the decrease of Eurasian watermilfoil (*Myriophyllum spicatum*) in the United States, but limited research has been conducted on their use.

Cost of Nonbiological Control of Aquatic Nuisance Plants

The history and development of aquatic-weed control by state and federal agencies in the United States and the assessment of current practices from 1971 to 1989 were summarized by Gallagher and Haller (1990). The biological control of aquatic and terrestrial weeds is a worldwide problem. The worldwide uses, release dates, and statuses of biological control agents and degrees of control were summarized by Julien (1987).

Among the greatest threats to Florida's water bodies is the uncontrolled growth of exotic aquatic plants. These biological pollutants have caused extensive problems for the economy, water-use, and resource management in Florida. Their introduction and spread have hindered navigation, flood control, recreation such as fishing, and other water sports, and their expansive growths have displaced native wildlife habitat and downgraded water quality (Anonymous 1971). Aquatic plant management is necessary to control many aggressive exotic aquatic and wetland plants in Florida (Joyce 1991). A comparison of the abilities of eight fish species to control nuisance aquatic plants was made by Avault et al. (1968). (Attempted control of aquatic nuisance weeds in the United States with insects is covered in the section on nonindigenous aquatic insects in this report.)

The history of aquatic plant management in Florida parallels the introduction of waterhyacinth (*Eichhornia crassipes*), alligatorweed (*Alternanthera philoxeroides*), and hydrilla (*Hydrila verticillata*) and the development of the state water resources. Before the 1900's, the predominant use of state waters was for commercial navigation. The introduction of waterhyacinth in 1884 quickly and seriously affected the navigability of Florida's rivers (Joyce 1991).

The costs for the control of aquatic plants in Florida are available from several sources, but assessment of their accuracy is difficult because of the possible overlap of reporting periods and funding records. Most management and control of aquatic plants in Florida's public waters are conducted with funding from two public agencies, the Cooperative Aquatic Plant Control Program and the State Funding for Aquatic Plant Control Program. Plant control in navigable waters with public boat ramps is usually conducted under the cooperative program. The role of all state and federal agencies in the control of nuisance plants in Florida is summarized by Nelson and Dupes (1988).

In 1955, the Florida legislature appropriated $226,500 and the Florida Game and Freshwater Fish Commission added $100,000 for a 2-year control of waterhyacinths (Schmitz et al. 1993). During 1984-1987, the cost for the control of nuisance plants under the cooperative program was $5.9 million on 17,501 ha at a cost of $336/ha (Nelson and Dupes 1988).

In 1986, the Water Resources Development Act changed the federal-state cost-sharing ratio from 70:30 to 50:50 and thus decreased the federal share. In 1987, the U.S. Army Corps of Engineers provided 30% of the funds, whereas the state of Florida provided 29%. Local governments, including water management districts, provided 26%. The remaining 15% is estimated expenditure by private individuals based on issued permits for the control of exotic aquatic weeds. Publicly funded weed-control costs in Florida were more than $11.6 million during 1987 (Nelson and Dupes 1988). The average cost per hectare was $462. All control costs included salaries, benefits, equipment rental, herbicides, contractual work, and indirect administrative costs. Almost half of the total control costs were for the control of hydrilla (Buckingham and Habeck 1990). The history and cost of controling hydrilla in Orange and Lochloosa Lakes in Alachua County, Florida was summarized by Hinkle (1995). Weather conditions at the time of application of herbicides, water levels at the time of application and shortly afterwards, water clarity, and hydrilla plants activity growing and not at the surface contributed to the efficacy of the herbicides. Control costs varied from $22 to $2600 per acre depending on the combination of the above conditions with the average cost being $114 per acre.

The identification and appropriate methods for the control of aquatic nuisance plants in aquaculture and in farm ponds is discussed by Thayer et al. (1990). Langeland (1990) discussed the current methods for the control of the four most serious nonindigenous woody pest-plant species in Florida: Australian pine (*Casuarina* spp.), Brazilian pepper (*Schinus terebinthifolius*), Asiatic columbine (*Aquilegia* spp.) and melaleuca (*Melaleuca quinquenervia*).

Between 1980 and 1989, the approximate cost of aquatic-plant management to public agencies in Florida was at least $104 million (Schmitz 1990). This amount does not include the total cost of aquatic-plant management in areas that are exempt from permit requirements by the Florida Department of Natural Resources. During the same period, more than $43 million were spent on managing the waterhyacinth and the waterlettuce and more than $55 million were spent on managing hydrilla in Florida's public waters. During the fiscal years 1991-1992, $6.2 million of federal, state, and local funds were spent to manage aquatic nuisance plants on 17,223 ha of the state's public lakes and rivers (Schardt 1991). Most of the funds were used to manage hydrilla, waterhyacinth, and waterlettuce. Presently, hydrilla is the most troublesome plant at an annual control expenditure of $7 million (Schmitz et al. 1993). Even with these expenditures, the number of new hydrilla infestations continues to increase. For example, hydrilla started to rapidly spread in Lake Istokpoga in 1987; by 1988 and 1989 more than $1.4 million were spent on fluridone applications to return hydrilla to maintenance control levels (Schmitz et al 1993). Waterhyacinth and waterlettuce are second in control costs of combined annual control expenditures near $2.5 million. The other nonindigenous plant species that were introduced or spread as forage grasses (torpedograss [Panicum repens] and para-grass [*Brachiaria mutica*]) are third in annual control expenditures. Other exotic plants such as alligatorweed (*Alternanthera philoxeroides*), salvinia (*Salvinia minima*), and hygro (*Hygrophila polysperma*) require approximately $386,000 of the annual $14 million for the control of exotic aquatic plants in Florida's waterways (Schmitz 1990; Schmitz et al. 1991; (Schmitz et al. 1993).

In 1987, the Florida Department of Natural Resources inventoried 481 water bodies and reported water hyacinth in 65% and hydrilla in 45%. Hydrilla covered more than 19,845 ha, a 17% increase since 1983, even though at least 4,860 ha were controlled annually (Buckingham and Habeck 1990).

Most people consider all effects of nonindigenous aquatic plants on the economy as undesirable. However, a full evaluation must weigh the harm against the economic gains by the large aquatic plant industry in Florida (earlier described in more detail). Some consideration also must be given to employment for many families in Florida in the control of nuisance plants. However, only relatively few people profit, but the harm from nuisance plants tends to be permanent and affects all people. A workable system that makes liable individuals or organizations responsible for the cost of correcting problems from introductions of nonindigenous organisms has not been identified. If adequate precautions had been taken before the importation and introduction of the nuisance plants, benefits could possibly have been realized without cost to the taxpayer for control.

Today, the most severe aquatic-plant problems in Florida are caused by water hyacinth and hydrilla. Both species can grow to densities that severely impair or prohibit navigation, restrict the flow of water, and limit or preclude the recreational use of water bodies. To minimize the harm from aquatic weed infestation, millions of dollars are spent each year by federal, state, and local agencies to control aquatic weeds in Florida. Despite the severity of the aquatic- weed problem in Florida, few studies have been conducted of the effects of weed infestations on user groups and the consequences for the economy of Florida (Milon et al. 1986).

Milon et al. (1986) conducted an economic analysis of the benefits of aquatic-weed control in north-central Florida. Their survey was designed to identify sport anglers' preferences and economic values of aquatic-weed control in the vicinity of Orange and Lochloosa lakes in north-central Florida. The responses--although not uniform across the surveyed population--indicated that anglers' decisions to visit fishing sites were influenced by aquatic-weed conditions. Anglers recognized the need for aquatic-weed controls and expressed a significant willingness to pay for different levels of control. The total economic benefits of aquatic-weed control to prevent severe infestation of hyacinth and hydrilla at Orange and Lochloosa lakes was an estimated $386,063 in 1985 (Milon et al. 1986). The incremental benefits of increasing weed control beyond prevention to reduce hyacinth and hydrilla to just small patches around the lakes was $194,433. In addition, aquatic-weed controls sustain a significant contribution for the local economy; total gross expenditures for sport fishing at Orange and Lochloosa lakes were an estimated $5,606,697 (Milon et al. 1986). With the addition of multiplier effects from nonresident expenditures for sport-fishing trips, total regional economic activity of $10,787,289 was attributed to weed control in Orange and Lochloosa lakes (Milon et al. 1986). Later, Milon and Welsh (1989) conducted an economic analysis of sport fishing and the effects of hydrilla management in Lake County, Florida. They reported the results of a telephone and mail survey to identify sport anglers' preferences and economic values for aquatic-plant control in lakes Harris and Griffin in Lake County. The survey was designed to evaluate the effects of different information about the effects of hydrilla management on anglers' preferences and willingness to pay for control. The survey results indicated that anglers prefer to have some hydrilla in lakes, but only few anglers wanted uncontrolled growth. Willingness to pay for hydrilla controls was estimated to range from $50,000 to $176,000/year and depended on the level of control. The largest portion of the benefits from hydrilla controls accrued to anglers from Lake County, however, nonresidents also received significant benefits. In addition, anglers who used the lakes generated total expenditures of more than $1.75 million in Lake County; the largest portion was attributable to resident anglers (Milon and Welsh 1989).

Colle et al. (1987) estimated the total annual expenditures associated with the sport fishing on Orange Lake as approximately $1 million in 1978-79. A decrease of expenditures by 90% in 1977 was due to almost total coverage of the lake by hydrilla

Nonindigenous Aquatic Mollusks

Abbott (1950) reported that in the past 100 years approximately 50 species of exotic land and freshwater mollusks were introduced and are established in North America. More recently, Turgeon et al. (1988) compiled a list of all native and introduced mollusks in North America to create uniformity and to avoid confusion in the nomenclature of the mollusks. In the six classes of mollusks, approximately 5,700 species from 332 families in 31 orders were listed. The list includes all species of mollusks--not all have been assigned common names--from the United States and Canada that live in freshwaters, in marine waters from shoreline habitats to a water depth of 200 m on the continental shelf, in estuaries, and in terrestrial habitats (e.g., gardens, woodlands, mountains, deserts, and caves). Mollusks from the Arctic Ocean, eastern Canada, the eastern United States, and the northern Gulf of Mexico to the mouth of the Rio Grande River were included. Mollusks from Mexico and offshore islands (e.g., Greenland, Iceland, Bermuda, the Bahamas, and the West Indies) were excluded unless their ranges also extended into the region outlined by Turgeon et al. (1988). More recently, Brown (1991) discussed the occurrence of gastropoda in the United States. Dundee (1970a,b, 1971, 1974, 1977) summarized the introductions of mollusks to the Gulf Coast.

With Turgeon et al. (1988) as a guide, we conducted a review of the literature about all reported introduced aquatic, nonindigenous mollusks in the United States. We also identified species that are nonindigenous to Florida (Table 5). Four more species, *Pomacea bridgesi*, *Melanoides tuberculatus*, *M. turriculus*, and *Tarebia granifera* are species that we consider introduced and nonindigenous but were not identified as such by Turgeon et al. (1988). Clench and Turner (1956) described the freshwater mollusks of Alabama, Georgia, and Florida. Additional information may be obtained from Feinberg (1979) and Stange (1990).

Recently, the edible brown mussel (*Perna perna*; Linnaeus,1758), was identified as having been introduced into the coastal waters of Texas (Hicks and Tunnell 1993; Carlton 1992b). However, no evidence of this species' expansion into Florida waters exists, and we therefore omitted the species from our accounts.

The following species of mollusks have been identified in the literature as aquatic and nonindigenous to Florida.

Corbiculidae

Asiatic Clam or corbicula (*Corbicula fluminea*) Müller 1774. The North American literature contains references to four species of nonindigenous clams in the genus *Corbicula*: *Corbicula fluminea*, *C. manilensis*, *C. fluminalis*, and *C. leana* that, however, may represent a single species, *C. fluminea*, with several varieties (Smith et al. 1979; Britton and Morton 1979). *Corbicula fluminea* is presently in Eurasia, in Southeast Asia, in Africa, in Australia, in the Pacific Islands, in South America, and in North America (Britton and Morton 1979). Clench (1970) and Gottfried and Osbourne (1982) discussed the presence of *C. manilensis* in southern Florida. Counts (1991) provided a compendium of zoological records of this species in North America.

Corbicula was first collected in North America as empty shells in Namaimo, Vancouver Island, British Columbia, in 1924 (Counts 1981; Britton 1979; Britton and Prezant 1986). It was first discovered in the United States in 1938 by Burch (1944) in the sand and gravel banks of the Columbia River, Washington. Later, Hanna (1966), Fox (1971a,b), and Morton (1973) identified the occurrence of this mollusk with the arrival of immigrant Chinese laborers in the United States. In the Orient, many people eat corbicula (Miller and McClure 1931). Details on the spread of this species in the United States into the southern Atlantic area are summarized by Dundee and Harman (1963),Dundee (1974), and Sinclair (1971a and b). Isom (1986) also traced the spread of this species from the West Coast through the lower Midwest and the southeastern United States. The distribution and occurrence of this species in Florida was summarized by Bass and Hitt (1974a).

Heinsohn (1958) was one of the first investigators of the introduction and life history of the Asian clam. More recently McMahon (1983) traced the chronological spread of the clam in the United States and concluded that the mussel was moved from the Northwest to the Midwest (Ohio River) in the late 1950's by unknown pathways. Heinsohn (1958) listed tourist curiosity, the bilge waters of pleasure boats, fishing bait, or aquarium hobbyists as possible pathways of introduction. After its initial introduction in the Midwest, the Asian clam spread through natural pathways southward and then eastward into Florida in the early 1960's. Counts (1986) summarized the present zoogeographic distribution and chronology of the invasion of this species on a state-by-state basis from museum records and discussed in detail many pathways that may have assisted in the rapid spread of corbicula. He incorrectly blamed the spread of this species from the western coast to the eastern coast of Florida on movement through the Cross-Florida Barge Canal; however, the canal was never completed.

Studies by Dreier (1977) and Thompson and Sparks (1977) indicated that migrating waterfowl were a probable means of spreading the species over long distances. The clam cannot survive even a short time in the digestive tract of waterfowl, however, Dundee et al. (1967) discovered that live terrestrial snails can be transported for short distances tangled in the feathers of some birds such as woodcocks. Rees (1965) in summarizing the works of others also found that birds can transport live snails. Sinclair and Isom (1963) discovered that live corbicula may be transported long distances in sand and gravel for construction. Fox (1970) reported that corbicula is sold in some states (e.g., in California) as bait to anglers who sometimes dump their unused bait. Abbott (1975) reported that corbicula is also sold by pet stores for aquaria. Although the pathways of spread may vary, corbicula may expand its range slowly and over short distances of its own accord. However, fast expansion of the range over great distances would have to be implemented by humans.

Corbicula can tolerate a wide range of water temperatures. Mattice and Dye (1976) reported that the upper 50% tolerance limits in continuous exposures were between 24° and 34°C when acclimation temperatures ranged from 5° to 30°C. The lower tolerance limits were between 2° and 12°C when acclimation temperatures ranged from 15° to 30°C. The expansion of corbicula northward is probably limited by low temperatures in winter (McMahon 1983). Some populations of this clam are farther north than expected, however, they are associated with anthropogenic warm-water discharges from power plants or with other thermal water discharges.

This clam is now in 35 states (Counts 1991). It is a freshwater species that does not enter brackish water (Haertel and Osterberg 1967; Sickel 1979). The taxonomy, significant effects, physiological ecology, life history, control measures, and future use of this species were discussed by McMahon (1983). It is a burrowing (infaunal) bivalve with a small byssus during only the first year of life. For the first 2 years, it is a protandric consecutive hermaphrodite (Morton 1977) that cannot tolerate exposure to greater-than-10% salinities for 10 days (Evans et al. 1979). However, it has a 20% survival rate in 80-day exposures to water with gradually increasing salinity.

Corbicula may create accumulations of dead shells and seriously impede water flow in irrigation canals that require dewatering and cleaning (Eng 1979). It fouls municipal water-treatment facilities, infests water-intake areas in which it damages centrifugal pumps, clogs main straining screens, and contributes to bad tastes and odor even after chemical treatment of the water (Ingram 1959; Ray 1962; Sinclair 1974; Smith et al. 1979). It has fouled raw water lines and reduced the efficiency of water-treatment plant operations (Sinclair 1964) and power plants (Page et al. 1986). The problems from corbicula in gravel for making cement are discussed by Sinclair and Isom (1961, 1963). While the concrete sets, the live clams move to the top and leave a void that weakens the set concrete product. Corbicula is also a major problem in cooling systems of power-generation plants where it fouls condensers and restricts water flows (McMahon 1983).

Corbicula populations were as dense as 5,000 clams/m^2 (Heinsohn 1958) in California, 12,000/m^2 (O'Kane 1976) in Texas, and 131,000 on sand bars in California (Eng 1979). When the concentration of clams reaches this level, native benthic communities are stressed from limitations of space and suspended food resources. Habitat invasion of this species may be the cause of declining abundances and elimination of native unionids and shaeriid endemics (Cooper and Johnson 1980; Boozer and Mirkes 1979; A.H. Clarke 1988; Fuller and Imlay 1976; Gardner et al. 1976; Sickel 1973; Taylor and Hughart 1981). Other studies revealed that corbicula has little or no effect on native species (Isom 1974; Kraemer 1979; Klippel and Parmalee 1979; Taylor 1980a&b). Some investigators concluded that, if the native environment was not already changed by human activities and the native flora and fauna were not already stressed, corbicula could not displace native species (Isom 1974; Fuller and Imlay 1976; Leff et al. 1990; Klippel and Parmalee 1979; Kraemer 1979; Taylor 1980a). Corbicula has an advantage over many native species because it tolerates anthropogenic activities and because it has an unusually high reproductive capacity, high growth rate, and short generation time that allow it to quickly adapt to disturbed environments (McMahon 1983). McMahon (1983) summarized the physiological ecology of Corbicula; its environmental need for substrate, salinity, and osmoregulation; temperature; exposure to air; general life history; and control measures.

Although most experts feel that the introduction of corbicula was economically and ecologically undesirable, Sinclair and Isom (1963) pointed out some benefits: its use as an index organism in pollution studies, as a local food for fishes and wildlife (Villadolid and Del Rosario 1930), as a fish bait (Metcalf 1966), and as possible food for ducks (Keup et al. 1963). Bass and Hitt (1974b) studied the food habits of many native fishes in Florida where the Asiatic clam is present and found that only the redear sunfish (*Lepomis microlophus*) eats this exotic and other species of fishes eat only a small amount of the clam.

Dreissenidae

Zebra Mussel (*Dreissena polymorpha*; Pallas, 1771). This species was introduced into the Great lakes in the ballast water of ships in 1988 (Herbert et al.1989). It has been spread by barge traffic into all major East Coast rivers of this country that are connected through canals to the Great Lakes. At first it was believed to be intolerant of the warm water in the southern parts of the United States, but now that it is established in the lower Mississippi River, there is some concern that it could survive in Florida if it were introduced. The species is also well established in the Tennessee River from where barge traffic will carry it south into the Tombigbee River system; establishment in Alabama and Georgia seems unavoidable (personal observation). The impact of this species on native species, especially rare and endangered shellfish species, is of particular concern. Because this species seems not to have spread into Florida, it is not be further discussed in this report.

Thiaridae

Thiarid Snail or Quilted Melania (*Tarebia granifera*-Thiara; (Lamarck 1758)). Three species of the Family Thiaridae in Florida were probably introduced incidentally with aquatic plants (Abbott 1950). Members of this family are in freshwater in the tropical and subtropical areas of the world. Some may occur in brackish waters. A synonym for this species is *Tarebia lateritia* (Lea; Thompson 1984). The thiarid snail is native to the Orient, the Far East, the western Pacific Islands, Madagascar, and east of India throughout Malaysia and the Philippines to the Society Islands and north to the Ryukyu Islands and Hawaii (Pace 1973). It was probably imported with exotic water plants and tropical fishes into California in 1936 (Abbott 1950).

In 1937, a dealer brought the snail to Tampa and sold it to aquarists as the "Philippine Horn of Plenty" (Roessler et al. 1977). The same dealer probably contaminated Lithia Springs, Florida, while cleaning his tanks and replenishing his plant stocks. Abbott (1952) was the first person to report that this species was in the wild in Florida. As many as 400 individuals/m^2 have been in Lithia Springs where it is still common on the sandy bottom of the spring (Abbott 1950). The snail cannot survive in water below 21.1°C; therefore, its natural spread to other nearby waters has been hindered. Abbott (1952) reports that this species prefers shallow riffles of fast flowing freshwater streams. The thiarid snail is a moderately important species because it can serve as the first intermediate host for the sheep liver fluke (*Clonorchis sinensis*) and for the human lung fluke (*Paragonimus westermani*) that causes a disease that is known as paragonimiasis (Abbott 1950). Because the parasite is presently not in this country, most foods that could contain the parasite are usually cooked, and the uncertainty that North American crayfishes would serve as intermediate hosts significantly lessens the threat to humans. However, this species is ecologically significant because it tends to replace native *Goniobasis* (*Elimia* spp.) species and become very abundant.

Thiaridae

Red Rimmed Melania (*Melanoides tuberculata*; Muller 1774). This species is native to a large part of Africa, to the eastern Mediterranean, and throughout India, Southeast Asia, Malaysia, and southern China north to the Ryukyu Islands of Japan and south and east through the Pacific Islands to Northern Australia and the New Hebrides (Pace 1973). This species was introduced into Florida (Dundee 1974; Burch and Tottenham 1980 a,b; Burch 1982) and is now widely distributed throughout the state. It is most common in rivers, streams, canals, and springs and can flourish in brackish water with salinity from 0 to 30 ppt (Roessler et al. 1977). First recorded in Florida in 1969 (Clench 1969; Russo 1974), this species was in the St. Johns River at population densities of $10,000/m^2$ in 1976 (Thompson 1984). This snail, like the others of established families in Florida, may replace the native *Goniobasis* (*Elimia* spp.). New populations of the red rimmed melania have been in freshwater canals of Dade and Collier counties and in the saline mangrove areas adjacent to Biscayne Bay in the Matheson Hammock-Snapper Creek Area of Coral Cables (Roessler et al. 1977). Although trematode larvae were not discovered in these snails, the extension of range of the red rimmed melania into brackish and marine waters increases the possibility of the spread of avian trematode infection because of the many potential intermediate crustacean hosts in the mangrove habitat (Roessler et al. 1977). The life history and cycle of the red rimmed melania is described by Abbott (1950). Its habitat requirements and distribution are described by Roessler et al. (1977). Murray (1971) reported that this species is a known intermediate host for the trematodes of human lung fluke (*Paragonimus westermani*) and of sheep lung fluke--also from the Orient. The adult lung fluke causes what is known as paragonimiasis by attacking the lungs and causing symptoms not unlike tuberculosis or broncho-pneumonia. It also attacks the brain and causes symptoms that are similar to the symptoms of infantile paralysis and meningitis. The chance of human infection in Florida is remote because of normal sanitation in the state. The transfer of aquatic vegetation around the state, however, will probably spread it throughout the canals and brackish waters of southern Florida.

Faune Melania (*Melanoides turricula*; Lea, 1850). This species is native to the Philippines and has been introduced into springs and spring-fed streams in Florida. It is in Alexander Springs, Lake County; Blue Springs and the Withlacoochee River, Marion County; and Eureka Springs, Hillsborough County. *Melanoides tuberculata* and *M. turricula* may be ecological varieties of a single species. In Florida, the two snails are ecologically segregated. *Melanoides tuberculata* is usually in quiet, euthrophic, turbid habitat, whereas *M. turricula* is in cleaner, oligotrophic springs and runs (Thompson 1984).

Piliidae

Giant or Colombian Ramshorn (*Marisa cornuarietis;* Linnaeus, 1758). This species is native to the lowlands of northern South America, Trinidad (Baker 1930) and has also been reported from Costa Rica and the islands of Tobago and Grenada and the drainage system of the Magdelena and Orinoco rivers (Michelson 1956). In the recent literature, it is sometimes classified under the genus *Ceratodes* (Robins 1971).

This large freshwater tropical snail was introduced from northern South America and southern Central America into southern Florida. The snail can reach a diameter of 5.7 cm. Its ability to completely denude vegetated areas may be undesirable (Hunt 1958). The exact date and means of introduction are unknown. In Florida, it is abundant in canals, marshes, and ponds in Palm Beach, Broward, Dade and Monroe counties (Robins 1971).

In February 1958, the snail was abundant in semi-brackish water along 8 km of canal in the middle of the city of Miami westward to the edge of the Everglades (Hunt 1958). During sampling later in the year, the species was well established farther upstream. By July, hundreds of snails of all ages, including eggs, were 1.6 km downstream. When the snail was first reported by Hunt (1958), its total distribution was in a 8 km section of a canal in Dade County that contained drained water from Lake Okeechobee. Since that time, the Colombian ramshorn has spread to all freshwater branches of the system in the Miami area except to heavily polluted waters with industrial wastes (Hunt 1958). This species was also collected in canals along the west boundary of the city limits in Coral Gables, Florida, in February 1957 (Hunt 1958). By 1971, it had spread into the Everglades east of Fort Myers but had not been reported in the national park (Hunt 1958). The introduction was probably by aquarium dumps and by individuals that escaped from wholesalers of aquarium plants and animals. The major means of natural dispersal of this species is by rafting downstream on floating mats of aquatic vegetation (Hunt 1958). The eggs of this species are laid in gelatinous cluster in the water.

A review of the food habits, habitat, daily movements, environmental requirements, and association with other species is described by Robins (1971). Salinity (4.8 ppt) and temperatures of less than 8 °C restrict the spread of this species. The establishment of this species in the mangrove swamps of southern Florida is of particular concern (Roessler et al. 1977).

The giant ramshorn is sold to aquarists but recently became unpopular because it damages aquarium plants. This habit may be the reason for its release into the canals by disgruntled aquarists (Hunt 1958). Hunt (1958) and later Blackburn et al. (1971b) suggested the use of this species as a weed-control agent in the canals of southern Florida. Studies revealed that this species retards the growth and flowering of water hyacinths by feeding on the roots of the plants (Robins 1971). The giant ramshorn has also been released in small ponds in the southern United States and in Puerto Rico to control submersed aquatic plants such as hydrilla (Holm et al. 1969). However, it may also feed on desirable plants such as rice (*Oryxa* spp.), watercress (*Nasturtuim officinale*), and water chestnuts (*Scirpus esculentus*). It feeds heavily on *Cabomba*, *Elodea*, dwarf saggitaria (*Sagittaria* spp.), and water cress (*Nasturtium officinale*). The giant ramshorn is not known to carry human diseases and has been used as food for humans in Puerto Rico (Holm et al. 1969).

Because of its indiscriminate feeding habits, the giant ramshorn has also been used as a biological control agent against snail populations (*Biomphalaria glabrata*) that are vectors of schistosomiasis (Oliver-Gonzales et al. 1956; Michelson and Augustine 1957). However, a major disadvantage of using this species as a biological control agent is that its sensitivity to temperatures below 8oC restricts its use in southern Florida.

Spiketopped or Brazilian Apple Snail (*Pomacea bridgesi*; Reeve). This large freshwater tropical snail is native to Brazil, was introduced into southern Florida, and became established in Monroe, Dade, Broward, and Palm Beach counties. It has also been introduced into isolated water bodies as far north as Alachua County (Thompson 1984). The shell is usually greenish with darker and lighter bands. A unicolor yellow form is raised commercially and marketed as the Albino Mystery Snail (Thompson 1984). The spiketopped snail is popular in the aquarium trade. It probably was initially released from fish farms and subsequently by aquarists.

Hale (1964) describes the significant effects of the spiketopped snail on the Everglades population of the apple snail (*Pomacea paludosa*) and the consequences to the feeding of the rare Everglades kite (*Rostrhamus sociabilis*) and the limpkin (*Aramus guarauna pictus*). This exotic snail is seemingly able to displace the native apple snail. The kite does not readily feed on the Brazilian apple snail (*Pomacea bridgesi*) because it is unable to extract its soft body from the slightly different shape of the shell since the curve of the shell does not conform to the shape of the kite's bill.

Achatinidae

Giant African Snail (*Achatina fulica*; Ferussac 1821). Information on the giant African snail (*Achatina fulica*), which is a terrestrial nonindigenous species, is discussed here because it is one of the few nonindigenous species that was eradicated.

The giant African snail is as long as 30 cm and was a food item of the Japanese armed forces during World War II (Lachner et al. 1970). Around 1967 or 1968, a tourist brought the snail into the North Miami area and eventually released it. By fall 1969, the restricted population exploded and the snail was abundant. It destroyed ornamental vegetation and damaged the paint on stucco walls of houses. Although the snail was confined to an area of approximately 40 city blocks, the spraying of a calcium-baited arsenic poison cost $30,000 (Lachner et al. 1970). A second treatment was needed, and the total cost to eliminate the snail was close to one million dollars.

The introduction of the charru mussel (*Mytella charruana*) into the coastal waters of Florida is discussed in the section on introductions into the marine environment.

Nonindigenous Aquatic Insects in Freshwater Systems

The total number of insect species in the United States is unknown. More than 10 years of collaboration by many people created a list of nonindigenous 1,683 species of insects and other established nonindigenous arthropods in the 48 contiguous states of the United States (Sailer 1983). Sailer (1983) anticipated that, when the effort was completed, the list would contain more than 2,000 species.

Frank and McCoy (1992) listed 271 species of insects that immigrated into Florida; 209 were first collected in Florida after 1970. In a later publication, Frank and McCoy (1993) listed another 351 insect species that were introduced into Florida after 1980 for potential biological control agents. Their lists contained species from published and unpublished records and indicated that 154 insects had been released, almost all of them (151) as biological control agents against insect pests and nuisance plants.

Florida is susceptible to invasions by exotic species through immigration and colonization. Clark et al. (1967) discussed the ecology of insect populations in theory and in practice. Other insects were purposely introduced to control nuisance species (Frank and McCoy 1990).

Frank and McCoy (1992) summarized the literature since 1970 that identified 271 exotic insects in Florida. The authors concluded that about 20 recent immigrants are or could become major pests in Florida (Table 6). At least 8% of the species seem to have arrived as stowaways, and many actual or potential major pests are among them. Thirteen orders of insects are represented in the tabulation. Immigrant species are not equitably distributed among orders or among families. To tabulate the immigrants, the authors searched published records and then verified the records by consulting authorities on the taxa. The authors are certain they produced a reasonably thorough tabulation but could not guarantee its completeness. They chose in advance to exclude four kinds of records from their tabulation: introductions they included in their later publication (Frank and McCoy 1993) to make their task manageable; records that were published before 1971; records of species that are native north of Mexico in North America, even if that part of their range was small; and records of species they called "taxonomic immigrants," which are species that were introduced in Florida because of improper identification. Examples of the second kind of record are two moths, *Eulipidotis metamorpha* Dyar and *Metalectra geminicincta* Schaus, that were reported in 1991 as new to Florida (Dickel 1991) and would have been included in the tabulation had they not been reported before 1971. An example of the third kind of report is an ant, *Pseudomyrmex mexicanus* Roger, found ca. 1960 (Whitcomb et al. 1972) that would have been included in the tabulation if Texas had not been part of its native range. The authors concluded that all or almost all of the 70 species of immigrant insects reported from northeastern North America by Hoebeke & Wheeler (1983) entered the continent as stowaways. The list of reported immigrant insects in Florida (Table 6) revealed that species arrived as stowaways and by other means such as flight, wind dispersal, or rafting. One identification of nonindigenous insects is by the assumption that all recorded immigrant species in Florida whose names are on the U.S. Department of Agriculture list of interceptions arrived in Florida as stowaways. Insects that were discovered on imported plants and plant materials at U.S. seaports and airports by USDA-Animal and Plant Health Inspection Service inspectors are treated as pests and are recorded and destroyed. This is done under the Plant Quarantine Act of 1917 (7 U.S. Code 151 et seq.) and the Federal Plant Pest Act of 1939 (7 U.S. Code 150aa et seq.) to protect agriculture, horticulture, and other human interests from damage by exotic insects (Sailer 1978, 1983). USDA-Animal and Plant Health Inspection Service publishes an annual list of insects the entries into the United States of which were intercepted. Frank and McCoy (1992) made the described assumption with the fiscal-year-1980 list of more than 18,000 interceptions (PITSS 1982) and annotated their list of immigrant insects accordingly with the letters "PS" to indicate potential stowaways (Frank and McCoy 1992).

To determine which insects on on their lists (Frank and McCoy 1992,1993) where aquatic, we asked D. J. Howard Frank to assist us with the identification of the aquatic insects, insects with a life stage that depends on water, or insects with close associations with aquatic or semi-aquatic environments. We used tables from Frank and McCoy (1992 and 1993) for the identifications. Much of the information on dates of original captures and countries of origin in this section was obtained from Frank and McCoy (1992, 1993).

Coleoptera:Chrysomelidae.

Microtheca ochroloma Stål. This beetle was first intercepted in New Orleans by inspectors of the Bureau of Entomology and Plant Quarantine; it was on grapes from Argentina (Chamberlin and Tippins 1948). A survey by Chamberlin and Tippins (1948) in early April 1947 of the newly discovered chrysomelid revealed that the beetle is distributed in the city limits of Mobile, Alabama, and in a considerable surrounding territory in Mobile County. The species feeds on cabbage, collards, mustard, turnips, and radishes. In 1972, it was on watercress at an Alabama nursery (Woodruff 1974), and it is now established in Alabama. Frank and McCoy (1991) reported that this species has immigrated into Florida, but give no additional details. It is native to South America (Woodruff 1974) and a serious pest of crucifers in Argentina and Uruguay (H. L. Parker, Research Entomologist, Bureau of Entomology and Plant Quarantine, U.S. Department of Agriculture, unpublished records).

Diptera:Chironomidae

Goeldichironomous amazonicus (Fittkau). This midge was found in 1977 and reported under the name *Siolimyia amazonica* Fittkau. It is native to the Bahamas, Central America, or South America and was probably brought to Florida as eggs or larvae on aquarium plants or on other aquatic plants (Wirth 1979).

A mass emergence of this aquatic midge was reported in August 1977 from near a small canal in a residential area in Kendall, Dade County, Florida. The species previously was known only from Brazil, Nicaragua, and Peru. Additional records are reported from the Bahamas, Mexico, and the Panama Canal Zone. On Lake Nicaragua, mass emergences of this species, called "Sayule" by the local people, are serious nuisances. Whether the species occurs naturally in tropical Florida or was recently introduced by commerce is unknown; if it was recently introduced, it may become a pest species (Wirth 1979).

Because of its recorded presence in the Bahamas, the species may occur naturally in the tropical parts of extreme southern Florida, perhaps varying in abundance with climatic cycles of temperature (Wirth 1979). However, if the Kendall population represents a recent introduction, the species may have arrived by air transport or in shipments of tropical fishes or fish food, and its abundance may increase to a population level and distribution that would class it as a nuisance species. In either case and because of its unusual biological characteristics, the species should be carefully studied by limnologists and by pest abatement agencies in southern Florida (Wirth 1979). The abundance of eutrophic shallow lakes and canals in southern Florida probably provides habitats that can support populations of this species at severe nuisance levels (Wirth 1979).

Diptera:Culiciadae

Aedes albopictus (Skuse). This mosquito was found in 1986 in Florida. It is probably from Japan and entered Florida from Texas (Craig 1993). Rai (1991) discussed the movement and status of *Aedes albopictus* in the Americas. The common name "Asian tiger mosquito" was given it by Peacock et al. (1988). In 1986, this species was at a waste-tire site in Jacksonville (Craven et al. 1988; Peacock et al. 1988). Hughes and Porter (1956) discussed the dispersal methods of mosquitoes during the larval stage. State-wide surveillance of *A. albopictus* (Skuse) was initiated in 1986 by the Entomology Services of the Florida Department of Health and Rehabilitative Services and by local mosquito control agencies (Smith et al. 1990). By the end of 1989, this exotic mosquito had been found exclusively in cemeteries of 11 of the 67 Florida counties (Smith et al. 1990). In a survey of this insect in Florida during 1990, it was detected in 40 more of 46 Florida counties. The search was initially focused near counties that were known to have populations of this species. Collections were made at tire and auto-repair shops, county landfills, illegal tire piles, and cemeteries (O'Meara et al. 1992). Most recent surveys by O'Meara et al. (1992) revealed this species in 53 of the 67 Florida counties. At several locations, it has become well-established in cemeteries before appearing in nearby accumulations of waste tires. The recycling of plastic floral baskets may be aiding the spread of this species. Mosquitoes were commonly in all types of flower-holding containers in cemeteries, except in bronze vases. In the laboratory, most *A. aegypti* eggs that were laid in bronze vases hatched, but larvae subsequently died. The spread of *A. albopictus* in cemeteries seems to occur at the expense of *A. aegypti* populations. At one cemetery, immature *A. albopictus* and *A. aegypti* were in about 70% of the containers with *Aedes* at the start of monitoring. In subsequent collections from this site, *A. albopictus* was in nearly all containers with *Aedes* but progressively decreased in containers with *A. aegypti*. This trend did not seem to be due to a seasonal pattern because in a nearby cemetery where *A. albopictus* was absent, *A. aegypti* did not show a similar decline. Limiting flower-holding containers to those with drain holes or to bronze vases would greatly limit mosquito production (O'Meara et al. 1992). Various types of micro- and macrohabitats make cemeteries ideal locations for investigating the environmental factors of the distribution and abundance of resident and exotic mosquitoes that inhabit containers (Schultz 1989).

Aedes albopictus was probably introduced into North America through the importation of used tires from Japan or Taiwan. During the 1980's, the number of imported used tires in the United States from countries where *A. albopictus* is indigenous increased. Most imported used tires arrived in containers that were not adequately inspected for mosquitoes at the ports of entry. Imported tires were sent to numerous locations where they were stored outdoors. Those that were not suitable for recapping ended up at illegal dump sites, and consequently *A. albopictus* became well-established in the United States. To date, *A. albopictus* has been detected in 22 states including Hawaii.

In Florida, *A. albopictus* is widely but sparsely distributed in the central part of the state, and it is rare in southern Florida. It will probably continue to expand its range down the Florida peninsula and become a common inhabitant of containers statewide. Although immature *A. albopictus* inhabit many different types of containers, scrap tires harbor this mosquito more frequently and in greater numbers than any other type of container. Other common anthropogenic habitats for immature *A. albopictus* include bird baths, water bowls for pets, buckets, plates under potted plants, clogged rain gutters, and flower vases. Natural containers, such as treeholes and tank bromeliads, also provide suitable habitats for immature *A. albopictus*. Indeed, this mosquito shows a much greater propensity than *A. aegypti* for using natural containers. This species is generally distributed across the northern portion of the state; more recent findings in Polk County suggested a southern spread. Dispersal of *A. albopictus* almost can be predicted by following used tire movement and storage (Smith et al. 1990).

Since the initial report of records in Duval and Escambia counties (Peacock et al. 1988), *A. albopictus* has been found in 28 more tire yards, in residential sites in Jacksonville (Duval County), and in five tire yards in the Pensacola area (Escambia County). Some of the new sites in Pensacola received tires from Mobile, Alabama, a city that is infested with the Asian tiger mosquito (*Aldes albopictus*). Another site of special interest is the Jacksonville Naval Air Station where shipment to new areas and countries is possible (Smith et al. 1990).

The Polk County (Polk City) record was from the state's largest known tire yard. An estimated 5 million tires occupy this site. Since the discovery in May 1989, two more tire yards with *Aedes* have been identified in this county; one was about 8 km south in Winter Haven and the other about 1.6 km south of Mulberry. These sites are east of the Tampa Bay area and represent the known southeastern limit of the *A. albopictus* distribution in the United States (Smith et al. 1990).

Thus far, only one adult female was collected from St. Johns County, and the primary source has not been located. The Clay County record was unique because it was from a site without nearby tires. That collection was made by military personnel who collected larvae from a cemetery site during field vector surveillance training (Smith et al. 1990).

Aedes albopictus has quickly become a serious pest species in many northern Florida communities where the annoyance level of this species is greater than that of *A. aegypti* populations (Smith et al. 1990, O'Meara and Gettmann 1991). A wider range of habitats tends to make *A. albopictus* more common than *A. aegypti*. Moreover, Florida populations of *A. albopictus* were probably derived from temperate zone stock that may be better adapted to northern Florida than *A. aegypti* that is primarily a tropical and subtropical mosquito.

The best approach for controlling *A. albopictus* (and *A. aegypti*) is the elimination of larval habitats. Control of *A. albopictus* in Florida continues to rely on monitoring the spread of the mosquito, public education, and the encouragement of source reduction (Smith et al 1990). The Solid Waste Disposal Act (1965; 42 U.S. Code 3251-3259) created regulation of waste-tire storage and disposal in Florida. If properly enforced, these rules should limit the production and spread of mosquitoes that breed in tires (Smith et al 1990).

Aedes bahamensis Berlin

This mosquito is native to the Bahamas (Pafume et al. 1988). It is now well-established in southern Florida, where it is widely distributed in urban and rural areas throughout Dade and southern Broward counties east of the Everglades. When discarded automobile tires were sampled in areas near human habitation, larvae and pupae of *A. bahamensis* were frequently in association with immature *A. aegypti*. Elsewhere, however, *A. bahamensis* generally occurred in the absence of *A. aegypti*. The persistence of *A. bahamensis* populations at specific sites was documented in egg collections from ovitraps and in larval samples from the water in discarded tires (O'Meara et al. 1989).

In southern Florida, *Aedes bahamensis* was initially discovered during fall 1986 in collections from light traps baited with dry ice and from ovitraps. Ironically, these ovitraps were used to evaluate the spread of another exotic mosquito, *Aedes albopictus* (Skuse) (Pafume et al. 1988). The establishment of *A. bahamensis* in southern Florida may have significant consequences for *A. aegypti* that in recent years has been a common domestic mosquito in this region. Here, *A. aegypti* larvae were most frequently in scrap tires that are improperly stored or illegally dumped (Frank 1981). O'Meara et al. (1989) investigated the current distribution of *A. bahamensis* and its association with *A. aegypti* by sampling for these mosquitoes in and around areas with discarded tires.

Immature forms of the mosquito were in sites with discarded tires or occasionally in sites with other types of artificial containers at 37 locations. At many of these sites (n = 20), *A. bahamensis* was found in association with *A. aegypti*. The two species occurred together over a wide range of habitats, including residential, commercial, and industrial zones of the city and in undeveloped or sparsely developed rural areas near human habitation.

Adult *A. bahamensis* are generally inactive during the daytime until about 1 or 2 hours before sunset. Flight and blood-seeking continue after sunset for at least a few hours. In contrast, *A. aegypti* is diurnal with two peaks of activity, one in midmorning and the other in the afternoon. These differences in daily activity patterns should be detected in any assessment of the relative pest status of *A. bahamensis* (O'Meara et al.1989).

(*Aedes aegypti*; L.) - Yellow Fever Mosquito. This mosquito was established in the United States before 1970. It is native to Africa, arrived in the United States before 1850, and is a serious pest species (Skiles 1989). The history of the attempted eradication of this mosquito is inseparable from the history of anthropogenic attempts to control yellow fever, a viral disease for which this species is the primary vector in human populations (Skiles 1989). It is, however, also the primary vector of the viral disease dengue and is a demonstrated or suspected vector of several other diseases of humans and animals (Skiles 1989). Skiles (1989) discussed the life history of this species and the futile efforts to eradicate it from many parts of the world. In the Western Hemisphere, this mosquito breeds in water that collected in anthropogenic containers of almost any kind inside houses and out-of-doors. They include containers for water collection or storage (cisterns, flower pots, water jugs, animal watering trough), discarded containers (pots, cans, bottles, auto tires, auto bodies, drums), masonry defects, and neglected containers (gutters, drain traps, unused toilets; Skiles 1989). Water in abandoned or infrequently used boats can also serve as a breeding place.

Frank (1981) discussed the role that discarded tires have had in the survival and the spread of *A. aegypti*. Larvae occur throughout the year in southern Florida, although breeding may stop during the coldest weeks. In Florida as in Puerto Rico, populations increase during the hotter, wetter months and have a clear seasonal life cycle. In Puerto Rico in 1973-1976, dengue cases correlated with monthly prevalence of larvae.

Because adults usually stay within a few hundred meters of their larval sites, long-range dispersal of the species depends primarily on humans. As a result, *A. aegypti* moves along human travel and trade routes and is particularly prevalent along coastal areas and harbors. The abundance of bilge water and the necessity of transporting fresh water on ships ensures species dispersal along shipping routes. Tonn et al. (1982) reported that almost every month at least one ship that enters Panamanian ports is infested with *A. aegypti*. Hence eradication alone is not sufficient to ensure freedom from infestation in a given locality. Continual surveillance is required to guard against reintroduction. *Aedes aegypti* was probably a forest species that bred in tree holes and in other natural water containers, as it often does in Africa today. But, as Tonn et al. (1982) noted with concern, occasional breeding of *A. aegyptic* in natural containers such as tree and rock holes is reported from many countries. Schliessmann (1967) reported that even in the United States, larvae were occasionally in tree holes and in leaf axils of bromeliads (Family Bromeliaceae) and of travelers' palms (Family Phoenicaceae).

The United States attempted to eradicate *A. aegypti* with DDT in 1964 and ceased operations in 1968. Although the hemisphere-wide eradication of yellon fever and *A. aegypti* is desirable, Schliessmann and Calheiros (1974) considered that their elimination as probably impossible for many reasons including the costs associated with its extermination. The attempted eradication of *A. aegypti,* despite the new control equipment and insecticides and millions of dollars annually has not been successful (Tonn et al. 1982).

Lepidoptera:Pyralidae

Parapoynx diminutalis Snellen. This moth was in Florida in 1976 on hydrilla. It is native to Asia (Del Fosse et al. 1976) and seemingly immigrated to Florida on hydrilla. Its feeding occasionally causes heavy defoliation of the host plant. This insect was found during constructions of plastic pools (3.05 m diam, 0.8 m deep) for herbicide-testing experiments on hydrilla by technicians of the U.S. Department of Agriculture at the Fort Lauderdale Agricultural Research Center. The workers who found the species reported that the worms were eating the plants. On examination of the plants, several small pyralid caterpillars and adult pyralids were noted. John Heppner of the Department of Entomology, University of Florida, Gainesville, identified some of the specimens as the common pyralid *Parapoynx allionealis* Walker, but most were *P. diminutalis* (Snellen) heretofore known only from Pakistan to Southeast Asia (Del Fosse et al. 1976). How or when this species was introduced are not known. The larvae caused considerable damage to hydrilla. The use of this insect was later rejected by researchers at the Fort Lauderdale Agricultural Research Center because of its broad host range in Asia and Florida. It seemingly prefers hydrilla (Buckingham and Habeck 1990; Buckingham and Bennett 1989; Center et al. 1991).

Odonata:Aeshnidae

Coryphaeschna adnexa (Hagen). Blue-Faced Darner. This insect was first discovered in southeastern Florida in 1980. Its range is south through the Greater Antilles and from northern Mexico to Argentina. Its habitat is weedy lakes, canals, and marshes. It flies all year in the tropics and commonly feeds over lawns and in clearings (Dunkle 1989).

Odonata:Lestidae

Lestes spumarius (Hagen in Selys) - Antillan Spreadwing. This spreadwing was found in Florida in 1988 and is from Cuba or the Bahamas (Dunkle 1990).

Odonata:Libellulidae

Crocothemis servilia - Scarlet Skimmer. This species is native to Asia and was found in Florida in 1975. Since August 1977, it has been established in a canal near Goulds, Dade County, Florida. Males, females, and young were collected (Paulson 1978; Begum et al. 1985).

Erythemis plebeja (Burmeister)-Black Pond Hawk.
This species was first discovered in Miami, Florida, in 1971 and was common. It has spread sparingly north from Cuba or from the Bahamas to Orlando and occurs in southern Texas south to Paraguay and the Great Antilles. It flies all year near its preferred habitat of quiet waters such as ponds, lakes, canals, and slow rivers (Dunkle 1989).

Micrathyria aequalis (Hagen) - Spottailed Skimmer.
This species was first discovered in the Miami area in 1985 (Dunkle 1989). It is uncommon and has not spread farther. This species occurs from southern Texas to Ecuador and in the West Indies. It flies all year in its normal habitats of permanent and temporary ponds, lakes, and sloughs. May (1980) studied this species.

Micrathyria didyma (Selys in Sagra) - Three-Striped Skimmer. This insect was first found in the Miami area in 1985. It is uncommon in southern Florida and has not spread farther. It is also in the Bahamas and West Indies and from northern Mexico to Ecuador. Its habitat is shady ponds and canals, and the species flies all year (Dunkle 1989).

Imported Insects for Biological Control Agents of Aquatic Nonindigenous Plant Species

In addition to immigrated insects, many insects in Florida were purposely imported for release as biological control agents (Frank and McCoy 1993). The principles that govern the use of biological control agents were laid out in 1938 when Harvey L. Sweetman at the Massachusetts State College, now the University of Massachusetts, published the notes for his graduate course *Enemies of Insects* (Sweetman 1958). Sweetman's book covers the broad field of biological control of plants and animals and is still a classic work. The early work on biological control of aquatic nuisance weeds was reviewed by Blackburn et al. (1971), Andres and Bennett (1975), and Gallagher and Haller (1990). The use of herbicides to control nuisance plants is frequently impractical if the species is allowed to spread over a large area before the decision is made to control it. If treatment is delayed, the cost of the herbicidal product and its application is too high and the environmental concerns over the potential toxic substance on the land and in the water and its effect on nontarget plants and animals cannot be ignored (Center 1984).

The use of insects to control aquatic weeds began with alligatorweed and was successful (Buckingham and Habeck 1990, Buckingham et a. 1983). Thus, other insects have been evaluated and released on several pest plant species such as hydrilla, waterhyacinth, and giant salvinia. Host-specific insects and plant pathogens have been released to increase leaf mortality, decrease plant size, and reduce population expansion. Herbicides are used for current management, however, insect control shows promise for long-term control (Schmitz et al. 1991). Charudattan and Browning (1992) and Charudattan (1990) discussed the special problems with the biological control of aquatic weeds.

Laing and Hamai (1976), Clausen (1978), Luck (1981), and Funasaki et al. (1988) tabulated the biological control agents that were introduced into various regions of the world. Denmark (1964) and Denmark and Porter (1973) had previously documented the introduction of biological control agents into Florida. Frank and McCoy (1993) expanded the scope of documentation and brought the records up-to-date. They determined that about 351 (a few species were lumped) insect species have been imported into Florida for potential release as biological control agents since 1890; many were never released. However, 151 were introduced as biological control agents of insect pests and weeds. Of the 351 taxa, 32 seem to have occurred already in Florida; 24 seemingly are natives and 8 seemingly are immigrants. Some of the immigrants, such as *Bathyplectes curculionis* (Thomson; Hymenoptera: Ichneumonidae), seem to have arrived in Florida by immigration from other states into which they had been imported, whereas others, such as *Megastigmus transvaalensis* (Hussey; Hymenoptera: Torymidae) and *Utetes anastrephae* (Viereck; Hymenoptera: Braconidae), may have arrived directly from abroad by stowing away in cargoes of plants and other materials (Frank & McCoy 1992). Another 11 taxa are thought to have been introduced (Frank and McCoy 1992) because permits were issued for their importation, but no actual records of importation could be located. Three of the released species are not biological control agents, leaving 151 taxa, consisting of 139 targeted insect pests and 12 targeted plant pests.

Biological control agents have been released in Florida since the 1890's (Frank and McCoy 1992). An estimated 24.5% of the released species for the control of insect pests and an estimated 66.7% for the control of weeds have established populations in Florida. The established proportion of insect predators (26.7%) was very similar to that of insect parasitoids (23.9%). Targeted insect pests were mainly Homoptera (48%), Lepidoptera (24%), and Coleoptera (10%). Most targeted insect pests (79%) and nuisance plants (75%) are not native to Florida; 43% of the insect pests are native to Asia, and 50% of the weeds are native to South America. None of the targeted native insect pests and weeds occurs only in Florida. No clear relations existed between the number of released individuals and their geographic origin, county in which they were released, and probability of establishment (Frank and McCoy 1993).

Almost all introduced insects that Frank and McCoy (1993) included in their tabulation were imported deliberately and deemed beneficial and suitable for release. However, Howarth (1991, 1992) questioned the certainty that a released insect does not harm that ranges from negligible to extinction of other species. Small changes that the organism causes can lead to large environmental problems that are completely unanticipated. Release of the biological control agents usually was subject to proof of host-specificity. All insects that were introduced into the United States for biological control require (1) a permit from the Animal and Plant Health Inspection Service, Plant Protection and Quarantine, of the U.S. Department of Agriculture, (2) a Declaration of Importation (for all live and dead specimens) from the U.S. Fish and Wildlife Service and (3) a permit from the Florida Department of Agricultural and Consumer Services for insects that are imported as biological control agents (personal communication from J.H. Frank, Entomology Department, University of Florida).

The cost of developing biological control agents is high and time-consuming and requires the investment of staff, other valuable resources, and--frequently--international cooperation. Few attempts to evaluate the total costs and benefits of control have been made (Djerassi et al. 1974). Schroeder and Goeden (1986) discussed the theory and practical considerations of the search for and evaluation and use of insects as biological control agents of introduced nuisance plants. Harris (1979) described the costs of the biological control of introduced nuisance plants with introduced insects in Canada. A model to calculate the expected net benefits from biological control was developed by Habeck et al. (1993).

Frank and McCoy (1993) included in their list of insects introduced into Florida since 1970 some unsolicited species that were shipped to the quarantine facility of the Florida Biological Control Laboratory by foreign suppliers and terminated in quarantine, some unexpected parasitoid species that emerged from their imported hosts in the quarantine facility, and two species that were imported by members of the public without permits and were released in Florida. They omitted from the list any imported pest species that were brought to the quarantine facility simply as a host for beneficial parasitoids or predators that were terminated in the quarantine facility, species that were imported by the pet trade or by members of the public without permits or other public record, species that were imported with permits for experimental purposes in secure laboratories, species that were imported with permits for educational purposes and not intended for release (such as exotic butterflies), and beneficial species that were imported with permits by commercial organizations as biological control agents for pests (Frank and McCoy 1993).

Since 1973, all insects that were purposely legally imported into the United States are tracked by the U.S. Department of Agriculture. This organization annually compiles a list of the insects imported and recorded on FORM AD 914.

J. H. Frank, Professor, Entomology Department, University of Florida, Gainesville, assisted us with the identification of all of the aquatic insects and insects that were imported to control aquatic or semi-aquatic nuisance plants (Frank and McCoy 1992 and 1993).

Toxorhynchites amboinensis (Doleschall). This insect, belonging to the Family Culicidae/Diperta, was imported from Indo-Malaysia via Louisiana and was released ca. 1986 and in subsequent years in Duval and St. Lucie counties, Florida, to control *Aedes aegypti* and other mosquitoes whose larvae inhabit artificial containers. It does not survive winters in Florida. (Frank and McCoy 1993). This species is not established at the present time.

Toxorhynchites splendens (Wiedemann). This insect, belonging to the Family Culicidae, was imported from Burma via Hawaii, Indiana, and Louisiana and was released in Florida in Bay County in 1986-1988, in Leon and Sarasota counties in 1990, in Palm Beach and Walton counties in 1991, and in Hillsborough County in 1992 to control *Aedes aegypti* and other mosquitoes the larvae of which inhabit artificial containers. It has not survived the winter at any of the localities where it was released (Frank and McCoy 1993).

Neohydronomus affinis Hustache. This small South American weevil, Family-Curculionidae, previously controlled waterlettuce in Australia and South Africa. It was originally tested and released in Australia, where profound control of waterlettuce at release sites was obtained within 18 months (Harley et al. 1984). It was imported into the United States from Brazil via Australia in 1986 and 1988 for the control of waterlettuce *Pistia stratiotes* and tested in quarantine in Gainesville, Florida, and released in April 1987 on a 30-ha waterlettuce infestation on Kraemer Island in Lake Okeechobee (Dray et al. 1990). By April 1989, the weevil population increased to extremely high densities and thoroughly suppressed the waterlettuce population. These results were repeated at other sites. The weevil was released in 1987-1988 in Broward, Palm Beach, and St. Lucie counties, Florida, and is now established and widely distributed in Florida (Frank and McCoy 1986, 1988; 1993; Thompson and Habeck 1989).

Spodoptera pectinicornis (Hampson). This moth, Family Noctuidae, previously identified as *Namangana pectinicornis* and as native to Southeast Asia, has been successfully used in Thailand where it was imported during 1986-1988 for the control of waterlettuce and released in 1990 in Glades, Palm Beach, and St. Lucie counties, and in 1991 in Brevard, Broward, Gadsden, Glades, Okeechobee, Putnam, and Sumter counties; it is not yet clear that establishment is permanent (Frank and McCoy 1986, 1987, 1988, 1993; Buckingham & Habeck 1990; Dray and Center 1992; D. H. Habeck, Professor, Entomology Department, University of Florida, Gainesville, personal communication). Center et al. (1991) considered it a potential, effective control agent. This species is still under study.

Three host-specific South American insects were found and eventually released as biological control agents of Alligatorweed (*Alternanthera philoxeroides*). These include the alligatorweed flea beetle (*Agasicles hygrophila*) that was released in 1964; the alligatorweed thrips (*Amynothrips andersoni*) that was released in 1967; and the alligatorweed stem borer (*Vogtia malloi*), a moth that was released in 1971 (Center et al. 1991).

Alligatorweed flea beetle (*Agasicles hygrophila*) Selman & Vogt. This flea beetle, family Chrysomelidae, was imported from Argentina. Lack of suitable chemical control for alligatorweed led to the consideration of biological control as a possible solution. This insect was identified as a possible control and was evaluated (Brown and Spencer 1973) and released in 1965-1972 to control alligatorweed in Alachua, Baker, Bradford, Broward, Calhoun, Citrus, Clay, Dixie, Duval, Escambia, Flagler, Glades, Hendry, Hillsborough, Marion, Palm Beach, Polk, Putnam, St. John's, St. Lucie, and Volusia counties where it is now established. It was released in 1979 in Alachua County (Zeiger 1967; Denmark and Porter 1973; Frank and McCoy 1974, 1993; Coulson 1977; Buckingham et al. 1983; Buckingham and 1990). This flea beetle was introduced to control alligatorweed by consuming leaves and portions of stems during the latter stages of an infestation (Buckingham and 1990). It is restricted by winter temperatures to Florida and to the coastal areas of other southern states, but beetles that are collected in the south and released in spring or early summer can provide control in northern areas (Cofrancesco 1984; Buckingham and 1990). The alligatorweed flea beetle is the most effective of the three insects that were introduced to control this pest. It is especially effective in coastal areas but less so farther inland (Center et al. 1991).

Alligatorweed stem borer (*Vogtia malloi* Pastrana). This moth, family Pyralidae,is native to Argentina and was released to control alligatorweed in 1971-1972 in Alachua, Broward, Duval, Orange, and St. Lucie counties, where it is established (Brown and Spencer 1973; Coulson 1977). Each summer, this moth flies northward in the Mississippi Valley from coastal sites and flies inland from South Carolina coasts. By mining the insides of the stems, the larvae cause the weed to wilt and die (Buckingham and 1990). The alligatorweed stem borer is a small, brown moth. Because of its high dispersive ability, this insect readily moves inland where it can become an important biosuppressant. Damage by the alligatorweed borer causes the stems to collapse and the mat to acquire a flattened appearance. This, in conjunction with defoliation by the flea beetle provides control (Center et al. 1991).

Alligatorweed Thrips (*Amynothrips andersoni*) O'Neill. This thrips, family Paleothripidae, is native to Argentina and was released for the control of alligatorweed in 1976-1972 in Alachua, Broward, Clay, Duval, Glades, Orange, and Palm Beach counties where it is now established (Coulson 1977; Buckingham and 1990). The alligatorweed thrips is the least well known of the three biological control agents of alligatorweed . They do not readily disperse, and they do not seem to severely impede alligatorweed growth. However, field evaluations of the effectiveness of the thrips have never been conducted (Center et al. 1991).

Eubrychius sp. This species, belonging to the family Curculionidae, is native to China and was imported in 1991 for the control of Eurasian watermilfoil (*Myriophyllum spicatum*). The culture was lost in quarantine (Frank and McCoy 1991, 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication).

Phytobius (*Litodactylus*) *leucogaster* (Marsham). This species, belonging to the family Curculionidae, was imported from California in 1978-1979 and was released for the control of Eurasian watermilfoil in 1979 in Levy County. It is probably not established (Frank and McCoy 1978, 1979, 1993; Buckingham and 1990; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication). This flower- and seed-eating weevil ranges across the northern United States to California (Buckingham and Bennett 1981).

Acentria ephemerella (Denis and Schiffermuller). This species belongs to the family Pyralidae and is native to the northern United States and was imported in 1975-1976 (under the name *Acentropus niveus*) and in 1978 to control Eurasian watermilfoil. The culture died in quarantine (Frank and McCoy 1975, 1976, 1978, 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication).

Parapoynx stratiotata L. This insect, belongs to the family Pyralidae, was imported from Italy via Delaware, from Yugoslavia, and from Italy in 1975-1976 by N. R. Spencer as a potential biocontrol agent of Eurasian watermilfoil. Research on it was terminated in quarantine (Frank and McCoy 1975, 1976, 1993; BIRL 1992; D. H. , Professor, Department of Entomology and Nematology, University of Florida, Gainesville, Florida, personal communication).

Worldwide surveys were begun in 1981 to find biological control agents for hydrilla (*Hydrilla verticillata*). Several species of insects were found. Two species from India and one from Australia were released. Other promising insects are known from different parts of the world but have not yet been evaluated. Two species of leaf-mining flies, *Hydrellia pakistanae* from India and an undescribed *Hydrellia balciunasi* from Australia, were released in Florida. The larva burrows and destroys as many as 12 leaves during its development. These flies have potential for control of hydrilla if they can be colonized in the field (Center et al. 1991).

Bagous affinis Hustache. This weevil, family Curculionidae, occurs naturally in India and Pakistan. It was imported in 1982-1983, 1986, and 1990-1991 for the control of hydrilla and released in 1987 in Lake Tohopekaliga, Osceola County. It was established temporarily (Frank and McCoy 1993; Buckingham 1988; Buckingham and 1990). This weevil is specific to hydrilla and attacks its tubers, also called subterranean turions, in dry water bodies. Its use will be limited primarily to drawn-down lakes or canals (Buckingham and 1990). Additional studies are needed to determine whether this weevil can control hydrilla tubers (Center et al. 1991). Bennett and Buckingham (1991) discussed the results of laboratory studies of this species.

Bagous dilgiri Vazirani. This weevil, family Curculionidae, was imported from India in 1983 for the control of hydrilla. It was terminated in quarantine (Bennett and Buckingham 1991; Frank and McCoy 1993) because the insect also developed on the native species *Potamogeton* spp. and *Najas* spp.

Bagous laevigatus O'Brien & Pajni. This weevil was imported from India in 1983 and in 1986 for the control of hydrilla. It was terminated in quarantine after host-range testing (Bennett and Buckingham 1991; Frank and McCoy 1993) because hydrilla was not its principal host plant.

Bagous vicinus Hustache. This weevil was imported from India in 1983 for the control of hydrilla. Research on it was terminated in quarantine (Bennett and Buckingham 1991; Frank and McCoy 1993) because this insect damaged only stems out of water.

Bagous hydrillae O'Brien. This weevil was imported from Australia in 1987, 1988, and 1991 for the control of hydrilla and was released in 1991 in Broward, Palm Beach and Sumter counties. Its establishment is still uncertain (Center 1992; Frank and McCoy 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication).

Polypedilum dewulfi Goetghebuer. This midge, family Chironomidae, was imported from Burundi in 1990 for the control of hydrilla (Frank and McCoy 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication), but it could not be colonized in quarantine.

Polypedilum wittae (Freeman). This midge was imported from Burundi in 1990 by G. R. Buckingham (Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication), but attempts to colonize it in quarantine were unsuccessful.

Hydrellia balciunasi Bock. This fly, belonging to the family Ephydridae, was imported from Australia in 1988, 1989, and 1991 for the control of hydrilla and was released in 1989 in Broward County, in 1990 in Broward County, and in 1991 in Broward, Collier, and Sumter counties. Its establishment is not certain (Buckingham and 1990; Center 1992; Frank and McCoy 1993). The results of the biological and host-range studies of this species were summarized by Buckingham and Okrah (1993).

Hydrellia pakistanae Deonier. This Indian leaf-mining fly, belonging to the family Ephydridae, has a native range including India, Pakistan, and China. It was imported in 1986 and 1990 for the control of hydrilla and released in 1987 in Polk and Marion counties, in 1988 in Broward, Glades and Palm Beach counties, in 1989 in Broward, Glades, Osceola, and Polk counties, and in 1990 in Broward, Glades, Jefferson, Lake, Okeechobee, Osceola, and Palm Beach counties where it is now established (Buckingham 1988; Buckingham and 1990; Center 1992; Frank and McCoy 1993). The results of the biological and host-range studies of this species were summarized by Buckingham and Okrah (1993). Its larvae consume the contents of hydrilla leaves that become transparent and eventually drop off (Buckingham and 1990).

Hydrellia sarahae Deonier. This fly was imported from India and China in 1990, 1991, and 1992 for the control of hydrilla. It has not yet been released (Frank and McCoy 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainesville, Florida, personal communication).

Parapoynx diminutalis Snellen. This small aquatic moth, family Pyralidae, from Southeast Asia was accidentally introduced, probably with imported aquarium plants. It is not widespread in the state and seems to be specific to hydrilla in the field. It occasionally causes heavy defoliation of hydrilla in Florida (Buckingham and 1990). Although little is known about it, the occurrence of this moth seems sporadic and unpredictable, and occurrences do not result in acceptable levels of control (Center et al. 1991). This species was imported from Asia via Panama in 1980-1982 for the control of hydrilla; however, the same species was already established elsewhere in Florida (Frank and McCoy 1993; G. R. Buckingham, Research Entomologist, Florida Biological Control Laboratory, Agricultural Research Service, U.S. Department of Agriculture, Gainsville, Florida, personal communication).

Three species of insects have been released to control waterhyacinth (*Eichhornia crassipes*). The first was a weevil, *Neochetina eichhorniae* (family Curculionidae), was released in Florida in 1972. The second was *Neochetina bruchi*, another weevil that is quite similar to the first (Center 1982). It was released in Florida in 1974. The third insect was a moth, *Sameodes albiguttalis* (family Pyralidae), named the waterhyacinth borer, and was released in 1977 (Center 1984; Center et al. 1991). The weevils (especially *N. eichhorniae*) have been the most effective of the waterhyacinth insects. Outbreaks of waterhyacinth borers are devastating to young waterhyacinth stands and sometimes prevent regrowth after herbicidal control. Because plants are attacked only briefly during early mat development, however, waterhyacinth borer populations seem sporadic. During this limited period, they effectively slow the rate of mat development. Because the presence of waterhyacinth borers may not be detected if sites are not surveyed regularly, the importance of this insect is easily underestimated (Center et al. 1991). Waterhyacinth weevils and borers suppressed waterhyacinth growth in many areas. This control is sometimes manifested as sudden declines, which are however rare. Instead, long-term decline of the plant population typifies the normal biocontrol pattern (Center et al. 1991). Charudattan et al. (1978) discussed the effects of fungi and bacteria on the decline of arthropod-damaged waterhyacinth.

Neochetina bruchi Hustache. This beetle was imported from Argentina in 1974 for the control of waterhyacinth and was released in 1974. It was also imported in 1975 and released in Lee County (Perkins and Maddox 1976; Grissell 1978; Cassani et al. 1981; Center and Durden 1986; Haag 1986; Buckingham and 1990; Frank and McCoy 1993). It is established in Florida. During the development of this project, it was discovered that two species of weevils were involved: *N. bruchi* and a new species, *N. eichhorniae* (Warner). The discovery that there were two weevils on the hyacinth delayed the program because some tests had to be repeated to determine whether the results were caused by one or both species. Both species are seemingly host specific to *E. crassipes* (Perkins and Maddox 1976).

Neochetina eichhorniae Warner. This weevil was imported from Argentina. It has been also reported from Bolivia and Trinidad. A preliminary summation of the studies on the host specificity this species was prepared and submitted to the Working Group on Biological Control of Weeds for clearance of quarantine in the United States. The Working Group granted this request but recommended additional testing on several aquatic plant species before release into the United States. Initially the testing and studies, including work on the additional test plants were conducted in Argentina in 1968-1971 and in quarantine in the United States in 1971. After approval, it was released in 1972, in Broward County and in 1974 in Glades and Lee counties. It was also imported in 1975 (Perkins 1973; Cassani et al. 1981; Center and Durden 1986; Haag 1986; Frank and McCoy 1993).

These two weevils were credited with reducing waterhyacinth in Florida lakes. By scraping the leaf surface, the feeding adults reduce photosynthesis; the larvae mine down the petioles, increasing the overall amount of pathogens that can attack the plant (Buckingham and 1990).

Acigona infusella (Walker). This moth, belonging to the family Pyralidae, insect was imported from Argentina in 1974-1975 for the control of waterhyacinth but was not released and died in quarantine (Frank and McCoy 1993).

Sameodes albiguttalis Warren. This moth, family Pyralidae was imported from Argentina in 1975-1976 and released for the control of waterhyacinth in Broward, Collier, Dade, and Pinellas counties in 1977-1979 (numbers not counted) and in 1979-1980 in Alachua County (79,093 in 1979,and 19,764 in 1980). It was established by 1979 (Center and Durden 1981; Center 1984; Buckingham and 1990; Frank and McCoy 1993).

Orthogalumna terebrantis Wallwork, Oribatid mite. This mite seems to be a South American immigrant that was already present in Florida. It only occasionally causes severe damage to waterhyacinth in southern Florida and does not seem to be an important agent (Buckingham and 1990).

Cercospora rodmanii Conway. This seemingly native fungus was found during a survey of the pathogens of waterhyacinth in the Rodman Reservoir, Florida. Conway et al. (1978) discussed the development of this fungi as a biological control agent of waterhyacinth. Additional information on this species can be found under the section titled Biological Control Agents Other Than Insects. Charudattan (1984, 1986) discussed the role that this species might play in controlling waterhyacinth.

Oxyops vitiosa Pascoe. This weevil, family Curculionidae, was imported from Australia in May 1992 and was approved for a quarantine study in the United States by the U.S. Department of Agriculture Animal and Plant Health Inspection Service. It is now under study in Gainesville, Florida. Preliminary laboratory and greenhouse tests indicate that the insect is specific to melaleuca (*Melaleuca quinquenervia*; Leist 1993) and may be released in 1994. Whether this insect alone will be able to control the plant is doubtful.

Other pest plant species that will be considered for control by arthropods include limnophila (*Limnophila sessiflora*), hygrophila (*Hygrophila polysperma*), water morning glory (*Ipomoea aquatica*), and parrotfeather (*Myriophyllum aquaticum*; Buckingham and 1990; Center et al. 1991). None is native to the United States.

Fire Ant - *Solenopsis invicta* and *S. richteri*. The history of the imported fire ant is controversial. Its pest status and public-health status and the control policies have been hotly debated topics since 1957 when the U.S. Department of Agriculture first decided to eradicate it (Vinson 1985, Vinson and Sorensen 1986). Recently the department again began to operate a large-scale, expensive control of fire ants, thereby stimulating renewed interest in the ant, in past control efforts, and in the efficacy of the current approach (Davidson and Stone 1989).

Black fire ant (*Solenopsis richteri* (Forel)). The less common black imported fire ant arrived mysteriously in the United States in 1918 through the port of Mobile, Alabama, but escaped recognition as a new arrival until 1930 (Summerlin and Green 1977). In South America, its range covers extensive areas in Brazil, Uruguay, and Argentina (Buren et al. 1974). In the United States, its distribution includes only northeastern Mississippi and northwestern Alabama. This limited range is probably due to competition from its relative, *Solenopsis invicta* Buren.

Solenopsis invicta. This fire ant is well established in most of Florida and from North Carolina to eastern Texas. Much of the early spread was by transportation of infested nursery stock. This species is native to the seasonally flooded Pantanal region of southern Brazil and was introduced by some form of shipping to the United States about 50 years ago (Lofgren 1986). The prediction of the ultimate range of *S. invicta* is contentious and depends on certain biological assumptions (Tschinkel 1993). There is evidence that it will not spread farther north than the northern boundaries of Mississippi, Alabama, Georgia, and the Carolinas. Colony development and reproduction are probably controlled by the brevity of the winter season and the fact that this species does not hibernate.

These two nonindigenous fire ant species inhabit approximately 93,120,000 ha in nine southern states, making them a familiar feature of life in these areas (Lofgren 1986). In that range are about 10 billion colonies (Metcalf et al. 1982; Davidson and Stone 1989). The ants are feared because, when a nest is disturbed, the ants swarm over any nearby object, delivering multiple, painful stings to the intruder. This aggressiveness extends only to a small area around the nest, which is a conspicuous mound (Sterling 1978). The behavior is, in fact, not unlike that of the well-known winged relatives of the ant -- bees and wasps (Davidson and Stone 1989).

The ant is ubiquitous in agriculture. It has been reported in almost every crop in the infested states; although it causes damage, it is also sometimes beneficial because it preys on a wide variety of insects (Davidson and Stone 1989).

Except for the expanded range, the status of the fire ant is similar to what it was in 1957 when the U.S. Department of Agriculture first attacked fire ants with the largest and most devastating eradication ever undertaken against an introduced insect pest. More than 25 years and close to $200 million later (Oliver et al. 1979), the situation is now worse than ever (Davidson and Stone 1989). The consequences from the introduction of this species for humans are harmful, effects in agriculture are both harmful and beneficial (Lofgren 1986; Tschinkel 1993).

Specific damage and benefits to some of the commonly cited crops were summarized by Davidson and Stone (1989). The most seriously affected crops are soybeans (*Soia soja*) and hay (bales left in the field overnight attract hordes of ants, and the mounds may obstruct cutting rigs). Fire ants are most beneficial to cotton because they prey on boll weevil (Sterling 1978) and *Heliothis* species and to sugarcane because they reduce sugarcane-borer populations to allow farmers to save one or two pesticide applications per season (Maxwell et al. 1982; Davidson and Stone 1989). Lofgren (1986) summarizes the economic importance and control of fire ants in the United States.

The general opinion in the literature before 1957 was that fire ants were not significant agricultural pests and may indeed be overall beneficial. The ants are a nuisance in certain settings. Green (1952) pointed out that the most serious damage in agriculture is that the imported fire ant build very large mounds in the fields causing problems during cultivation.. Brown 1982 reported that infestations may have as many as 198-222/ha and in severe cases as many as 1500/ha in Texas. Tschinkel (1982) claimed that the upper limit is 49-62/ha in large, mature colonies. Even in this smaller number, however, the presence of ant mounds can seriously affect agricultural cutting and mowing. Because the ant mounds can reach a height of 30.5 cm and a diameter of 61 cm, damage to farm machinery is inevitable if mounds are scattered throughout a field. Crop costs rise from broken combine blades or from times of equipment repair (Davidson and Stone 1989).

Efficiency of farmworkers is lost if workers must constantly avoid ants. Absences from the workplace for medical treatment and medical expenses introduces additional costs. Some activities, such as removing infested bales of hay and making on-the-spot repairs of machinery near ant mounds, are impossible in the presence of angry fire ants (Davidson and Stone 1989).

Attacks on newborn calves and other livestock have been recorded but are poorly documented. Fire ants reportedly kill quail, ground squirrels, young deer, and even earthworms (Brown 1982; Davidson and Stone 1989).

Several points relate specifically to consideration of eradication. First, fire ants may have already reached the limits of their range in the United States. Cold temperatures stopped their northward spread, and the need for warm rain may prevent their westward movement. Texas west of the hundredth meridian may be too dry, and California, which lacks summer rains, may be too dry in the warmer months (Davidson and Stone 1989).

Second, mature colonies of fire ants are territorial. Within an area around its nest, a colony does not tolerate ants from another colony and kills newly mated queens that attempt to found a nest. As a result, fire ant populations have a self-imposed carrying capacity of approximately 62 mature mounds/ha (Tschinkel 1982). Counts higher than this indicate young colonies in the growth phase (Davidson and Stone 1989).

The feasibility of eradication was broached and answered in the negative only after the situation had been badly mishandled (van den Bosch 1978). If the biology of the ant had been examined, the environmental poisons heptachlor and dieldrin would probably not have been considered. The idea of using a broad-spectrum pesticide on a species that is well adapted to colonizing disturbed areas would have seemed ridiculous (Davidson and Stone 1989).

By steadfastly refusing to succumb, fire ants forced a reexamination of eradication philosophy. But the costs of that lesson have been considerable in dollars and in harm to the environment (Davidson and Stone 1989).

The native ant fauna of the United States includes two fire ants, the tropical fire ant (*Solenopsis geminata* (F.)) and the southern fire ant (*S. xyloni* McCook). Both are regarded as inconspicuous members of the southern ant fauna. They make smaller mounds than the imported fire ants and are relatively unaggressive (Summerlin and Green 1977).

Lovebugs (*Plecia nearctica*). Love bugs, also called marsh flies, belong to the Family (Bibionidae). This species was first described by D. E. Hardy in 1940 in Louisiana, where many larvae developed in grass clippings along highway subgrades. Although Hardy's description of the species did not list any localities east of the Mississippi Gulf Coast, he indicated that the species was widely distributed and extended into Mexico and Central Mexico (Hetrick 1970).

Love bugs are not native to Florida but migrated into Florida from the west. The first reported love bug in Florida was in Escambia County in 1947 (Kuitert and Short 1993). The first time they were reported in Alachua-Marion counties was in 1955-1956. They have progressively moved southward each year to Homestead and northward to Georgia and South Carolina. Flights of large numbers of adults are present for 4 weeks each year in May and September. The flight of the love bug is restricted to daylight hours. At night, the bugs rest in low-growing vegetation (Kuitert and Short 1993). Individual insects do not live long but are constantly being replaced by others of the same generation. Male love bugs live for 2 or 3 days, whereas females may live for 1 week or longer and may mate with more than one male (Hetrick 1970).

In September 1971, love bugs were reported as far south as south-central Florida, and scattered flights were seem as far south as the Lake Okeechobee area (Kuitert and Short, 1993). Adult love bugs are harmless and do not sting or bite. They feed on nectar and pollen of various flowers, especially goldenrod (Solidgo spp.), sweet clover (Melilotus spp.) and Brazilian pepper (Schinus terebinthifolius).

The love bug is a nuisance but not yet an environmental pest. However, its population has increased, and its range has spread in such proportions that some form of ecological imbalance may be expected (Peckham 1977). Love bugs spatter and stick to trucks and automobiles during daylight hours, often clog the cooling fins of the radiator, and may cause automobiles that travel at high speeds for extended time to overheat. Windshields that are covered with these insects obscure the driver's vision, and a cars finish may be damaged if the bugs are not cleaned off in a reasonable time (Kuitert and Short 1993).

At the present time, the chemical control of this species is impractical and environmentally unsound. The larval and adult stages of this species have many enemies, including birds, earwigs, centipedes, and two species of beetles (Kuitert and Short 1993).

The ecological factors that are responsible for the population explosion of this species in north central Florida are not known (Hetrick 1970). Love bugs occur in great numbers along the highways because the photochemical reaction of automobile exhaust fumes and UV radiation attract and hold them over the highway (Callahan and Denmark 1973).

Nonindigenous Fishes in Freshwater Systems

International Trade of Nonindigenous Fish

The movement of exotic species around the world essentially began in the middle of the nineteenth century. A compilation of international introductions of nonindigenous freshwater aquatic species includes 1,354 introductions of 237 species into 140 countries (Welcomme 1988). The first transferred fish species was probably the common carp during 1200-1500 (Welcomme 1988). Welcomme (1984) discussed the purposes of many transfers and the observed results. He found that not all introductions were intentional, generally that little or no environmental research was completed before the intentional introductions were made. Only 25% of the introductions fulfilled intents or gave rise to important fisheries outside the original scope of the introduction. Thirty-two percent are viewed with mixed feelings because they either were highly successful in some areas and not in others or were successful in some areas and caused significant problems in others (Welcomme 1984). Welcomme (1984) also discussed philosophical differences between industrial societies in temperate climates and rural societies in the tropics. Welcomme (1988) found that industrial countries, usually located in temperate zones, tended to only introduce those species that enhanced its environment with little chance that the species would have negative impacts, while rural nations, usually in the tropics, were more interested in introducing species to provide new sources of food protein with little or no concern for long term possible negative impacts to the environment.

The ecology of biological invasions on a global perspective is described by Elton (1958), Pearsall (1959), and Drake and Mooney (1989). Howarth (1992) discussed the worldwide regulation of introduced freshwater fishes.

The estimated annual worldwide economic value of the aquarium-fish industry is approximately $1,800 million retail and $600 million wholesale (Shotts and Gratzek 1984). During the first half of 1992, ornamental fishes imported into the United States for the aquarium trade, including cultured and wild-caught fishes, was valued at $21.4 million (Harvey 1992). During this period, the United States had a trade deficit in ornamental fishes of $13.3 million. More than 70% of the imported ornamental fishes were imported from southeastern Asia (Singapore, Thailand, Indonesia, Hong Kong, and the Philippines). In the Western Hemisphere, imported, mostly wild-caught ornamental fishes were mainly from Colombia, Brazil, Costa Rica, and Trinidad. From January to June 1992, United States exports of ornamental fishes totaled $8.1 million, 26% more than in 1991. Exports from the domestic tropical fish market are shipped to Canada, Japan, and the European market, mostly to the United Kingdom and France (Harvey 1992).

National Trade of Nonindigenous Fishes

Dispersal of living organisms into the aquatic ecosystems of this country is discussed by Rosenfield and Mann (1992). The largest number of imported nonindigenous fishes is for the tropical aquarium industry. The early history of the aquarium hobby in America is presented by Klee (1966, 1967, and 1969 a, b,c,). One of the first efforts to estimate the number of imported exotic aquarium fishes was accomplished by examining the official importation records of October 1971 (Ramsey 1985). In that month, eight million live aquarium fishes from 35 countries were imported and included members of at least 581 species in 100 families. Freshwater fishes were 63% of the species and 99.4% of the total numbers. Freshwater fishes were imported from 25 countries: 63.2% from Asia, 36.7% from South America, and less than 1% from Africa and Europe combined. Exploitation of wild populations is the predominant source in South America, whereas in the Philippines the major source is wild-caught saltwater reef fishes.

The occurrence and distribution of exotic fishes in the open waters of the United States were traced by Robins et al. (1980) and Courtenay et al. (1984, 1986, 1991). In 1980, Lee et al. (1980) found that in addition to the 790 native fishes that inhabit freshwaters of Canada and the United States, 32 exotic fish species had been released and were believed to have become established in the waters of North America. The range distributions of all species were presented. Since 1978, the National Fisheries Research Center of the U.S. Fish and Wildlife Service in Gainesville, Florida, has been monitoring the status, distribution, and potential effects of all known exotic fish species in the open waters of the United States (Williams and Jennings 1991). To date, 126 species of exotic fishes have been taken from the open continental waters of the United States, and 46 of them are established. The National Fisheries Research Center, now under the National Biological Survey, developed a computer database with information on all exotic fish species taken from waters of the United States. More than 10,000 entries are in the database; 46 exotic fish species are established in the waters of the United States, and another 80 reported but unestablished species were identified (Table 7). In addition, Courtenay and Taylor (1984) identified 168 species of native fishes in the United States that were transplanted beyond their original ranges into other parts of the country, nine of them into Florida. Courtenay (1993) provided a recent review of the biological pollution from the movement of exotic species, their effects, pathways, and possible future controls. Courtenay and Stauffer (1990) pointed out that of the 46 exotic fish species, at least 28 and possibly as many as 30 are popular in the aquarium trade and hobby. Most of these tropical fish species are not well suited to the ecosystems into which they were introduced; therefore, many have only established localized populations. Many have made little, if any, known changes in the receiving ecosystem. Others that were introduced into already stressed or altered ecosystems found favorable conditions, and their populations exploded and are causing clear, immediate changes, especially in the southwestern United States. In Florida, only few of the species have had any significant impacts. Frequently, impacts from introductions are confounded by other changes in the environment and cannot be accurately determined. Sheldon and Smitherman (1984), Courtenay and Stauffer (1990), Courtenay and Williams (1992), and Davidson et al. (1992) discussed the introduction of exotic species for aquaculture, and Kushlan (1986, 1987) discussed the environmental changes exotic fishes made in the Florida everglades.

Annual sales of aquarium fishes in the United States range from 75 to 350 million fishes, averaging 20 fishes in each of 16.3 million households. This approximates about 326 million aquarium fishes valued at between $115 and $344 million in the United States. Axelrod (1971) estimated that 20 million aquaria are in homes, 6,000 in pet stores, and 1,000 in variety stores selling aquarium fishes and supplies and that more than 450 manufacturers and importers of aquarium supplies are in the United States. He stated that the three largest suppliers had annual retail sales of more than $350 million. In addition to sales of the fishes are sales of aquaria, air pumps, filters, foods, medications, and other supplies and profits from fish culture, breeding, holding, and shipping facilities (Courtenay and Stauffer 1990).

Potential Effects of Nonindigenous Fishes

Welcomme (1988) listed potential adverse impacts from unwise introductions: degradation or disruption of the receiving environment, predation, overcrowding and stunting, genetic degradation, introductions of disease, and socio-economic effects. Potential consequences from introduced nonindigenous fish species in the United States were summarized by Taylor et al. (1984) and include: (1) habitat alterations from removal of vegetation by consumption, uprooting, or increased turbidity; degradation of water quality-siltation, substrate erosion, and eutrophication; (2) introduction of parasites and diseases; (3) trophic alterations from forage supplementation, competition for food, and predation; (4) hybridization; and (5) spatial alteration from aggressive effects and overcrowding. Stroud (1969) summarized an invitational, multiagency conference in Washington D.C. in February 1969 that dealt with exotic fish introductions and the related problems.

Except for a few species in isolated bodies of water (such as peacock cichlids (*Cichla ocellaris*), grass carp (*Ctenopharyngodon idella*), and blue tilapia (*Tilapia aurea*), little research has been conducted in Florida to measure the beneficial or detrimental consequences from the introductions of nonindigenous fishes on native flora or fauna.

Tropical Fish Industry in Florida

Florida has a subtropical to temperate climate, an abundance of groundwater near the surface, mild winters with only sporadic freezes, and mild spring and fall temperatures and thereby permits the production of several crops of fishes per year. The establishment of a large tropical aquarium-fish and plant-culture industry in Florida was primarily due to the climate, water temperatures, and availability of less expensive land, especially where the groundwater is close to the surface or in the floodplain of open waters. These facilitate construction of small, shallow production ponds. Availability of good air freight facilities at the international airports in Tampa and Miami, in part, determines the location of the two industries in Florida. Closeness of production ponds to the floodplains of the numerous rivers and streams throughout Florida significantly increases the chances that heavy precipitation, which is frequent in Florida, causes floods and, by mixing fish-production waters with surface waters, allows the escape of cultured fishes and contamination of the production ponds with wild fishes.

Aquaculture in Florida consists of two main entities, usually conducted in separate facilities: the culture of fishes for aquarium use and an industry for raising nonindigenous fishes for human consumption. The tropical aquarium-fish industry of Florida was described by Meryman (1978), Belleville (1981), and Fishman (1982 a,b). Ramsey (1985) reviewed most of the literature prior to 1970 on the early development of the aquarium hobby in the United States. Aquarium fish and plant farming in Florida, as we know it today, was initiated in 1930 by Albert Greenberg in a business he called Everglades Aquatic Nurseries (Ross B. Socolof, Past President, Florida Tropical Fish Farmers Association, Bredenton, Florida, personal communication). The first fishes he raised in his hand-dug ponds were four varieties of platies (*Xiphophorus* spp.), swordtails (*Xiphophorus* spp.), paradise fishes (*Macropodus opercularis*), rosy barbs (*Puntius conchonius*), black mollies (*Poecilia* spp.), Sphenops mollies (*Poecilia* spp.) and guppies (*Poecilia reticulata*). Aquatic plants were taken from the wild. He also cultured Cryptocoryne (*Cryplocoryne* sp.), Amazon sword plants (*Echinodorus paniculatus*), and the rare Madagascar lace plant (*Aponogeton fenestralis*).

Because of the importance of marketing and profit margin, many fish farmers benefit a great deal by manipulating the market. Almost half of them are also shippers who buy heavily from other farmers to keep their product line diversified. From pond to retail buyer, the price of the fish is usually increased by 400%. Marine fishes, which are usually trapped wild or imported, are a relatively small part of the tropical-fish industry of Florida (Belleville 1981). Presently, the farming of marine tropical fishes in Florida is restricted to two or three growers that produce two or three species. Shireman and Lindberg (1985) stated that marine species are in high demand, but the lack of technology and biological information impede production. They estimated that the sale of marine species in the U.S. market accounts for 10% of the total market and for 20% of the value. Nevertheless, imported freshwater tropical fishes sold in the United States play a large competitive role. A market survey, reported by Ford (1981), showed that 60-70% of ornamental fishes imported into United States came from Southeast Asia, 25% from South America, and the remaining 5-10% from domestic productions. Florida tropical-fish producers supplied an estimated 80% of the domestic aquarium fish needs of this country (Boozer 1973, Anonymous 1979). The size and importance of the ornamental aquarium fish industry in Florida is not widely known. Aquarium fishes and their transportation water comprise the largest percentage by weight of air freight into and out of Tampa-St. Petersburg and the second largest into and out of Miami. The industry provides a livelihood for thousands of people in Florida and in other states. In 1991, the Florida Agricultural Statistics Service (Florida Agricultural Statistics Service 1992) reported that 396 of the 448 aquaculture producers in Florida reported a total sale of $58 million in aquaculture products. One hundred ninety-three growers of tropical fishes accounted for $32.8 million or approximately 60% of the total 1991 aquaculture sales. Additionally, 79 growers of aquatic plants netted $9.9 million in sales. Producers used 5.02 million m^2 of water-surface. Fishes harvested from the wild are not included in the statistics (Florida Agricultural Statistics Service 1988). In 1987 growers sold another $6.9 million tropical fishes that they imported for immediate sale (Florida Agricultural Statistical Services 1988). Adams (1986) and Prochaska and Adams (1985) outlined the general economic considerations that should be evaluated by anyone interested in entering aquaculture in Florida. They describe the possible gains and losses. In southern Florida, high water temperatures and oxygen deficiencies in summer are major reasons for loss of production of cultured fishes (Shireman and Linberg 1985). In some years, as in 1989 and in 1991, cold weather is the major factor of the loss of tropical aquarium fishes and aquatic plants. In those years, more than half of the fish loss was due to cold weather.

Some of the more prominent freshwater tropical fish species raised today in Florida include guppies (*Poecilia reticulata*), mollies (*Poecilia* spp.), swordtails (*Xiphophorus* spp.), variatus(*Xiphophorus variatus*), platies (*Xiphophorus* spp.), tetras (Family Characinae), gouramies (*Trichogaster* spp.), goldfishes (*Carassius auratus*), cichlids (*Cichlidae*), barbs (*Barbus* spp.), tropical catfishes (Family Bagridae), and many others (Axelrod and Schultz 1955). The tropical fish and plant industry is expanding in Florida; nine new growers of tropical fishes and eight new growers of tropical plants were expected to enter the industry in 1992 (Florida Agricultural Statistics Service 1992).

In 1971, a group of 130 tropical-fish farmers in Florida banded together and formed the Florida Tropical Fish Farmers Association, Inc. The purpose of the association was to represent the fish farmers when the industry felt threatened by state or federal regulatory agencies, to provide public relations for the industry, to organize symposia and workshops, and to establish a cooperative store (Boozer 1973). In 1993, the association reported 192 members (David Boozer, Executive Director, Florida Tropical Fish Farmers Association, personal communication). Approximately 118 of the members are located within 60 miles of Tampa and 26 within 60 miles of Miami. Tropical aquarium-fish production is concentrated in Hillsborough and Polk counties, and a smaller concentration of fish farms is in Dade and Palm Beach counties. Fish farms in Dade and Palm Beach counties usually raise higher-priced tropical fish species or grow imported fishes to commercial size (David Boozer, Executive Director, Florida Tropical Fish Farmers Association, personal communication). Fish farms in Hillsbough County are usually larger in size and usually concentrate on raising large numbers of the lower priced fishes.

Historically, major reasons for the escape or release of tropical fishes from production facilities were due to the flooding of ponds in high water, pumping of pond water with an excess of unharvested fishes into surrounding streams during cleaning of production ponds or tanks, and the movement of fishes by predatory birds. The release of water with fishes is now forbidden by state regulations. Of the 46 exotic fish species now established in the United States (Courtenay et al. 1991), 31 are believed to have escaped or to have been released from aquarium or aquaculture facilities. The spread of tropical fishes in Florida and especially in the other parts of the country is partly due to releases by aquarium hobbyists.

Shireman and Lindberg (1985) also discussed the current status and prospects for the future development of Florida aquaculture. The aquaculture industry in Florida includes the culture of many nonindigenous species such as aquarium fishes, tilapia, chinese carps (grass, bighead [*Hypophthalmichthys nobilis*] and silver carp [*Hypophthalmichthys molitrix*]), saltwater shrimp (*Penalus* spp.), and aquatic plants. They also briefly discuss the five federal and state agencies that regulate the industry with 30 statutes or rules. Shafland (1986) presented a review of efforts to regulate, assess, and manage exotic fish species and the aquarium aquaculture industry in Florida. Rosenthal (1985) discussed constraints and perspectives of aquaculture development in the United States. Management, philosophy, strategy, and current regulations of the Florida Game and Fresh Water Fish Commission for freshwater fishes are summarized by Shafland (1991). Federal activities, authorities, and regulations about importation, possession, sale, and transport of exotic species were summarized by Stanley et al. (1991) and Peoples et al. (1992).

The tilapias sold in Florida for human consumption are raised in fish farms or netted from the open waters of the state. Tilapia production in Florida fish farms is primarily the red hybrid tilapia--a blue (*Tilapia aurea*) and Mozambique (*Tilapia mossambica*) tilapia hybrid. Blue tilapia make up the largest volume of the wild-caught fishes sold for human consumption, however, some blackchin tilapia are netted along the east and west coasts of Florida as an incidental species and are sold in local markets.

Another nonindigenous aquaculture product in Florida is the grass carp, which is sold as a weed-control agent. Without a permit, possession of fertile, diploid grass carp is illegal in Florida to prevent escape and reproduction in the wild. At present, only triploid grass carp, which are sterile, are allowed for weed control (Clayton and Shireman 1987). Anyone permitted by the state to use grass carp for weed control may purchase triploid fishes from out-of-state producers or from one of four Florida producers in Center Hill, Dunnellon, Micanopy, or Waldo. All grass carp for weed control must be checked for triploidy before they can be officially released.

Courtenay and Williams (1992) and Shelton and Smitherman (1984) discussed releases or escapes of nonindigenous fishes from aquaculture facilities. Historically, tropical fish farmers released some species of aquarium fishes, mainly those that grow to larger sizes, into open water to establish an adult population that could later be harvested from the wild for sale. These wild fishes are usually larger than those grown on fish farms, considered a specialty item, and demand higher prices.

Fish cultures are usually where habitats have optimal growing conditions and where concomitantly escaped individuals survive in the surrounding open waters. The construction and operation of a facility have been impossible without occasional escapes or releases and convinced most professional aquaculturist and fishery biologist that the culture of any species where it is not native eventually results in its introduction and survival (Shelton and Smitherman 1984, McCann 1993). Early culturists and managers did not anticipate the dangers to the native populations from the release of nonindigenous species and failed to take adequate measures to contain the species. Increased awareness by tropical fish and plant culturists and fishery managers to potential problems from releasing nonindigenous species increased efforts to prevent new introductions. Hocutt (1984) discussed ethics about the introduction of exotic fish species. Methods to reduce all unwanted introductions are presently being evaluated. Possible mechanisms to reduce or stop new introductions are being evaluated and developed (U.S. Congress 1993; U.S. Interagency Task Force 1992; Shafland 1986; Courtenay and Taylor 1986). Protocols to reduce the escape of nonindigenous fishes from research facilities have also been developed (Jennings and McCann 1991; McCann 1993).

Established Nonindigenous Fish Species in Florida

The presence of exotic fishes in Florida waters has been recorded by Burgess (1958), Crittenden (1962), Springer and Finucane (1963), Rivas (1965), Ware (1966), King (1968), Buntz and Manooch (1969a,b), Buckow (1969), Idyll (1969), Ogilvie (1966a,b), Buntz and Chapman (1971), Lachner et al. (1970), Courtenay and Ogilvie (1971), Courtenay and Robins (1973), and Courtenay et al. (1974), Hogg (1974, 1976a,b), Courtenay et al. (1974), Courtenay (1980), Shafland (1976, 1979), Dial and Wainright (1983), Courtenay, Jennings and Williams (1991) and Courtenay (1993). Prior to 1970, no organized attempt was made in Florida to identify or determine the statewide status or distribution of nonindigenous fish species. The first comprehensive study was conducted during July 1970-July 1974 (Courtenay et al. 1974). Thirty-eight species and several hybrids of exotic species were found in Florida waters. The date, place, and pathway of introduction were provided if known. A follow-up survey, conducted by Courtenay and funded by the National Fisheries Research Laboratory, Gainesville, Florida, was initiated in January 1978 (Courtenay 1980).

Most information on the status, distribution, history, and pathway of introduction of exotic fishes in Florida presented below was taken from Courtenay et al. (1974, 1984, 1986) and Courtenay and Stauffer (1990). Identification of presently established exotic species in Florida was taken from Courtenay et al. (1991). Species are presented in phyletic sequence of fish families. The presence of exotic species in Florida is monitored and tracked by a form-and-reporting system that the Non-Native Fish Research Laboratory, Florida Game and Freshwater Fish Commission's Laboratory in Boca Raton, Florida, developed. All agency personnel are asked to fill out the form and submit it to the laboratory as soon as possible (Courtenay and Hensley 1980). The data are maintained in the commission and are not available outside the agency. On a nationwide basis the National Fisheries Research Center in Gainesville, Florida, tracks the distributions and statuses of nonindigenous fish species released into the nation's open waters (Jennings and Williams 1992). This information is computerized and can be obtained by contacting the Federal Laboratory. The rate of introduction has slackened during 1984-94 because of increased awareness of the problems from introductions and subsequent increased regulations. Courtenay (1993) listed only two unintentional introductions and establishment of nonindigenous species, the Mayan (*Cichlasoma urophthalmus*) and the Midas (*Cichlasoma citrinellum*) cichlids, into Florida since the early 1980's. Only one of the releases was believed to have escaped from a fish farm, whereas the other was probably released by an aquarist. The large number of reported exotic species that were introduced into Florida during 1950-1980 probably reflected more the effort to find introduced species rather than the actual dates of releases.

When tropical species are found in the wild, determination of the sources of the introductions are sometimes difficult. We tried to identify the most probable pathways of introductions. Courtenay and Meffe (1989) discussed introductions of livebearers in the United States. In general, if the species is sold by the tropical-fish industry and is established in an area of fish farming, the fishes are assumed to have escaped or to have been released from a fish farm; however, they may have been released by tropical fish hobbyists. Isolated populations at a distance from fish farms are considered releases by hobbyists (aquarium dumps) unless other evidence exists. Courtenay and Stauffer (1990) and Courtenay and

Williams (1992) discussed the relation between the tropical fish industry and releases of tropical aquarium and aquaculture fishes. Courtenay (1989) reviewed the statuses, distributions, and pathways of exotic fishes and their effects on the national park system.

Common and scientific names of fishes in this report follow the Committee on Names of Fishes, American Fisheries Society (Robins et al. 1991a). Names of nonindigenous fish species in Florida not in that publication follow the common and scientific names in Courtenay et al. (1991) and Robins et al. (1991b).

Cyprinidae - Carps and Minnows

Goldfish (*Carassius auratus*). The goldfish is native to the People's Republic of China, Taiwan, southern Manchuria, Korea, Japan, Hainan, and the Lena River of eastern Europe to the Amur Basin and the Tym and Poronai rivers of Sakhalin (Berg 1949a). This was the first known introduced exotic fish species in North America (Courtenay and Hensley 1980). DeKay (1842) recorded the first releases as having been in the late 1600s (Sutton and Vandiver 1985). This fish has now been collected in the wild in every state except in Alaska.

Although specimens are collected periodically, self-sustaining populations seem to be lacking in Florida. Releases seem to have been made by aquarists, ornamental-pondfish hobbyists, and anglers (as excess bait). Escaped individuals are from culture facilities, including state and federal hatcheries where the goldfish is used as forage for game fishes. Lack of cold winter temperatures in Florida may interfere with gonad maturation, preventing natural reproduction.

Grass Carp (*Ctenopharyngodon idella*). The grass carp, also called white amur, is native to the middle and lower Amur River (as far north as Blagoveshchensk, East Russia, Asia, the Sungari and Ussuri rivers and Lake Khanka, in eastward flowing rivers of the People's Republic of China south to Guangzhou, Kwangtung Province [Berg 1949a]). This species is established in the lower Mississippi River near Eudora, Chicot County, Arkansas; near Simmesport, Avoyelles Parish, Louisiana; near St. Francisville, West Feliciana Parish, Louisiana (Conner et al. 1980); and in the Trinity River, Texas (Robert Howell,Fish Biologist, Department of Texas Parks and Wildlife, Austin, Texas, personal communication). As of 1977, specimens of grass carp have been collected in the wild in Alabama, Arkansas, Florida, Georgia, Maryland, Michigan, Missouri and New York. Unconfirmed reports indicate the presence of this fish in the Mississippi River in Wisconsin and Minnesota and in the Missouri River in Kansas and Nebraska as far upstream as Gavins Point Dam near Yankton, South Dakota (Courtenay et al. 1986).

Introduction of the grass carp into the United States as an aquatic-plant control agent was first recommended by Swingle (1957). The grass carp was first imported by the U.S. Fish and Wildlife Service Fish Farming Experimental Station (Stuttgart, Arkansas) from Malaysia and by the Auburn University (Auburn, Alabama) from Taiwan in 1963 (Guillory and Gasaway 1978). It was subsequently distributed to research agencies or companies in 11 states (Provine 1975). As predicted by Stanley et al. (1978), grass carp became established in the lower Mississippi River (Connor et al. 1980). The age of the adults taken from the Mississippi River indicated that they were from the 1966 age-class (Guillory and Gasaway 1978), meaning the adults were hatched only 3 years after the species was introduced into this country. The grass carp is becoming a major species in the lower Mississippi River basin.

Guillory and Gasaway (1978) summarized the distribution and the history of the grass carp in the United States as of 1976. The species was first brought into Florida as a weed control agent in the early 1960s (Sutton and Vandiver 1986). Disagreement on whether environmental conditions in Florida allow the species to reproduce has been considerable. Now, reproduction is unlikely because the transport of fertile, diploid grass carp into Florida without a permit from the Florida Game and Freshwater Fish Commission is illegal. Adult grass carp have been taken from the open waters of Florida and are probably fishes that escaped from efforts to control nuisance aquatic weeds rather than the result of natural reproduction.

Several biological synopses have been completed on the grass carp (Shireman and Smith 1983; Smith and Shireman 1981). A review of the literature does not provide any evidence that the species can reproduce in standing bodies of water; in fact, reproducing populations have been found only in large river systems. After reviewing locations and spawning conditions in the grass carp's native range and where it had been introduced and became established, Stanley (1976) concluded that grass carp would become established in the Mississippi River in 1978 or 1979. Requirements for natural spawning of grass carp, such as suitable water temperature, water level, spawning site, water velocity, length of river, and water quality were discussed by Stanley et al. (1978). Fish egg and larvae samples from the Mississippi River in 1975 contained grass carp specimens and revealed spawning in the lower river (Conner et al. 1980). Zimpfer et al. (1987) obtained close correlations when they compared spawning conditions in the Mississippi River when grass carp eggs and larvae were found there with the conditions in other major rivers in the world where the species is established. These researchers also emphasized the location of suitable feeding areas at correct distances downstream from spawning grounds to provide necessary nursery grounds. By 1983, grass carp were 23% of the ichthyoplankton catch and were second only to the freshwater drum (*Aplodinotus grunniens*) in total abundance (Zimpfer et al. 1987). Although the species is now well established in the Mississippi River and entering the commercial catch, no harm has yet been attributed to the introduction of this species.

Introductions of nonindigenous parasites with the grass carp into the United States and Florida were discussed by Riley (1978). Although he found no evidence that exotic parasites had been introduced with grass carp into Florida, he found that grass carp had become infected with a native parasite that previously had never been reported. He found that no examination of grass carp had been made before they were introduced into Florida and recommended that this species should be quarantined and inspected for parasites and diseases before it is imported into Florida. The introduction of grass carp was responsible for the introduction and spread of a fish tapeworm (*Bothriocephalus opsarichthydis*) to other cyprinid fishes in the United States (Hoffman and Schubert 1984).

The rationale for importation and introduction of this fish was for its use as a biological control agent of aquatic weeds, many of which are exotic species. The concern about using the grass carp for the control of aquatic vegetation is centered around whether the species could reproduce in the wild, overpopulate, and remove all vegetation. Research at the Fish Farming Experimental Station at Stuttgart, Arkansas, to develop year classes of pure female grass carp that could be considered sterile if no adult male grass carp are in the water.

Use of monosex populations, usually all females, was short-lived because the fishes were fertile and the identification of sex was difficult when the fishes were young, facilitating the accidental introduction of males and reproduction. Early attempts to develop a sterile grass carp concentrated on the development of a hybrid between male bighead carp and female grass carp (Allen and Wattendorf 1987). Studies revealed the hybrid fry had lower survival and slower growth rates and consumed less vegetation (Shireman et al. 1980 and 1983), and its habit of schooling near the surface made it vulnerable to predation by birds. As a result, the hybrid was dropped from further consideration as a control agent. In the early 1970's, methods were developed to produce pure (unhybridized) grass carp triploids (Purdom 1983). Application of this procedure was simple after the technique was developed. The fertilized egg has to be shocked by either extreme cold or pressure changes to inhibit the second maturation division of meiosis of the fertilized egg and cause retention of an extra set of chromosomes (Allen and Wattendorf 1978). Correct application of the technique produces almost 100% triploids. Verification of triploidy is easy with a Coulter Counter (Wattendorf 1986). Triploid grass carp are sterile and similar to diploids in their ability to consume nuisance vegetation. Wattendorf and Shafland (1983) studied consumption of hydrilla in Florida with triploid hybrid grass carp. Most states, including Florida, require use of verified triploid grass carp (Allen and Wattendorf 1987).

One major environmental concern has been the effect of grass carp on the ecology of lakes and waterfowl (Gasaway and Deda 1977; Gasaway et al. 1977, 1978). In January 1976, the Waterways Experimental Station, U.S. Army Corps of Engineers, initiated a study with monosex grass carp on Lake Conway near Orlando, Florida. To avoid escape of the grass carp from the lake, the corps purchased monosex grass carp from the United States Department of Interior Fish Farming Experimental Station in Stuttgart, Arkansas, and introduced them into the lake after 1 year of baseline information had been collected on the lake's water and sediment chemistry, the plankton and benthic invertebrates, fishes, waterfowl, aquatic mammals, herpetofauna, aquatic macrophytes, hydrology, and nutrient sources (Lazor 1983). The study also included a computer model to simulate the response of the lake and its organisms to introduction of the grass carp (Theriot and Decell 1978). The study on this five-pool lake system was completed after the analysis of data from the 3 post-stocking years. The stocking rate of 7-12 fishes/ha reduced the three most common aquatic plants (*Hydrilla*, *Nitella*, and *Potamogeton*) by 90%. *Vallisneria*, the fourth most abundant plant, increased slightly because of the reduced competition from other plants and because it is not a preferred food of grass carp. The abundance of small fishes that lived in the vegetation dropped, and the larger fishes such as the largemouth bass (*Micropterus salmoides*) moved into deeper water and gained weight from eating the smaller fishes that lacked cover. The angler success doubled. The two most common ducks, the ring-necked duck (*Aythya collaris*) and the American coot (*Fulica americana*), increased their intake of amphipods. Phytoplankton species were significantly fewer in all pools during the latter part of the study. The dominance of Chorophyta and Chrysophyta in summer were eliminated; Cyanophyta (blue-green) algae replaced them and remained high all year. Except in one pool, phytoplankton was significantly greater in all pools during the middle 2 years of the test. The reduction of the vegetation was followed by the reduction of periphyton. The total number of zooplankton decreased throughout the entire study, although the mean number of species per sample did not decline. Sediment and water chemistry and the populations of benthic macroinvertebrates, herpetofauna, waterfowl, and aquatic mammals seemingly were not directly affected by the introduction of the grass carp. Other factors such as state-wide reduction in waterfowl, lack of normal rainfall, falling water levels, and increased residential development masked small changes. The most pronounced environmental change was the increase in phytoplankton abundance. Independent removal of vegetation by private land owners around the lake complex also made it difficult to fully evaluate the effects of the grass carp.

A recent symposium in Florida (Shireman 1995) summarized the present status of the grass carp in Florida and its use as a weed control agent in both large and small bodies of water. Noble et al. (1986) discusses the consideration that need to be made when considering its use in large open systems.

Common Carp (*Cyprinus carpio*). The native range of the common carp encompasses the basins of the Black, Caspian, and Aral seas and possibly eastern Europe, the Volga River, the rivers flowing into the Pacific Ocean and eastern Asia from the Amur River southward to Burma (Berg 1949a). Misik (1958), Balon (1974) and others suggested that the species first appeared in Asia Minor and in the basin of the Caspian Sea and spread from there into western Europe and eastward to China (Courtenay et al. 1986).

Self-sustaining populations of common carp are in the 48 contiguous states (Allen 1980) and in the provinces of British Columbia, Manitoba, Ontario, Quebec, and Saskatchewan (Scott and Crossman 1973). In North America, the greatest population densities of this fish are in the midwestern states. A citizen is responsible for the first introduction into North America via the Hudson River in New York in 1831 (DeKay 1842). In 1872, five carp were imported from Germany and released in a pond in the Sonoma Valley, California (Moyle 1976). In May 1877, the U.S. Fish Commission imported 338 specimens from Germany and subsequently began distributing this species for culture and for introduction to applicants throughout the United States and Canada until 1896 (Laycock 1966; Scott and Crossman 1973; Baird 1879).

The common carp has been taken from many bodies of water throughout most of Florida, even as far south as Lake Okeechobee where it was probably introduced as bait by anglers. It is supposedly established in only several river systems including the Apalachicola and Ochlocknee rivers in the panhandle of Florida, and has been recorded in these systems for several years. No studies have been conducted to determine whether its introduction has had adverse impacts. Advantages and disadvantages from the introduction of the common carp into the United States are discussed in detail in a group of published papers (Cooper 1987). Efforts to control nuisance populations, particularly in the midwestern United States, have cost millions of dollars. In some national wildlife refuges, the harmful effects by common carp on rooted vegetation have been the most serious environmental problem.

The greatest harm by the common carp in some areas of the country is from its habit of uprooting aquatic vegetation and muddying the water, which covers the nests of spawning fishes, and increasing turbidity. This reduces light penetration for a healthy aquatic plant population (Taylor et al. 1984).

In some midwestern states such as Iowa, carp are taken from state waters by large nets and sold in fish markets in New York and in southeastern Florida. Interest in raising this species in aquaculture facilities to supplement the wild commercial catch is also rising, and efforts have been made to promote it as a game species. This species is still considered an undesirable introduction by most environmentally oriented professionals.

Silver Carp (*Hypophthalmichthys molitrix*). Silver carp were first imported into the United States in 1972 under an agreement of maintenance with the Arkansas Game and Fish Commission (Shelton and Smitherman 1984). Shelton and Smitherman (1984) summarized the early work on this species in the United States. The silver carp was imported as a potential food fish and for its ability to filter phytoplankton. It has also been used as a biological control agent to reduce phytoplankton populations in tertiary-water treatment systems. Courtenay and Williams (1992) reported that in the early 1970's, this species was taken from open waters in Arkansas where it apparently had been released from an aquaculture facility. They stated that the silver and the bighead carp are seriously considered for aquaculture in several states. Although the silver carp is presently cultured in Florida, releases or establishments in the state have not been recorded. Like the grass carp, this species is not expected to establish itself in Florida.

Bighead Carp (*Hypophthalmichthys nobilis*). The bighead carp was first imported into the United States in 1972 (Cremer and Smitherman 1980) because of its potential as a food fish. Shelton and Smitherman (1984) summarized the early research into this species in the United States. The bighead carp feeds primarily on zooplankton and has been considered as an agent for tertiary-water treatment systems. It is presently cultured in Florida but is not considered established. A biological synopsis on this species was recently completed (Jennings 1988). Like the grass carp, it is not expected to become established in Florida however where its use may be beneficial, sterile bighead carp may be a better choice.

Cobitidae - Loaches

Oriental Weatherfish (*Misgurnus anguillicaudatus*). The native range of this popular aquarium fish is eastern Asia, including the Tugur and Amur river basins; the Tym and Poronai rivers of Sakhalin; the Sedanka River near Vladivostok, U.S.S.R.; the Tumen'-Ula River in North Korea; Hokkaido and Kyushu in Japan; Taiwan (where it was probably introduced); the People's Republic of China from the Liao River south to Guangzhou, Kwangtung Province, and inland to Yunnan Province, Hainan; the headwaters of the Irrawaddy River in Burma; and the Tomkin and Annam provinces of North Viet Nam (Berg 1949a). In North America, this fish is established in several flood-control channels in Huntington Beach and Westminster, Orange County, California (St. Amant and Hoover 1969; (Courtenay et al. 1984), and in the headwaters of the Shiawassee River, Oakland County, Michigan, since the 1930's (Schultz 1960; Coortenay et al. 1984). Imported as an aquarium-fish since at least the late 1930's, the weatherfish is believed to have escaped from an aquarium-fish culture facility in Westminster, California (St. Amant and Hoover 1969).

This species was recently captured by personnel of the National Fisheries Research Center - Gainesville in several tributaries to Tampa Bay in Hillsborough County, Florida. The presence of several size classes in these streams indicates that the species is probably established. The weatherfish probably escaped from tropical-fish farms in the area. Although it may expand its distribution in these streams, the weatherfish's dispersal beyond these streams without additional introductions is doubtful.

Characidae - Characins

Pirambeba (*Serrasalmus humeralis*, probably *S. rhombeus*). The genus *Serrasalmus* is native to the Rio Orinoco, Rio San Francisco, Rio de la Plata Systems, and the Amazon River in South America (Myers 1972). Importation of any piranha species into Florida is prohibited because of strong concerns that the species could become established in Florida waters (Paul Shafland, Director, Non-native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, Boca Raton, Florida, personal communication). Myers (1972) edited a monograph on piranhas and discussed relative dangers of the different species of piranha and their relatives. Popularity of this species peaked in 1960 and 1961 and has since declined. Piranha are now on the Prohibited Species List in Florida. Mixed with similar looking species such as the silver dollars (*Metynnis hypsauchen*) or pacu (*Myleus pacu*), piranha are still found in shipments into Florida. Although Moe (1964) admitted that not enough was known about the basic biology and life histories of piranhas in their native ranges in South America, he predicted establishment of potential piranhas in Florida if introduced. The temperature range of the pirambeba's native range is similar to temperatures in southern Florida--between 20.0° C and 27.0° C (Moe 1964). His predictions about the piranha's survival in Florida were correct.

In 1977, an established population of *Serrasalmus humeralis* was found in a display pool--a small confined sinkhole in Monkey Jungle, an amusement park south of Miami--in Florida. The pool was seemingly stocked with them in 1963 or 1964. The pool received water from a small, well-fed stream. In September 1977, personnel of the Florida Game and Fresh Water Fish Commission discovered the fishes and treated the pool with 5% emulsified rotenone. They removed 53 piranha, consisting of three year classes (Shafland and Foote 1979) and verifying that some species of piranha could survive and reproduce in Florida if introduced. Moe (1964) discussed the spawning of this species in captivity in the United States. He found that water conditions, including water temperatures, were suitable for establishment of piranhas in Florida, especially for piranhas from the southern part of their range. Temperature-tolerance tests revealed the lower lethal water temperature was 11° C (Shafland and Foote 1979) and the possible survival of this species in most of Florida. The Florida Game and Fresh Water Fish Commission is concerned about introductions of piranhas into Florida and is engaged in preventing them from entering Florida. Single specimens of a dangerous species, the red piranha (*Pygocentrus nattereri*; formerly called the red bellied piranha) continue to be taken from the waters of Florida but without evidence of establishment. Red piranhas in waters of Florida are probably released pets who had grown too large for their owners' aquariums or individuals that were released when their owners moved to Florida and discovered that keeping the species is illegal. Although the normal diet of pirambeba includes shrimp, fish, and sometimes other animals, and small amounts of vegetation, they have been known to attack humans and terrestrial animals (Braga 1954).

Clariidae - Labyrinth Catfishes

Walking Catfish (*Clarias batrachus*). The walking catfish is in fresh and brackish waters of Sri Lanka, eastern India, Bangladesh, Burma, and the Malay Archipelago (Mookerjee and Mazumdar 1950; Sterba 1966). It is established in Brevard, Broward, Charlotte, Collier, Dade, DeSoto, Glades, Hendry, Highlands, Hillsborough, Indian River, Lee, Manatee, Martin, Monroe, Okeechobee, Palm Beach, Polk, Sarasota, and St. Lucie counties in Florida (Courtenay 1978, 1979a); it is possibly established in Orange and Osceola counties (Courtenay et al. 1984). Although it has been taken in other states (California, Nevada, and Massachusetts) there is no evidence of establishment outside of Florida.

Albino juvenile walking catfishes were imported from Bangkok, Thailand, in the early 1960's for sale in the aquarium-fish trade. In the mid-1960's, adults--subsequently imported as brood stock--either escaped from culture facilities such as a large fish farm west of Deerfield Beach, in what is now the city of Parkland, Broward County (Courtenay et al. 1974) or from a truck transporting brood fishes between Miami and Parkland in Broward County, Florida (Courtenay 1979 b) in the mid-1960's. Releases in the Tampa Bay area, Hillsborough County, in about 1968 resulted in the establishment of at least one population (Courtenay et al. 1974; Courtenay and Miley 1975). In 1968, this exotic fish was confined to three Florida counties; by 1978 it had spread to 20 counties in the southern half of peninsular Florida--a profound feat for a fish (Courtenay 1978, 1979b). The species is capable of overland migrations that normally take place at night or during periods of rain. Reasons for these migrations have not been determined. During a fish kill of unknown origin in early 1976 near the Big Cypress Swamp, Collier County, almost 90% of the kill consisted of walking catfishes. This indicated that the fish is able under the right conditions to become a dominant species. As many as 3,703 kg/ha of walking catfish have been seined from some small natural ponds in Florida (Lachner et al. 1970). Abundances of that magnitude must affect the native species. No studies, however, have been conducted to measure the ecological or economic impacts of this species.

Shortly after the walking catfish became established, some tropical-fish farmers sustained losses when the walking catfish entered their ponds and destroyed their crops. The farmers' solution to the problem was to build 46-cm wire fences to keep the walking catfish out. These precautions were not effective when the ponds flooded. State extension agents now recommend that the fish farmers increase the height of the dirt berms around the ponds above the high-water elevation (Craig Watson, Aquaculture Extension Agent, University of Florida, personal communication). This construction has almost stopped all walking catfish predation on cultured fishes and reduced the loss of valuable tropical fishes from the walking catfish and flooding.

Environmentalists' concerns about the walking catfish in Florida depends on the area of Florida. In the southern part of the state where the fish has been present for many years, fishery personnel of the Florida Game and Fresh Water Fish Commission have little concern and, in fact, believe populations have declined greatly. However, the species has been reported as still extremely abundant in the Shark Valley and in the Anhinga Tracts of the Everglades National Park and is of local concern (C.R. Robins , Professor of Fisheries, University of Miami personal communication). In northern areas of the state where the finding of the species is still a novelty and where it is reported often, managers are concerned about its effect, but no studies of its effects in Florida have been initiated.

Studies of temperature tolerance in this species (Shafland and Pestrak 1982) indicated that cold water temperatures in winter do not limit the species from spreading much farther north than its present distribution near Orlando. Its habit of burrowing in mud during short periods of cold and its ability to survive in warm springs also allow it to survive in at least small numbers farther north than expected. This and all other clariid catfishes are on the

Federal Injurious Species List (50 CFR Part 16) and therefore cannot be imported into this country without a federal permit.

Food-habit studies of this species indicate that its diet in southern Florida consists of 35% aquatic insects (*Haliplus* sp., dytiscid beetles, mayflies, dragonflies, other beetles), 18% fishes (*Fundulus*, *Gambusia*, and *Lepomis*), and 10% plant material (Courtenay et al. 1974). Waldners (1974) studies revealed similar food habits. In addition to benthic organisms, Ostracoda, Tendipedidea, Hyalella, and Brachyura, he found large amounts of detritus in the stomachs of walking catfishes. He concluded that the walking catfish is an opportunistic feeder and could compete with native fishes if the food supply was limited. Walking catfishes are sometimes found in the intracoastal waterway in salinities of 18 ppt. Success of this species has been attributed to its ability to survive in poorer water quality than most species of native fishes and its guarding of its young into even the free-swimming stages (Taylor et al. 1984).

Loricariidae - Suckermouth Catfishes

Suckermouth Catfishes (*Hypostomus* spp.). Most early records of the suckermouth in this country were of *Hypostomus plecostomus* (Linnaeus 1766); however, accurate identification of the species depends on knowing the origin of the species, which is usually unknown. Most specimens were probably of the genus *Pterygoplichthys* (*Liposarcus*). The native range of *Hypostomus* is from the Rio de la Plata system northward throughout South America (except the Pacific Slope drainages in Chile and Peru), Panama and Costa Rica (Fowler 1954; Bussing 1966). At least three morphologically distinct but unidentified species of *Hypostomus* were established in the United States. One is in Six Mile Creek near Eureka Springs, Hillsborough County, Florida (Courtenay et al. 1974). The Hillsborough County population allegedly escaped from a culture facility (Burgess 1958). The suckermouth catfishes are popular aquarium fishes. There have been no recent reports that this species has been taken in Florida. We believe that this species is probably not established in Florida, however, additional sampling for the species are necessary before we could be certain.

Sailfin Catfish or Radiated Ptero (*Pterygoplichthys* [*Liposarcus*] *multiradiatus*). This genus is native to the Rio Magdalena, Colombia Guyana; throughout the Orinoco River, Amazon River, and Rio San Francisco, Brazil; upper Amazon tributaries in Bolivia, Peru, and Venezuela; Rio de la Plata, Paraguay and Argentina (Gosline 1945; Fowler 1954; Isbrücker 1980; Courtenay et al. 1984, 1986). The identification of the members of this family is confusing even to the experts (Burgess 1958; Barnett 1972; Courtenay and Hensley 1979a; Ludlow and Walsh 1991). Single individuals of this catfish have been collected at separate locations in Dade County since 1971 (Courtenay et al. 1986). There have been no ecological or environmental studies of this species. In June 1983, biologists of the Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, found an established population of this species in a canal in northeastern Dade County, Florida (P. L. Shafland, Director, Non-native Fish Research Laboratory, Boca Raton, Florida, personal communication). The species is now established in Palm Beach County, Florida (W. R. Countenay, Professor, Florida Atlantic University, Boca Raton, Florida, personal communication). This popular tropical aquarium fish was recently taken by National Biological Survey personnel (National Fisheries Research Center - Gainesville, Florida, personal communication) in southern and west-central Florida, indicating that the species is expanding its range.

Poeciliidae - Livebearers

Pike Killifish (*Belonesox belizanus*). The native range of this species is the Atlantic Slope of Middle America from the Laguna San Julian, northwest of Ciudad Veracruz, Mexico, to Costa Rica (Caldwell et al. 1959; Miller 1966). It is established in canal systems and in saline (40 ppt) cooling canals in southeastern Dade County, Florida (Belshe 1961; Rivas 1965; Lachner et al. 1970; Courtenay and Robins 1973; Courtenay et al. 1974; Miley 1978). This species is the largest member of the live-bearing family, reaching lengths of 150 mm (Regan 1913). After termination of research, (Belshe 1961; Miley 1978) in November 1957, personnel of the Department of Medicine at the University of Miami released experimental pike killifishes into a canal along SW 87th Avenue in Dade County. The original release consisted of 50 excess fishes (Belshe 1961).

The pike killifish's preferred habitat is along the banks of slow moving streams of mangrove (*Rhizophora mangle*) and reed (*Phragmites communis*) swamps and around inlets into salty bays (Connaly 1968). Turner and Snelson (1984) found this species reproducing in salinities from 0 to 35 ppt. In experimental food-habit studies, Miley (1978) found that the pike killifish feeds on native fishes and concluded that under certain conditions (scant cover for prey refugia and low water levels) it caused drastic reductions in densities of cyprinodonttids and poecilliids, particularly the mosquitofish (*Gambusia holbrooki*). It is not only a predator on smaller species or on young-of-year of larger species but competes with them for food. The species does not reach great densities where cover is sparse and large predators are present. Its establishment is of particular concern to mosquito-control personnel if chemical control has to be used to control the mosquitoes in the future. Some fishery biologists do not believe that mosquitofishes are effective control agents of mosquitoes, except in rare situations (Courtenay and Meffe 1989). Belshe (1961), Miley (1978), and Anderson (1981, 1982) conducted food-habit studies that revealed diet overlaps between this species and native species. Turner (1981) studied the population structure and reproduction of the pike killifish in Florida.

The pike killifish has been taken from several new localities in southern Florida, indicating its range expansion in recent years (W. F. Loftus, Biologist, Everglades National Park, National Biological Survey, personal communication).

Guppy (*Poecilia reticulata*). The guppy occurs naturally in the Netherlands, in the Antilles and Venezuelan islands, on Trinidad, in the Windward (Barbados) and Leeward (St. Thomas and Antigua) islands, and from western Venezuela to Guyana (Courtenay et al. 1984). The distribution of this species in the United States is presented by Courtenay et al. (1984). The widespread nature of the distribution of this species, especially in isolated warmwater springs, was probably due to dumped aquaria.

Courtenay et al. (1974) listed this species as established in Hillsborough and Palm Beach counties, Florida. It is not considered established now. Populations from Hillsborough County are probably not self-sustaining but escapees from local tropical-fish farms. The formerly established local population in Boca Raton, Palm Beach County, was exterminated when its habitat dried in the late 1970s. The guppy has also been collected in Dade County, but it is not believed to be established in this area (R. Robins, Professor of Fisheries, University of Miami, personal communication). Although some populations are in the immediate vicinities of fish farms, most populations in Florida seem to be ephemeral.

Green Swordtail (*Xiphophorus helleri*). The native range of the green swordtail is the Atlantic Slope of Middle America from the Rio Nautla, Veracruz, Mexico, to northwestern Honduras (Rosen 1960; Rosen and Kallman 1969). This popular aquarium fish was reported from Brevard County in Florida (Dial and Wainright 1983) but was not collected there in late 1983 or in 1984. Established populations in Florida seem to have escaped from local aquarium-fish farms (Courtenay et al. 1986). This species is considered to be stenohaline, requiring low salinities. At least two populations in eastern and southern Florida have persisted for several years and seem to be established locally.

The most probable pathway of introduction of this species depends on the location. Dumped aquaria and escaped or released individuals from fish farms are probable sources.

Southern Platyfish (*Xiphophorus maculatus*). Miller (1966) described the native range of this fish as the Atlantic Slope from just south of Ciudad Veracruz, Mexico, to northern Belize. It was reported as established in canals at Satellite Beach, Brevard County, and in some roadside ditches near Ruskin and perhaps elsewhere in Hillsborough County, Florida (Courtenay et al. 1974; Dial and Wainright 1983). Although formerly abundant in the Satellite Beach Civic Center pond, it has not been collected there since 1982 (Courtenay et al. 1984). The southern platyfish at Satellite Beach, Florida, was probably from a released aquarium. Individuals near Ruskin and Delray Beach, Florida, seem to have been escapees from nearby fish farms (Courtenay et al. 1986). The species has been collected from several localities in Florida in the last few years. Some sites are near fish farms; some individuals seem to have been dumped from aquariums. Some populations are considered locally established.

Variable Platyfish (*Xiphophorus variatus*). The variable platyfish is endemic to Mexico, occurring in southern Tamaulipas, eastern San Luis Potosi, and northern Veracruz (Rosen 1960). It has been reported as established in canals and roadside ditches of the eastern shore of Tampa Bay, Hillsborough County, Florida (Courtenay and Robins 1973; Courtenay et al. 1974). The current status of several of these populations is uncertain, although the formerly established population in ditches in Gibsonton, Hillsborough County, is no longer extant. Burgess et al. (1977) and we found established populations in Gainesville, Alachua County, Florida, on the campus of the University of Florida near a student dormitory and in a small stream near the center of town. The introductions are considered the result of dumped aquaria. There are also reports that the species was at one time a popular bait for black crappie (*Pomoxis nigromaculatus*). This species was recently taken near fish farms; some individuals seem to have been released by hobbyists. This species is considered locally established.

Cichlidae - Cichlids

Oscar (*Astronotus ocellatus*). The oscar is native to the Orinoco, Amazon, and La Plata river systems of South America. This popular aquarium species first appeared in canals in Miami, Dade County, Florida, in the late 1950s after a deliberate release from an aquarium fish farm (Courtenay et al. 1974). It is now established in Broward, Dade, Glades, Hendry (probably), and Palm Beach counties. Although the original release may have been from a fish farm, the spread of this species has been aided by anglers who stocked water bodies with the species to start new populations. The oscar is a popular sport and food fish throughout southern Florida and is sought by anglers (P. Shafland, Director, Non-native Fish Research Laboratory, Boca Raton, Florida, personal communication). Food-habit studies revealed the diet overlap of this species with native species and predation by this species on native species. The bulk of the material in the stomachs of 23 oscars was of animal origin and included insects, fishes, fish scales, amphibians, and some plant material, mainly unidentified seeds (Hogg 1974).

Peacock Cichlid (*Cichla ocellaris*). This species is sometimes called the butterfly peacock and belongs to the genus *Cichla*, which contains several species that are not well described. This creates confusion among professional fishery biologists. Eigenmann and Allen (1942) lumped several species as synonyms for *Cichla ocellaris* and *C. temensis* (Ogilvie 1966). The native range of the genus includes the rivers and lakes of the Amazon regions of Brazil and Bolivia, Peru, Venezuela, and Guyana. Ogilvie (1966a,b) summarized the general life-history information and the efforts to evaluate several species of peacock cichlids for introductions into Florida. Four seemingly different species were imported into Florida from the Orinoco River in Venezuela. All of the fishes were evaluated for introduction as game. Some isolated ponds were stocked with them, but none of the fishes survived, probably because of water temperatures in winter (Paul Shafland, Director, Non-native Fish Research Laboratory, Boca Raton, Florida, personal communication). All species were strictly pisciverous and not selective about size or species of forage fish. In their native range, some species grow to a maximum size of 13.5 kg, whereas other species average 1 to 2 kg. All species were potential sport fishes.

In the 1980's, fingerlings of *Cichla ocellaris* and *C. temensis* were imported from different geographical areas in South America (Brazil, Guyana, and Peru) into Florida and cross bred within species to maximize genetic species specific variability (Shafland 1984). Additional peacock cichlids, obtained from Texas, that had originally been obtained from Florida from the earlier stock, were bred with the recent imports. Resulting young were raised in Boca Raton, Florida. Between 1984 and 1986, Dade County canals were stocked with 20,000 peacock cichlid. Spawning began at 27° C. Shafland (1984) stated that studies with control temperatures conclusively revealed the inability of the peacock cichlid to survive water temperatures less than 15° C. After comparing the temperature tolerance found in the literature (Swingle 1966; Guest et al. 1979; Guest and Lyons 1980) with the results of temperature tolerance tests that he had completed earlier for other tropical fish species (Shafland and Piestrak 1982), Shafland (1984) concluded that peacock cichlid are considerably less tolerant of low water temperatures than any other currently established tropical fishes in Florida. Shafland (1984) later stated that the peacock cichlid, because of its lower lethal temperature tolerance of 15° C, could only survive in several major drainage canals in the most southern part of Florida. Temperatures in the North New River Canal near Ft. Lauderdale normally fall below 15.6° C (Anderson 1975). Water temperatures in winter during 1982-83 indicated that the species could survive in canals south of Miami but not in most natural freshwater habitats like the Everglades--not even during mild winters (Shafland 1984, 1989, 1990). Peacock cichlids cannot survive salinities that exceed 18 ppt.

The present established range of the peacock cichlid includes the coastal canals of eastern Dade and Broward counties within 50 km of the east coast of Florida and north to the Palm Beach-Broward county line (Morello 1993). The westward spread extends to the edge of the Everglades Conservation Area, 4.8 to 9.6 km south of the junction of U.S. Highway 27 and Interstate Highway 75 (Alligator Alley), where peacock cichlids have been caught by anglers. Although some fishery biologists are concerned that the peacock cichlid will become established in the Everglades National Park, Shafland (P. Shafland, Director, Non-native Fish Research Laboratory, Boca Raton, Florida, personal communication) believes that the existing range of the species will be reduced to the coastal canals of Dade County as soon as a colder-than-average winter occurs. This species is expanding its range because of its own ability to spread through interconnecting canals, the continued stocking of waters with the fish by the Game and Freshwater Fish Commission, and unofficial releases by anglers into favorite fishing areas. No studies have been conducted to determine the impact on largemouth bass populations that were in the canals before the introduction of the peacock cichlids.

The peacock cichlid, released in 1984 by the Florida Game and Freshwater Fish Commission, was the first legally introduced exotic species into the waters of Florida (Shafland 1993). It has overwintered and reproduced every year since it was introduced. Self-sustaining populations now exist in 530 km of canals, where they are heavily sought after by anglers. Bait and tackle stores are promoting the taking of the species, and special guide services have developed for this species (Tucker 1988). In 1989, a 12-month standard creel census revealed that people fished for this species. The estimated fishing pressure was 31,662 hours on 40 surface hectares of canal (792 h/ha). This provides an estimated 425,000 hours of recreational fishing year and an estimated annual economic worth of $1.4 million (Shafland 1993). Only 2 peacock cichlids/day can be taken, and only one can be more than 43.2 cm in total length. The current state record is a 3.4 kg fish caught by an angler in April 1992. The average size caught by anglers is in the range of 0.5-1.0 kg, but fishes as heavy as 4.5 kg may be taken.

Speckled Pavon (*Cichla temensis*). This species is sometimes called the speckled peacock. It was collected from the Orinoco River, Venezuela, during earlier efforts to determine the feasibility of introducing it into Florida (Ogilvie 1966a). It grows at a slower rate and may be less prolific than the peacock cichlid and is still protected from harvest in Florida (Chapman 1989). In its native waters, fishes as heavy as 13.6 kg have been taken. This species is not yet listed as established in Florida.

Black Acara (*Cichlasoma bimaculatum*). In earlier literature (Robins et al. 1991), this species was called the port cichlid (*Aequidens portalegrensis*). It was a popular aquarium fish during 1930-1950. Its native range is eastern Venezuela and Trinidad, Guyana, Surinam, French Guiana, Brazil, Ecuador (possibly), Bolivia, Paraguay, Uruguay, and northern Argentina (Regan 1905; Fowler 1954; Ringuelet et al. 1967). It is established in Broward, Collier, Dade, Glades (probably), Hendry, Monroe, and Palm Beach counties of Florida (Rivas 1965; Lachner et al. 1970; Kushlan 1972; Courtenay et al. 1974; Hogg 1976a,b). The first specimens in the open waters of Florida were found in the early 1960's (Rivas 1965) and probably escaped or were released from aquarium-fish farms (Courtnay et al. 1984). Survival and rapid rate of spread of this species can be attributed to several factors. It is a prolific breeder that spawns every month and guards its young well into the free-swimming stage (Taylor et al. 1984). Examination of 23 stomachs of this species indicated that plant material was a dominant food item and included filamentous algae and vascular plant fiber; stomach contents also included some chironomidae larvae and fish scales (Hogg 1974). This species has been collected in several new localities in southern Florida, indicating that it is continuing to expand its range (W. Loftus, Biologist, Everglades National Park, National Biological Survey, personal communication).

Midas Cichlid (*Cichlasoma citrinellum*). This species is native to the Atlantic slope of Nicaragua, including the Great Lakes basin south to Costa Rica (Miller 1966). In 1981, an established population of this species was discovered in the Black Creek Canal in southeastern Dade County, Florida (Anderson et al. 1984). The population extended approximately 10.5 km westward from the salinity structure. A pair of midas cichlids with young were seen in the C-102 canal in June 1982. An analysis of the contents of the intestines and stomachs of 16 specimens revealed plecypods, detritus, gastopods, and plant material. Barlow (1976) reported that midas cichlids eat young fishes including their own and shift to a more piscivorous diet as they grow larger. Anderson et al. (1984) found its lower lethal temperature was 11 °C and predicted that this limits the species' distribution to south of a line connecting Tampa and Melbourne. The source of this introduction is unknown, but it is generally believed that the fish was released from one of the fish farms in the area. Anderson et al. (1984) concluded that any harm from this species would be on fishes that already suffer from introductions of other nonindigenous species. Recent observations of this species indicated that it has persisted where it was established but does not seem to be expanding its range beyond extreme southern Florida.

Firemouth Cichlid (*Cichlasoma meeki*). The native distribution of this popular aquarium fish species is the Atlantic Slope drainages of South America from the Rio Tonala in Veracruz and Tabasco, Mexico, to southern Belize, including the Yucatan Peninsula and the upper Usumacinta basin in Guatemala (Courtenay et al. 1980).

This species shows stress when water temperatures drop below 17.9 °C and dies at 10.3 °C (Shafland and Pestrak 1983). Barlow (1974) classified this species as a substrate sifter, whereas Hogg (1976a) reported that it fed on nonfilamentous algae, filamentous chlorophyta, molluscan shell fragments, vascular plant fiber, fish eggs, and insect parts. Larger fishes tend to feed less on plant material.

Courtenay et al. (1986) discussed the early distribution in Dade and Palm Beach counties, Florida. It is established in vicinities of aquarium fish farms in the Tamiami and Snapper creek canals in Dade County. Page and Burr (1991) reported the species as established in Dade County, Florida. In 1993, personnel of the National Biological Survey (National Fisheries Research Center-Gainesville, Florida, personal communication) found the firemouth cichlid established in several small mosquito drainage ditches on Big Pine Key, Florida.

Rio Grande Cichlid (*Cichlasoma cyanoguttatum*). This species--sometimes called the Rio Grande perch or Texas cichlid--is native to southern Texas, the lower Rio Grande River and its lower tributaries, and southward into Mexico. It was probably first introduced into Florida from Texas stock in 1941 by a private individual (Courtenay et al. 1974). It was established in an abandoned phosphate pit near Mulberry, Polk County, where it was reported as numerous, in Dade County southwest of Miami, and in Hillsbough County. Some of the releases or escaped individuals were from fish farms. This species is locally established; its divided populations have not expanded their ranges.

Rio Grande cichlids show stress when the water temperatures drop to 18.2 °C and die at 5 °C (Shafland and Pestrak 1982). Darnell (1962) found that the species is omnivorous but feeds mainly on vascular plant matter, filamentous fungi and algae, insect larvae, caterpillars, beetles, water mites, cladocera, and protozoans. Other researchers also found fish eggs and scales in stomach contents (Buchan 1971).

Jack Dempsey (*Cichlasoma octofasciatum*). This popular aquarium fish is native to the Atlantic Slope drainages from the Rio Chachalacas basin, Veracruz, Mexico, to the Rio Ulua basin in Honduras, including the Yucatan Peninsula (Miller 1966). It is established in four Florida counties: in ditches on the University of Florida campus, Gainesville, Alachua County (Shafland 1982; Courtenay et al. 1986; Jennings 1986); in canals near the Satellite Beach Civic Center and in other canals from Satellite Beach to Canova Beach, Brevard County (Dial and Wainright 1983); in Black Creek and Snapper creek canals, Dade County (Courtenay et al. 1974; Hogg 1976a,b); and in a roadside ditch in Ruskin, Hillsborough County (Courtenay et al. 1974). An established population of this fish was eradicated from a rockpit in Levy County by the Florida Game and Fresh Water Fish Commission (Levine et al. 1979). Another population was established in a canal near an aquarium-fish farm west of Lantana in Palm Beach County (Courtenay et al. 1974) but seems to have died out. This species has been collected near Micco, Brevard County, but does not seem to be established there (Courtenay et al. 1986). This species can survive a salinity of 2-8 ppt. Populations in Dade and Hillsborough counties seem to be escaped individuals or releases from aquarium-fish farms; those in Alachua and Brevard counties probably started with released aquarium fishes. A population of this species, which was studied by Jennings (1986), is still established in Gainesville, Alacuha County, Florida. Food-habit studies (ref) indicated that it is omnivorous and feeds opportunistically on invertebrates, insects, fishes, and vegetation. Hogg (1976a) found its stomach contained filamentous algae, crayfish exoskeletons, mollusk shell fragments, and various unidentified material. Levine et al. (1979) found a predominance of animal matter in its diet.

Temperature tolerance tests indicated that the lower lethal temperature for this species was 8 °C (Shafland and Pestrak 1982). Nevertheless, Jennings (1986) collected it from a small creek (0.5-4.0-m width and 6-20-cm depth) in Gainesville, Florida, where it was able to survive an evening air temperature of -2.8 °C. The water source was from an underground drainage system that produced an initial water temperature of about 25 °C. Seemingly small heat sinks, such as existed in the above case, are sufficient for overwintering by cold-sensitive populations much farther north than anticipated. This species has the reputation of being a very aggressive fish. Local populations continue to exist but do no seem to be expanding. Populations started with escaped individuals from fish farms or with released aquariums fishes. This species is considered locally established.

Mayan Cichlid (*Cichlasoma urophthalmus*). The native range of this species includes the Atlantic Slope from the Rio Coatzacoalcos basin in Veracruz, Mexico, south to Nicaragua and the Yucatan Peninsula, Cozumel, and to Isla Mujeres (Miller 1966).

Specimens of this species were first collected from Florida's open waters in January 1983 in Snook Creek, a mangrove-lined, highly hyaline tributary of Joe Bay in the northeastern Florida Bay, Everglades National Park (Loftus 1987). Later in the year, Loftus collected more specimens from the Anhinga Trail ponds in the park. Both sites were in Taylor's Slough. Repeated visits revealed spawning by this species in both areas (Loftus 1987). This euryhaline cichlid is considered to be established by Loftus (1987) because it has survived adverse environmental conditions such as cold spells, droughts, and floods for 3 years. The source of this introduction is unknown, but it was probably a release into the two disjunct areas by an aquarium hobbyist (Loftus and Kushlan 1987; Loftus 1989). The Mayan cichlid has continued to expand its range and has been taken in several new locations in the Everglades (W. Loftus, Biologist, Everglades National Park, National Biological Survey, personal communication). Stomach contents of eight fishes from Snook Creek consisted of *Cerithium*, other snails, and *Chara*.

Convict Cichlid (*Cichlasoma nigrofasciatum*). The convict cichlid is native to the Pacific Slope drainages from Guatemala to Costa Rica and to the Atlantic Slope drainage of Costa Rica (Miller 1966). It has been reported as established in Nevada, Arizona, and Florida (Courtenay et al. 1986), however, the population in Florida, reported by Rivas (1965) in a rockpit in northwest Miami, Dade County, has not been observed in recent years (Courtenay et al. 1986). This species is no longer considered as established in Florida.

Yellowbelly Cichlid (*Cichlasoma salvini*). This cichlid is native to southern Mexico, Guatemala, Yucatan, and Honduras and from the Atlantic drainage of the Rio Papaloapam, Veracrux, Mexico, to the Sulphur River near Puerto Barrios, Guatemala. This species is considered a snappish and quarrelsome species in aquaria, and, although it is a very attractive fish, it is not a popular aquarium species. It can survive in water temperatures of slightly less than 20°C (Sterba 1966). A well-established, reproducing population of this species was found in a borrow pit in an abandoned amusement park in Dania, Broward County, in March 1980. Established *C. meeki* were also found in the same borrow pit. Because the yellowbelly cichlid population was able to survive unusual and extremely cold temperatures in February 1981, it was eradicated by the Florida Game and Fresh Water Fish Commission later that year. However, in 1992 and 1993, the yellowbelly cichlid was found in a canal in Davie, Broward County, by personnel of the National Biological Survey (National Fisheries Research Center-Gainesville, Florida, personal communication). The presence of different size classes suggested multiple spawnings. The species is considered locally established in Florida.

Redstriped Eartheater (*Geophagus surinamensis*). The native range of this species includes the Guianas and the Amazon river basins of Bolivia, Brazil, Colombia, and Peru (Gosse 1975). In 1982, a reproducing population of this species was found by personnel of the Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, in the Snapper Creek Canal, Dade County, Florida (Metzger and Shafland 1984). Its presence there may be the result of escaped individuals from a fish farm or from a dumped aquarium. As other locally established populations of cichlids in southern Florida, the redstriped eartheater has the potential to expand its range. It was recently collected by National Biological Survey personnel (National Fisheries Research Center-Gainesville, Florida, personal communication) from the Snapper Creek Canal in the same general area where the first specimens were collected. Because the population shows no signs of spreading, it is considered locally established. This popular aquarium fish (Axelrod et al. 1980) grows to a maximum total length of 30 cm (Puyo 1949) and is a bottom feeder.

African Jewelfish (*Hemichromis bimaculatus*; now identified as *H. letourneauxi* by Smith-Vaniz). This species is native to rivers and lakes throughout western Africa, in the Chad Basin, in the Nile River, and south to the Congo River (Daget and Iltis 1965). In Dade County, Florida, it is established in the Hialeah Canal and in connecting canals to the west and south of the Miami International Airport and in the Comfort Canal, the channelized South Fork of the Miami River (Rivas 1965; Courtenay and Robins 1973; Courtenay et al. 1974; Hogg 1976a,b). Courtenay et al. (1984) reported its probable establishment in a canal east of Goulds, Florida, and in the Snapper Creek, north of the Tamiami Canal. It has been collected in a canal near an aquarium-fish farm near Micco, Brevard County, Florida, but there is no evidence of its establishment. This species seems to be increasing its range recently because it has been collected in several new localities (Bill Loftus, Biologist, Everglades National Park, National Biology Survey, personal communication).

The sources for the introduction of this fish in Dade County are unknown. Its distribution is largely centered in canals around the Miami International Airport, which is a major port of entry for aquarium fishes. Possibly, the jewelfish was released near the airport or from aquarium-fish farms northward along the Hialeah Canal.

Examinations of 26 stomachs of the African jewelfish revealed filamentous algae, its own young, assorted insects parts, and predominantly plant material (Hogg 1976a).

Blue Tilapia (*Tilapia aurea* = *Oreochromis aureus*). This species is native to the Senegal River, the middle Niger River as far south as Bussa (not recorded from the lower Niger or from the Volta River), Lake Chad, pools and lagoons of the lower Chari and Logone rivers, the lower Nile from near Cairo to the Delta lakes (but seemingly only in freshwater), the Jordan River system, the Na'aman and Yarkon rivers in Israel, and the Asraq marshes and hot pools at Ein Fashkha, Jordan (Trewavas 1966).

Sources and reasons for the introduction of this species into the United States and the establishment of wild populations are varied and in some cases only suggested. Shelton and Smitherman (1984) summarized the suitability of this species for aquaculture. Introductions in Alabama were made by the Auburn University for research (Smith-Vaniz 1968). To determine the general biology of the species, McBay (1962) conducted laboratory studies at the Auburn University from April 1959 to May 1960 and misidentified the fish as *Tilapia nilotica*. This study included investigations of spawning behavior and early life history, food habits, and lower lethal temperature. The species was introduced into Florida initially by the Florida Game and Fresh Water Fish Commission for research (mostly biological control) and subsequently by individuals (Crittenden 1962; Buntz and Manooch 1969a; Courtenay and Robins 1973, 1975; Courtenay et al. 1974; Harris 1978).

In 1961, 3,000 Nile tilapia (*Tilapia nilotica*), later correctly identified as *Tilapia aurea* (Smith-Vaniz 1968), were imported into Florida by the Florida Game and Freshwater Fish Commission for experimental studies. The purpose was to determine the fish's use as a biological control agent of nuisance aquatic plants and as a sport fish (Crittenden 1965). Phosphate pits at the Pleasant Grove Research Station near Tampa were stocked (Ware and

Fish 1971; Ware 1973). The species proved to be a failure as a control agent and as a sport fish; however, public relation had already promoted it as a superfish. Before the study could be completed and the results published, the public gained access to the fish and began spreading it throughout the state. The species may have also unofficially been given to friends for private ponds. By 1964, Barkuloo (1964) strongly recommended that this species not be introduced into Florida's freshwater because experimental studies revealed it provided little recreation, could survive Florida winters, could become very abundant, and probably could interfere with the native forage base in some water bodies.

The spread of the blue tilapia has been rapid. During a routine survey in 1966, reproducing tilapia were found in Lake Morton, Polk County (Ware 1973). Eradication was immediately started. The estimated standing crop in the lake was 163 kg/ha; and blue tilapia were the second-most abundant species in the lake. The size distribution revealed three year classes, indicating that the species had reached that population level in only 3 years. When a reproducing population was found in Lake Parker, an 810 ha lake, which is in the headwaters of the Peace River watershed, all efforts to stop its spread were abandoned (Ware 1973). In 1968-1969, only 2 years after the introduction, blue tilapia comprised 5% of the composition by weight in samples from Lake Parker (Horel 1969). By 1972, this fiqure jumped to 68% of the composition by weight (Babcock 1974). The tilapia population remained at a high level until an apparent die-off from cold weather. Some tilapia survived or the lake was again stocked with them because they are still present there. The existence of a power plant on the lake almost guarantees survival of the species in even cold years.

In 1976, blue tilapia were first collected in Lake Tohopekaliga, Florida. During 1979-1981, the juvenile tilapia population increased by approximately 500%/year (Hulon and Williams 1983). The lake is eutrophic because it receives in excess of 91 million liters/day of secondarily treated sewage effluent from the greater Orlando metropolitan area.

The rapid spread of the tilapia across the state can be attributed to its releases by humans, flooding, natural migrations, and piscivorous birds (Foote 1977). The existence of highly eutrophic water bodies also assisted in its survival and spread. Establishment of this species may harm some Florida ecosystems; however, it created a commercial fishery in some lakes that would otherwise have been ecosystems with low yields (Langford et al. 1978). Wattendorf et al. (1980) studied the interspecific interactions between blue tilapia and other native fishes in Florida.

In Florida this species is now established in 18 counties: Alachua, Brevard, Dade, DeSoto, Hardee, Hernando, Hillsborough, Lake, Manatee, Marion, Orange, Osceola, Palm Beach, Pinellas, Polk, Sarasota, Seminole, and Volusia. Foote (1977) recorded the species from Broward, Charlotte, Glades, and Pasco counties, but we know of no specimens from these counties. This species is also reproducing in the saline waters of Tampa Bay.

Zale (1984) summarized the literature on the lower lethal-temperature tolerance of the blue tilapia. It varied from 5 to 12°C, depending on the circumstances or the type of test (Yashou 1960; McBay 1962; Crittenden 1965; Germany and Noble 1978; Lee 1979; Shafland and Prestrak 1982). The fishes exhibited some form of stress as the temperature dropped below 12°C and died at 5°C. If the species is preconditioned for warmer temperatures, the fish is already stressed, the period of decreasing temperatures is prolonged, or the drop in temperature is rapid, death can occur at higher than 5 °C. In the wild, the northern expansion of the blue tilapia population in the United States is limited to the southern part of the southern tier of states unless a source of heated water such as a power plant or a warmwater spring is available. During cold weather, all culture of this species in the colder climates depends on a heated water source or overwintering of the species indoors. Zale (1987) discussed the behavior of the blue tilapia that seasonally migrate into stenothermal spring runs in north-central Florida to escape colder waters of the St. Johns River, Florida, in winter. The species can probably survive in larger water bodies in Florida without seeking refuge.

The main component of the blue tilapia diet is phytoplankton, a small percentage of which is insects such as chironomid larvae (McBay 1962; Manooch 1972; Stickney 1976). McBay (1962) found that the smaller, less-than-50-mm tilapia used zooplankton such as rotifers, copepodes, cladocerns, and ostracodes (Foote 1977).

The impact of blue tilapia on receiving ecosystems can vary by ecosystem and by the relative abundance of the fishes to native species. In some water bodies, the tilapia population does not explode but remains in balance with native predators that control it. In fact, in some water bodies, the tilapia may be an important prey species of native predators (Shafland and Pestrak 1981). In other water bodies--probably because native predators were inadequate to control the tilapia, the system was already stressed, or turbidity or vegetation cover interfered with predation on the tilapia (Schramm and Zale 1985)--the tilapia population exploded. Noble et al. (1975) found that, when the tilapia population reached a high biomass near 1,121 kg/ha, the blue tilapia spatially displaced native species and interfered with their reproduction. Competition for spawning sites between native centrarchids and mouth-brooding tilapia in Florida have repeatedly been cited (Buntz and Manooch 1969a; Babcock and Chapman 1973; Courtenay et al. 1974; Harris 1978 and Zale 1984). Noble et al. (1975) concluded that if blue tilapia could be managed at an intermediate level where they did not interfere with the reproduction of largemouth bass, they would not only be a valuable forage for bass but could provide a sizeable, harvestable food fish. A large population of blue tilapia in a body of water can suppress recruitment in largemouth bass. Swingle (1956), Chew (1973), and Shafland and Pestrak (1983) discussed the possible mechanisms: behavioral interactions (harassment) during reproduction; predation by normally non-piscivorous species because of crowding; and competition for food between basses and tilapia young-of-year or chemical suppressive factors (Swingle 1956; Chew 1973). Blue tilapia build nests on or close to preferred spawning sites of largemouth bass and bluegills. Because they usually begin to build nests when largemouth bass and bluegills spawn, male tilapia may interfere with the spawning of the two species. Zale (1984) found that male tilapia occupied the spawning beds in Silver Glenn Springs several months before they were ready to spawn. When nest building by tilapia is most active in 1-2 m of clear water, the shoreline looks as if it had been bombed with large 30-cm-wide depressions--some are as deep as 45 cm. No nests or spawning by native species is usually evident in or near tilapia nesting areas while the tilapia are spawning (personal observation). Our recent visits to Silver Glenn Springs in mid-February 1993 revealed that the tilapia population was not as large as during the early 1980's (Zale 1984), and many nests were abandoned. We also observed bow fishing from recreational boats in the clear water run from the spring. Interviews with hunters in three boats indicated that this sport was popular in this area and conducted almost year round; however, it was concentrated in the colder months when the fishes sought refuge in the warmer water. This hunting effort removed large numbers of fishes and probably helped to manage the tilapia population. By 10:00 h on the day of the observations, more than 35 adult fishes with an estimated weight of more than 2.25 kg had been removed prior to our interview of the group. Discussions with the hunters indicated that hunting had been slow that day. No information was available on the total number of annually removed fishes or the total number of removed fishes on that day.

Like most other tilapia species, the blue tilapia has a tendency to overpopulate waters where native predators are stressed or already low in abundance or where turbidity impedes efficient feeding by predators (Forest Ware, Florida Game and Fresh Water Fish Commission, Tallahassee personnel commnuication). Highly eutrophic water bodies with heavy algae blooms tend to become overpopulated with tilapia. Shafland and Pestrak (1983) speculated that an abundance of this species in any water body may also adversely affect the forage base of the community. In Texas and Florida, increases in densities of blue tilapia in eutrophic water bodies negatively related to sharp declines in native shad populations (Horel 1969; Babcock and Chapman 1973; Ware 1973; Shafland et al. 1980; Wattendorf 1981, 1982). Food-habitat studies by McBay (1962) revealed overlapping diets with native species.

Rapid spread and high standing crops of this species have been reported many times (Buntz and Manooch 1969a; Courtenay and Robins 1973; Ware 1973; Courtenay et al. 1974). Horel (1969) and Babcock and Chapman (1973) documented an explosion of the tilapia population in Lake Parker, Polk County, Florida. Ware (1973) concluded that the abundance of blue tilapia depends on primary productivity of the water body. High densities develop in eutrophic waters. Denzer (1966) believes that the ability of blue tilapia to withstand periods of low dissolved-oxygen concentrations may allow it to survive and flourish in hyper-eutrophic systems in which many native species cannot survive.

Overpopulation and stunting of tilapia in Florida adversely affect spawning of native species (Shafland and Pestrak 1983). In March 1973, in Lake Effie near the city of Lake Wales, almost the entire population of tilapia died from water pollution (Chapman and Young 1973). The dead blue tilapia weighed more than 2,242 kg/ha. Lake Effie receives waste water from two citrus processing plants, and the water is hyper-eutrophic and sometimes anoxic. Constant aeration is now required to prevent the lake from going anoxic. Zale (1984) found indications that the spawning of blue tilapia in Silver Glenn Springs, which discharges directly into the St. Johns River, may interfere with the spawning of largemouth bass.

In 1970, blue tilapia were first collected from Lake Lena near Auburndale in Polk County. From 1978 to 1989, fish populations were sampled and plankton and water chemistry data were collected to evaluate changes that took place with establishment and increase of the tilapia population (P. L. Shafland, Director, Non-native Fish Research Laboratory, Boca Raton, Florida, personal communication). The data tentatively showed that some populations of native species were affected as the tilapia populations expanded. Analysis of the data is presently underway.

Commercial fishing for tilapia by haul seines is legal in several Florida lakes (lakes Banana, Cannon, Conine, Effie, Hancock, Hollingsworth, Howard, Lulu, Parker, and Shipp) with a permit from the Florida Game and Fresh Water Fish Commission (Langford 1976).

The lakes are shallow and enriched with heavy blue-green algae blooms and muck bottoms. Banana and Lulu lakes are enriched with inflows of domestic sewage, and heated water from power plant is discharged into Lake Parker (Langford et al. 1978). The lakes have highly urbanized shorelines and receive storm-water drainage. Commercial fishery landing of tilapia from each lake were made every year during 1972-1977 (Langford et al. 1978). The highest yield, 1,973.2 kg/ha, was from the 41.2-ha Lake Effie in 1975 (Langford et al. 1978). Some of the lakes still support a small commercial haul-seine or castnet fishery.

Sale of tilapia produced in the United States must compete with foreign imports. From July 1992 to June 1993, tilapia imports into the United States totaled 8.3 million kg at a value of $14.7 million. The American Tilapia Association estimated that the 1992 U.S. production reached 4.08 million kg (Zajicek 1993). The volume and value of imports reduced profits from tilapia by Florida's aquaculture industry (Florida Game and Fresh Water Fish Commission, Gainesville, Fl., unpublished records). Two years ago, fresh, ice packed tilapia fillets sold for approximately $7.85/kg. In 1993, imported frozen tilapia fillets sold for $1.32-$5.48/kg, depending on the country of origin (Zajicek 1993). The farm-gate prices for live tilapia in 1994 are about $2.75 at ethnic Asian markets of Chicago, Philadelphia, New York, and Atlanta.

A computer list, compiled in 1993 by the Florida Game and Fresh Water Fish Commission, Tallahassee, Florida, showed that there were 56 permit holders registered for possessing tilapia. A total of 32 permits allowed the culture or sale of tilapia. Only three producers were selling tilapia in 1993. In 1991, 16 tilapia growers reported Florida's tilapia sales totalled $572 thousand. Seventy-seven hectares were used in production, mostly in private phosphorus pits. The sale of tilapia from aquaculture operations in Florida is in competition with the capture of wild tilapia with haul seines and cast nets. Because the records and sales of cultured and wild tilapia are not reported separately, the size of the catch of the wild tilapia cannot be determined (R. Freie, State Statistician, Florida Aquaculture Statistics Service, Orlando, Florida, personal communication).

The potential of tilapia for aquaculture in the United States is discussed by Suffern (1980). He summarized that tilapia can be grown outdoors year round only in the deep south or in areas with a supply of supplemental industrial, solar, or geothermal heat. In some years, the fishes survive a mild winter, such as the exceptionally warm winter of 1971-72 in Luverne, Alabama (Habel 1975). In this case, the overwintering of the fishes resulted in the removal of almost 14.2 metric tons of harvestably sized tilapia, 15 cm or longer, from this 21.4-ha public fishing lake in 1972-73, showing the capability of this species to increase its biomass in a short time under favorable conditions.

Nile Tilapia (*Tilapia nilotica = Oreochromis niloticus*). The Nile tilapia is native to the Nile River and to coastal rivers of west-central Africa. It is a relatively large tilapia that attains a total length of 50 cm. It is superficially like the blue tilapia, *Tilapia aureas*. Trewavas (1966) distinguished the Nile tilapia from the blue tilapia and subsequently (Trewavas 1983) contrasted the Nile tilapia with other tilapia species. Trewavas (1983) also recognized four subspecies of *Oreochromis niloticus*.

The only Florida record of the Nile Tilapia a locally established population in Lake Seminole, Jackson County. Based on a report in 1993 from the manager of a fishing camp on

Lake Seminole, this tilapia has been caught in the lake since 1988 or 1990. He provided photographs and specimens of Nile tilapia taken during 1991-93. Survival of this species during winter is probably linked to availability of warmwater discharges from numerous springs in the lake. The pathway of this introduction is unknown but is probably associated with private aquaculture in the area.

Spotted Tilapia (*Tilapia mariae*). *Tilapia mariae* is native to coastal lowlands in freshwater from the middle Ivory Coast to southwestern Ghana and from southeastern Benin to southwestern Cameroon (Thys van den Audenaerde 1966; Trewavas 1974). In its native habitat, this species prefers brackish water. It is established in Dade County and Broward County (Hogg 1974, 1976a,b; Courtenay and Hensley 1979, 1980; W. R. Courtenay Jr., Professor, Florida Atlantic University, Boca Raton, Florida, personal communication). It has also been reported from a pond south of Copeland and now occupies much of southern Collier County (W. R. Courtenay Jr., Professor, Florida Atlantic University, Boca Raton, Florida, personal communication). A population was established near Micco, Brevard County, in 1979 but subsequently died out. Continuing its rapid expansion in southeastern Florida, this species now occurs throughout the New River Canal system in central Broward County, the Tamiami Canal in western Dade County, in the Aerojet Canal system in Dade County, and throughout much of the Everglades National Park (Loftus 1989). Based on recent collections of National Biological Survey personnel (National Fisheries Research Center-Gainsville, Florida, personal communication), it is the most common nonindigenous species in canals in southern Florida. It has been found below salinity dams in three Dade County canals leading into Biscayne Bay, and monitoring of movements by this euryhaline species is underway. Hogg (1974, 1976a,b) suggested that Florida populations originated with escaped individuals or releases from aquarium-fish farms. Courtenay and Hensley (1980) suggested a possible purposeful release of this fish near Miami.

Adults grow to a length of approximately 23 cm. It is not a mouth brooder but protect its eggs and fry (Courtenay and Hensley 1979b). The species is aggressive toward native and toward other nonindigenous species. This species could replace many other species because it is expanding its population. The success of this species is attributed to its prolific reproduction, spawning during all months of the year, and guarding of its young into the free-swimming stage (Taylor et al. 1984). The contents of 58 stomachs of this species contained filamentous algae, non-filamentous algae, vascular plant fibers, and bryozoa. Plant material was five times more important than animal material. The smaller individuals are more omnivorous, but larger individuals were herbivorous. The species seems to do best in canal systems with steep sides and limited shallow areas.

Blackchin Tilapia (*Tilapia melanotheron = Sarotherodon melanotheron*). This species is native to river-delta lagoons from middle Liberia to southern Cameroon (Thys van den Audenaerde 1971). It is established in Florida in Hillsborough County from Lithia Springs to the mouth of the Alafia River, and southward along the eastern shore of Tampa Bay to Cockroach Bay, Manatee County (Springer and Finucane 1963; Finucane and Rinckey 1964; Buntz and Manooch 1969b; Lachner et al. 1970; Courtenay et al. 1974).

It is also established in Brevard County in canals near Satellite Beach and in the Indian and Banana rivers from Merritt Island southward to below Canova Beach, a distance of 27 km (Dial and Wainright 1983). Springer and Finucane (1963) suggested that this species either escaped or was released from an aquarium-fish farm on the eastern shore of Tampa Bay. The Brevard County population may have resulted from aquarium-fish releases into the reflecting pool at the Satellite Beach Civic Center or by anglers attempting to establish a sport or commercial fishery on the east coast similar to the one on the west coast of Florida. This species is now taken in commercial catches by netting in estuarine waters and by hook and line in freshwater (Dial and Wainright 1983). Finucane and Rinckey (1964) and Anderson (1981) summarized the results of food-habit studies that revealed the diet overlap between this species and native species.

On the east coast of Florida, this species spread southward to the Jupiter Inlet, Palm Beach County, by August 1990. The northern limit of its range is the Ponce de Leon Inlet near New Smyrna Beach, Volusia County (Jennings and Williams 1992). They found the species in a variety of habitats including canals, drainage ditches, lagoonal areas at the mouth of creeks and canals, open water areas, and freshwater tributaries. The species prefers quiet backwaters with aquatic vegetation and a mucky, organic substrate. There is no recent information of its status on the west coast of Florida in the Tampa Bay tributaries except that it is still present in some of the same streams where it was previously found. Its population is considered to be expanding at least on the east coast of Florida.

Mozambique Tilapia (*Tilapia mossambica* = *Oreochromis mossambicus*). The native range of this species is the eastward-flowing rivers of Africa from the lower Zambezi and Shire river systems in Mozambique southward in coastal drainages to Algoa Bay, South Africa (Jubb 1967; Thys van den Audenaerde 1968). It is established in Florida in the saline Banana River near Cocoa Beach, Brevard County (Dial and Wainright 1983), and throughout Dade County (Courtenay et al. 1984; W. R. Courtenay Jr., Professor, Florida Atlantic University, Boca Raton, Florida, personal communication). Dial and Wainright (1983) found this species in brackish water with salinity as high as 8 ppt in the Satellite Beach area. Populations in Brevard County seem to have originated from stocks of aquarium fishes released at Satellite Beach (Courtenay et al. 1974; Dial and Wainright 1983). Most of those in Dade County probably escaped from aquarium-fish farms. At one locality, their establishment resulted from an introduction for aquatic plant control by a developer (Courtenay et al. 1984). The Mozambique tilapia seems to have maintained populations in canals where it was originally found in Dade County, Florida. It seemingly has not spread over any appreciable distance in recent years in southern Florida. No Mozambique tilapia were found during the surveys of nonindigenous fishes in the Indian River system by Jennings and Williams (1992).

Lower lethal-temperature tests indicated that this fish stops feeding at 15.6°C; individuals began to die at 14.4°C, and all individuals were dead at 8.3 - 9.4°C (Kelly 1955). Kelly (1955) concluded that this species could not survive winter conditions throughout most of the Southeast.

Kelly (1955) conducted food studies that revealed diet overlap of this species with native species. Studies in its native range of South Africa indicated that young of this species fed mainly on detritus and neuston in eulittoral pools and in shallow margins along shore. Adults fed mainly on detritus, periphyton, and insects in shallow water (Bruton and Boltt 1975). Kelly (1955) reported that the diet of this species was mainly composed of planktonic forms of plants and animals. Wieland et al. (1982) compiled a complete biological synopsis on this species.

Hybrid crosses of this species with other tilapia species have been used in Florida and elsewhere in the United States for aquaculture (Wieland et al. 1985). Most culture of this species in Florida is used for brood stock to establish and supply aquaculture facilities in foreign countries. This species has a tendency toward overpopulating waters and toward having stunted growth, thus making it a problem in culture and in the open waters (Wieland et al. 1985). Swingle (1958) discussed the use of this species for culture in ponds. Most commercially sold tilapia in Florida are blue tilapia, not Mozambique tilapia.

The Mozambique tilapia was introduced into open waters as a weed-control agent in Arizona (Minckley 1973) and as control agents of aquatic plants, mosquitos, and chironomids in California (Knaggs 1977; Legner and Pelsue 1977) and elsewhere in the world. Its ability to control nuisance aquatic plants is now considered questionable because its well being seems to depend on the availability of other food. The destruction of higher plants seems to be the result of the tilapia scraping the periphyton from the leaves and from the stalks of the plants. In doing so, the Mozambique tilapia injure the plants enough to control their growth (Wieland et al. 1985). Released individuals of these species to control weeds in California created established, overpopulating populations that are replacing native species, especially in estuaries (Knaggs 1977; Legner et al. 1980).

Redbelly Tilapia (*Tilapia zilli*). This species of tilapia occurs in Africa in the Bandama, Benue, Chari, Ituri, Niger, Sassandra, Senegal, Ubangi, Uele, Volta rivers; in lakes Albert, Chad, and George; and in the Near East in the Jordan River (Thys van den Audenaerde 1968).

In Florida, the species was established in a rockpit near Perrine, Dade County, but was eradicated by personnel of the Florida Game and Fresh Water Fish Commission (Courtenay et al. 1984). Prior to its eradication, it hybridized with introduced spotted tilapia (Taylor et al. 1986). The redbelly tilapia recently was found in several mosquito drainage ditches on Big Pine Key, Monroe County, Florida.

Congo Tilapia (*Tilapia rendalli*). This species, formerly identified as *T. melanopleura*, was studied as a possible biological control agent of aquatic plants at Lake Wales, Polk County. The studies revealed that it was highly aggressive, potentially threatening to native vegetation, and capable of causing problematic management of native fishes and waterfowl; therefore, the research was terminated and the population destroyed (Courtenay et al. 1974).

Anabantidae

Croaking Gourmi (*Trichopsis vittata*). *Trichopsis vittata* is native to Borneo, Cambodia, Java, Laos, Malaya, Sumatra, Thailand, and Vietnam (Smith 1945). It is established in a small area on the southern side of the Lake Worth Drainage District Canal L-36, Delray Beach, Palm Beach County, Florida. It probably escaped from one of the nearby aquarium-fish farms (Courtenay et al. 1986). Collections by National Biological Survey personnel (Southeastern Biological Service Center, National Biological Survey, Gainsville, Fl., personal communication) in recent years confirmed the persistence of the croaking gourmi in the canal where it was originally found. It has also been taken in another canal adjacent to an aquarium-fish farm that is no longer operational. The species is still extant (W. R. Courtenay, Jr., Professor, Florida Atlantic University, personal communication), and it is considered locally established.

In addition to the exotic fishes in Florida waters, nine species in six families of fishes that are native to the United States also were transplanted into Florida. In some cases, the fishes were originally introduced into states north of Florida, such as Alabama and Georgia, and subsequent dispersal resulted in the downstream movement into Florida. None of these introductions has been examined to determine the effect, if any, on the receiving ecosystem.

As described earlier in more detail, one transplanted species, the Rio Grande cichlid (*Cichlasoma cyanoguttatum*) was brought into Florida by the aquarium-fish industry. The presence of this species in the open waters of Florida started with escaped individuals from aquaculture facilities and the release of aquarium fishes. It is locally established in Hillsborough and Monroe counties.

The remaining 8 transplanted species of five families were introductions for with sport fishing (Southeastern Biological Science Center, National Biological Survey, Gainesville, Fl., unpublished data). One species, the fathead minnow (*Pimephales promelas*) was brought into Florida as a bait fish for sport fishing. Four sport fishes, the flathead catfish *(Pylodictis olivaris*) and 3 species in the Family Percidae, the yellow perch (*Perca flavescens)*, sauger (*Stizostedion canadense)*, and walleye (*S. vitreum)* seemingly were introduced into the Chattahoochee River system upstream of the Florida border and dispersed downstream into the Apalachicola River. The orangespotted sunfish (*Lepomis humilis*) was introduced incidentally into the state with other fishes because this species is too small to be of value as a sport fish.

The remaining two fishes, the white crappie (*Pomoxis annularis*) and the white bass (*Morone chrysops*) were intentional introductions. These fishes were introduced for sport fishing by the Florida Game and Fresh Water Fish Commission (Southeastern Biological Service Center, National Biological Survey, Gainsville, Fl., personal communication). The white crappie is established in several rivers in western Florida. White bass are established in the Apalachicola River.

Nonindigenous Amphibians and Reptiles

The nonindigenous herpetofauna of Florida is a serious problem. However, some individuals still believe that introductions of nonindigenous amphibians and reptiles are not detrimental to the native herpetofauna. For example, Smith and Kohler (1978:18) stated:

> The view is proposed that introduction of exotic species has considerable merit providing it results in a reasonably harmonious resource-portioning with native species. Interactions in nature are of course difficult to anticipate with invariable accuracy, but can be predicted with reasonable reliability. The potential for man-guided diversification is tremendous and if exploited intelligently would result in a much larger portion of successes than failures. The unoccupied niches that exist for co-existence of species in tropical, subtropical, and warm temperate areas, as in southern United States, where access by potential inhabitants has been severely limited by natural barriers, are certainly numerous but very crudely understood. Hasty attempts to fill some of them could be disastrous, but careful appraisal with the broadest possible perspectives could lead gradually to a very satisfying enrichment yielding important information on many evolutionary processes and providing ready access to a wide variety of materials for laboratory and field study. Utilization of resources that already exist and are available for betterment of the environment, not only for man but for a more richly diverse biota than already exists, has scarcely been touched.

More reptiles have been introduced into Florida than into any other state (Ashton and Ashton 1991; Table 8). Reptiles were introduced accidentally on agricultural products and intentionally to help control pests and to augment the pet trade. Many pet traders also illegally transport species into Florida and release them to avoid prosecution for possession of an illegally imported animal. Pet dealers may even release exotics simply to rid themselves of an unprofitable species. Most nonindigenous reptiles are restricted to the Miami area in Dade County (Ashton and Ashton 1991). The most frequent problem from exotic amphibians and reptiles is the replacement of native species because of competition. The most notable example is the giant toad (*Bufo marinus*) that is replacing the native southern toad (*Bufo terrestris*) in the cities of southern Florida; the Bahamian bark anole (*Anolis distichus*), green bark anole (*A. d. distichus*), Bahamian ground anole (*A. sagrai ordinatus*), and Cuban ground anole (*A. s. sagrai*) are replacing the native Carolina anole (*A. c. carolinensis*), and the Cuban treefrog (*Hyla osteopilis septentrionalis*) is preying on the local green treefrogs (*H. v. versicolor*) and squirrel treefrogs (*H. squirella*; (King 1968).

Marine Toad (*Bufo marinus*). The native range of the giant toad extends from southern Texas through Mexico and Central America to Brazil in South America. Currently, the marine toad is widespread, occurring outside its natural range in such varied places as Australia, Fiji, Guam, Hawaii, Japan, New Guinea, the Philippines, Solomon Islands, Tonga, several islands in the West Indies, and southern Florida (Wilson and Porras 1983). It was initially introduced as a biological control agent of native pests such as insects and snails and became established throughout most of the tropical regions of the world (Krakauer 1970). In

1936, the Agricultural Experimental Station of the University of Florida imported 200 marine toads from Puerto Rico and released them at Canal Point and Belle Glade in Palm Beach County to control sugar cane (*Saccharum officianarum*) pests; but the toads disappeared in less than 1 year (Kratzauer 1968, 1970; Riemer 1958). Around 1944, the United States Sugar Corporation introduced the marine toad at Clewiston, Hendry County, but these animals also did not establish themselves; the introductions of two other species of cold-adapted giant toads also failed (Krakauer 1970). A third unsuccessful attempt to introduce the marine toad in southern Florida occurred at a cane field at Pennsuco, Dade County (Duellman and Schwartz 1958; Reimer 1958;).

The present population originated with the accidental release of approximately 100 individuals before May 1955 by a former importer at the Miami International Airport (King and Krakauer 1966). The population remained for several years in the western part of Miami and was breeding in rock pits south of the airport runways; however, in 1958, a canal was constructed to link the Blue Lagoon with the extensive canal system of southern Florida, and the marine toad began to appear in regions distant from the airport (Krakauer 1968). The marine toad is common in many urban and agricultural areas in southeastern Florida and is present on the fringes of the Everglades (e.g., the vicinity of the Chekika State Recreation Area west of Florida City and near the junction of the Tamaiami Trail and U.S. 27; Wilson & Porras 1983). Krakauer (1968) first reported the giant toad from Palm Beach County. The toad was also recorded as established on Stock Island near Key West. Currently it occurs from Homestead in southern Dade County north to Broward County. An isolated population that was probably transplanted is also established in West Palm Beach, Palm Beach County. Animal dealers have deliberately released this species in 1963 at Pembroke Park, Broward County, and in 1964 at Kendall, Dade County (Duellman et al. 1958). Crowe and Stevenson (1992) discovered the giant toad on July 1991 in Dade City, Pasco County. Specimens have been found as far north as Ocala (R.E. Ashton, Vertebrate Ecologist, Water and Air Research, Inc., Gainesville, Florida, personal communication). The marine toad is absent from the wet savanna (Everglades) west of the coastal ridge (Krakauer 1968). It is limited by the Atlantic Ocean to the east and by the Everglades to the west (Krakauer 1968). The distribution of this species is also limited by low temperatures and scarcity of habitat (Krakauer 1968). It is most frequent in disturbed areas, where it occupies two distinct habitats, areas around buildings and suburban backyards and the shores of canals and ponds. The marine toads are most frequently seen under the street lights of the suburbs.

Physiologically, the marine toad is aquatic because its eggs are laid in temporary pools and in roadside ditches. A large female lays more than 5,000 eggs at a single laying. One observer claimed that a single female laid a total of 32,000 eggs (Krakauer 1970). The marine toad's large fertility obviously contributes greatly to this species' ability to expand so rapidly. Although they have mature eggs and seem to be ready to spawn throughout the year, low temperatures and scarce rainfall inhibit breeding in winter (Krakauer 1968). In November 1965, the toad population increased to a point that it was declared a public nuisance and a Dade County official proposed that a bounty be placed on the toad (Krakauer 1968). Krakauer (1968,1970) predicted that the marine toad will extend its population northward along the coast of Florida because of warm temperatures and protection from cold around houses.

In 1968, King stated that the marine toad is replacing the native southern toad *Bufo* *terrestris* in residential areas. Because they could not adapt to anthropogenic changes, populations of southern toads declined and were replaced by marine toads (Wilson and Porras 1983). The expansion of the Miami metropolitan area is simultaneously destroying the preferred habitats of the southern toad but creating new habitat for the marine toad; therefore, the marine toad continues to prevail in its present range (Krakauer 1968).

Marine toads have voracious appetites and eat any small, moving or non-moving objects such as insects, snails, snakes, garbage, and dog food (Alexander 1964; Krakauer 1968). Any resident of southern Florida can give at least one account of seeing a marine toad eat from a pet's food bowl. If bitten, the toads release milky bufotoxin from the parotoid glands that makes pets ill; however, cats and dogs learn to avoid this noxious species after only one encounter (Ashton and Ashton 1988). Although wildlife in southern Florida usually does not prey on this species, Garrett and Boyer (1993) saw an opossum *Didelphis marsupialis* attack and possibly eat this toad even after it had a reaction to the bufotoxin. However, Ashton and Ashton (1988) believe that the marine toad is harmless and makes a good pet.

Many people buy the giant marine toads and release them in their back yards to control garden insects and slugs and have thus increased the rapid range expansion of the species and possibly the creation of the satellite populations in Palm Beach and Monroe counties. Accordingly, some people feel that the toads are useful predators and valuable additions to the local fauna (Krakauer 1970). However, the marine toad is suspected of preying heavily on native toads and on other small organisms--but investigations of the effect of the marine toad on native fauna have yet to be implemented.

Cuban Treefrog (*Osteopilus septentrionalis*). The Cuban treefrog is an immigrant from the West Indies and is one of the largest of the eastern and central American treefrogs (Conant and Collins 1991). During the nineteenth century, it probably arrived in the Florida Keys in a ship's cargo and expanded its range in southern Florida (Ashton and Ashton 1988). It has been recorded along the Atlantic Ocean from Dade to Indian River counties and on the west coast from Monroe to Sarasota counties. It was first reported in Key West by Barbour (1931), since then dispersed northward (Austin 1975), and was reported on the Upper Matacumbe Key by Trapido (1947), in Key Largo by Allen and Neill (1953), in Miami by Schwartz (1952), in Dania by King (1960), on the Broward-Palm Beach County line by Lee (1969), in Palm Beach County by Austin (1975), and in Saint Lucie and Indian River counties by Myers (1977). This species has also been reported on the western coast in Naples by Duellman and Crombie (1970), and Wilson and Porras (1983) reported it from Fort Myers, Sanibel Island, and Fort Myers Beach. Somma and Crawford (1993) discovered the Cuban treefrog in Pinellas County and noted its occurrence in Glades County. Wilson and Porras (1983) speculated that this species arrived in southern Florida by rafting.

The Cuban treefrog is aquatic because it lays its eggs in rain pools, temporary ponds, and ditches. This species is so flexible that it can live in the suburbs and in rural areas such as pinelands and mesic-tropical hammocks (Ashton and Ashton 1988). Because it preys on local insects and other treefrogs, it may be considerably harmful to the native treefrogs of Florida (Ashton and Ashton 1988). However, the knight anole (*Anolis equestris*) preys on this species (Wilson and Porras 1983).

Common Caiman (*Caiman crocodilus*). The number of imported common caimans in the United States for primarily the pet industry increased drastically because the American alligator (*Alligator mississippiensis*) was protected from trading in the early 1950's (Moore 1954). Common caimans are natives of Central and South America and were probably introduced for the pet trade throughout Florida and other gulf states (Smith and Kohler 1978). The U.S. Fish and Wildlife Service reported 112,402 individuals that entered the United States through the Miami port-of-entry during 1970 (King 1974).

Presently, common caimans are breeding in the canals of the Miami area; more specifically, in the late 1950's Louis Pourra observed several caimans of various sizes in a section of a canal that extended from Maule Lake to N.W. 27th Avenue, and Ellis (1980) reported the presence of common caimans in canals in Miami as early as 1960. In 1968, a local collector brought common caimans from a canal in North Miami, around N.W. 22nd Avenue and 197th Street, into the animal trade. The collector reported the presence of nests in that area (Wilson and Porras 1983). An adult common caiman with several young on its back was spotted in 1976 and in 1980 near Coopertown on the Tamiami Trail (Wilson and Porras 1983). Ellis (1980) reported an established and breeding population confined to the canal system on the Homestead Air Force Base; the population was first discovered in 1974. Most of these populations are restricted to drainage canals less than 50 m from the main housing area and within 10 m of a constantly traveled concourse.

After its introduction into open waters, the common caiman increased so drastically that in 1977 extirpation began with the sanctions of the state of Florida and the federal government (Ellis 1980). Although extensive efforts have been made to extirpate the caiman populations in Homestead, frequent sightings in other areas suggest that more intensive efforts are needed to substantially arrest permanent populations in Florida (Ellis 1980). Efforts to extirpate these populations have not been successful (Wilson and Porras 1983).

Red Eared Turtle (*Tachemys scripta elegans*). This turtle is a variety of the slider (*Pseudemys scripta*) and occupies the Mississippi Valley from Illinois to the Gulf of Mexico (Ernst and Barbour 1972). Ashton and Ashton (1991) noted that it is one of the most popular turtles in the pet trade. It is not indigenous to southern Florida. Since 1958, breeding individuals have been reported throughout canals in metropolitan Dade County and in Collier, Duval, Marion, and Orange counties (Ashton and Ashton 1991). Populations are also in the Swannee drainage and near High Springs (R.E. Ashton, Vertebrate Ecologist, Air and Water Research, Inc., Gainesville, Florida, personal communication). Hutchison (1992) noted a viable population in the Fox Hall Pond on Eckerd College in Pinellas County. As human development continues, the southern populations of the red eared turtle may expand their range and eventually join the northern populations (Hutchison 1992).

Nonindigenous Aquatic Birds

Importation of Nonindigenous Birds

Many people are tempted to introduce a species with a potential for establishment to promote hunting or other human activities (Evans 1960). Such preferences have led to international exploitation of species and to the releases of many birds. Most birds that are traded are perching birds (Passeriformes), and the most threatened birds are the parrots (Psittaciformes; Anonymous 1992). Although governmental restrictions reduced the number of traded wild birds since 1980, Argentina, Guyana, Indonesia, Senegal, and Tanzania continue to be major exporters (Anonymous 1992). The September 1992 TRAFFIC (USA) newsletter reported that approximately 2-5 million live birds are internationally traded every year (Anonymous 1992). At least 119 species have been introduced into North America; 39 species became established, 17 may be established, and 63 did or probably did not become established (Long 1989). Many nonindigenous birds have been introduced into Florida (Table 9). Between 1968 and 1970, approximately 123,721 canary winged parakeets (*Brotogeris versicolurus*) among 300,000 parrots were imported into the United States; and from 1968 to 1972, 3,706,500 birds in addition to canaries and parrots were imported (Long 1989). Examples of these imported species--which are rare in their native ranges because of habitat loss and commercial exploitation--are hyacinth macaws (*Anodorhynchus hyacinthinus*), caninde macaws (*Ara caninde*), and palm cockatoos (*Probosciger aterrimus*; Anonymous 1992). Many countries of the world have problems with unintentional introductions of birds.

Pathways of Introduction

Some birds followed ships, and many others are unintentionally transported by plane (Long 1989). Some indigenous birds are welcomed. In 1956, the spot-breasted oriole (*Icterus pectoralis*) was greeted with open arms by bird watchers in Florida who viewed this bird as a striking immigrant (Brookfield and Griswold 1956). Bird watchers sought to protect this species when it entered the state of Florida. Brookfield and Griswold (1956:263) stated, "[An educational campaign] will be directed toward commercial bird importers, pet-shop dealers, federal and local government officials, and also the commercial catchers of birds in Central America, so that all concerned will know of this oriole's protection and the ban on its further commercial importation." Cunningham (1962) describes the spread of the range of the spotted-breasted oriole.

Many species such as the spot-breasted oriole became established simply because Florida's resources are accommodating. In 1973, Owre (1973) stated that southeastern Florida is preconditioned for exotic invasion because of its many uninhabited shallow-water habitats that suit many species for breeding. Even before 1973, the flora of southeastern Florida contained elements of the world's tropics; therefore, almost every exotic, tropical bird finds characteristics of Florida that are similar to its native land (Owre 1973).

Crider (1968) pointed out that the abundance of canals in tropical southern Florida would probably provide suitable habitat for non-native waterfowl introduced from similar habitat, and that if a waterfowl species suitable for hunting and eating was found its introduction would be advantageous. This and Brookfield and Griswold's (1956) statement clearly illustrate the public's view of the establishment of nonindigenous species. Cruickshank (1980) discussed the birds that exist in southern Florida, and Neville (1990) listed the exotic birds in southern Florida. This rapid establishment may also be seen in the number of established nonindigenous bird species. Del Hoyo (1992) stated that 11 exotic bird species have self-sustaining wild populations in the state since the implementation of agriculture (Table 9).

Although there are several early records of human transportation of birds from one area to another, not much is known about the exact time deliberate releases became commonplace practice (Long 1989). Several reasons people list for introducing birds are aesthetics, food, hunting and sport, controlling pests, escapees, aviculture, and accidental introductions (Long 1989). Some releases of waterfowl are examples of birds that were introduced for aesthetic reasons. Birds such as the mute swan (*Cygnus olor*) gave social status to those who released them on their lands (Long 1989). However, the successful introduction of nonindigenous birds has caused problems such as competition for resources, the introduction of diseases and parasites, and damage to agricultural crops in many areas of the world (Long 1989). For example, the house sparrow (*Passer domesticus*) was introduced to control dropworm (*Oiketicus* sp.) in the United States but has been accused of spreading the cestodes and nematodes in poultry (Long 1989). Other diseases that were introduced by caged bird species such as parrots are positive-Newcastle disease and influenza Type-A virus from caged birds imported from southeastern Asia into North America (Long 1989).

Muscovy Duck (*Cairina moschata*). This species, sometimes called the royal duck (Pato real), is a native of neotropical lowlands from Mexico south to Central and South America. The first release of this species in Florida was made in 1967 on Fisheating Creek in Glades County where the Florida Game and Fresh Water Fish Commission and the U. S. Bureau of Sport Fisheries and Wildlife released approximately 24 of 100 muscovy ducks that had been imported from Central and South America (Hutt 1967; Crider 1968). After the ducks arrived and were quarantined at the Miami International Airport Port of Entry, a study was conducted from July 1966 through June 1967 to determine the feasibility of the establishment of wild populations of this species in Florida. The ducks were tested on the Fisheating Creek Refuge, in the Guano River Wildlife Management Area, in the Camp Blanding Wildlife Management Area, in the Tallahassee Research Area, and in the Caribbean Gardens. The study revealed that this duck could survive in those areas. Although the attempted establishment of the birds was probably unsuccessful, the fates of these individuals are unknown. The population that is established in Florida was probably established from escaped or released domestic stock that seems to have hybridized with the mallard duck (*Anas platyrhynchos*) and other waterfowl (Robertson and Woolfenden 1992). At present, muscovy ducks are the most commonly seen waterfowl species in the waters of suburban Florida. Although muscovys ducks fight among themselves, they mingle with other ducks.

Mute Swan (*Cygnus olor*). This species is indigenous to Europe where it was domesticated by the nobility and by the wealthy (Esch 1993). This swan decorated the homes of the rich and was immortalized in the literature by Yeats and Hans Christian Anderson and by music by Tchaikovsky. Most wild mute swans in the Atlantic Flyway (a corridor from Quebec, Canada, to Florida) are related to captive swans that were released in southeastern New York around 1910 (Esch 1993). The number of wild mute swans has increased by 3,000 since 1987 and now exceeds 8,000 in the Atlantic Flyway, (Esch 1993). Since the 1960's, this species has been reported in Bay, Brevard, Dade, De Soto, Hillsborough, Martin, Palm Beach, and Polk counties (Robertson and Woolfenden 1992). The mute swan is not established in Florida.

Although it can be aggressive and even dangerous to other birds in its territory, the mute swan is one of the most popular captive birds. It eats large amounts of water plants; aggressively defends its nesting area (as large as 4 ha) against ducks, geese, and canoeists; and fouls beaches and reservoirs with cigar-size droppings (Esch 1993). In New York, mute swans have foiled attempts to restore wetlands along the Hudson River. These birds eat new plants as quickly as they are planted (Esch 1993). Chuck Keene, a naturalist at the Museum of the Hudson Highlands, New York, stated that although the mute swans are aesthetically pleasing, they reduce the river's ability to sustain the Atlantic fishery, native waterfowl, and native muskrats (Esch 1993). Eradication has centered on shaking swan eggs to kill the developing embryo, shooting the swans, or trapping and sending the swans to zoos or to private ponds; however, many people do not want the swans killed because they are aesthetically pleasing.

Black Swan (*Cygnus atratus*). The black swan is a native to Australia and less aggressive than the mute swan. Black swans have been reported in Hillsborough, Monroe, Orange, Palm Beach, and Polk counties in 1961 and in the 1980's (Robertson and Woolfenden 1992). Although this species is not established, populations may increase, and control measures such as hunting and the harvesting of eggs may become necessary.

Greater Flamingo (*Phoenicopterus ruber*). Until at least 1902, several thousand flamingos migrated annually (June-February, timing variable) from the West Indies (possibly northwestern Andros, Bahamas) into the Florida Bay to molt (Robertson and Wolfenden 1992). In January 1931, a flock of flamingos was shipped to Miami from Cuba and released on the Hialeah Race Course (Allen 1954, 1956). The birds were not pinioned and flew away 1 day after the release. Although wild flamingos were often reported in Florida in the 1930's, breeding colonies were never established. However, in 1942, another flock was pinioned and introduced, and a yearly breeding colony of 65 birds was established (Terres 1980). Because of their resistance to harsh conditions such as high levels of chlorides, sodium carbonate, sulfates, and fluoride, and low ambient temperatures of 68°, greater flamingos are used as tourist attractions in areas that other species cannot tolerate.

Because of the remoteness of their habitats in the wild and their diet of algae and invertebrates, flamingos rarely conflict with human economic interests (del Hoyo 1992). The only reported conflict arose when humans moved the Camargue rice fields of Florida into the flamingo's habitat in 1978 and the birds crushed the rice plants during foraging at night (del Hoyo 1992).

Scarlet Ibis (*Eudocimus ruber*). The natural distribution and breeding range of the scarlet ibis is confined to northern South America. Although 17 birds fledged from 24 scarlet ibis eggs that were introduced into the nests of white ibises (*Guara alba*) in the rookery of Greynolds Park, this species is not established in Florida (Bondy 1962). Birds from Dade County have interbred with resident white ibis populations (Quincy 1977). Birds often escaped from the Bush Gardens in Tampa (Robertson 1962). Scarlet ibises outside the species' breeding range are usually individuals that were transferred by storms or by humans (Quincy 1977). This species is expected to disappear soon because it currently exists in an urban area where frequent disturbances preclude breeding. Human encroachment, pollution, predation by cats, and nest competition also preclude establishment (Quincy 1977).

White-cheeked pintail (*Anas bahamensis*). At one time, the Florida Game and Freshwater Fish Commission desired to introduce the white-cheeked pintail (also known as Bahama pintail and Bahama duck) in Florida to alleviate hunting pressure on the mottled duck (*Anas fulvigula*) that is native to Florida. This introduction was not made because the Bahamian government would not trade white-tailed deer (*Odocoileus virginianus*) for this species for fear of introducing diseases of the Florida population of white-tailed deer into the deer populations on their islands (Evans 1960). The white-cheeked pintail was probably the most promising species for introduction and establishment because its northernmost native range was only 80 km from the Florida mainland, indicating a strong probability of survival in Florida (Evans 1960). Pough (1951) indicated that in Florida the white-cheeked pintail was historically hunted near Cape Canaveral and that it may have naturally occurred in Florida as a rare vagrant (Robertson and Woolfenden 1992). Although the Florida Game and Freshwater Fish Commission viewed the white-cheeked pintail as an excellent buffer species for the mottled duck, Sincock (1957) pointed out the possibility of a population explosion of the white-cheeked pintail if it were established. The white-cheeked pintail is not only a prolific breeder but vulnerable to excessive hunting (Evans 1960). Odum (1954) stated that management of an established native species with recreational value such as the mottled duck is wiser than the introduction of a nonindigenous species. Therefore, in 1960, Evans (1960) concluded that the white-cheeked pintail should not be introduced in Florida.

Nonindigenous Nonaquatic Birds of Special Interest

Red-whiskered Bulbul (*Pycnonotus jocosus*). This species is native to Burma, East Pakistan, Thailand, South China, and the lowlands of eastern India (Reilly 1968). In 1960, 5-10 red-whiskered bulbuls, originally from Calcutta, India, escaped from captivity at the Miami Rare Bird Farm and established themselves in a suburban area in the southern fringes of Miami, Florida (Owre 1973). They first nested in 1961, and by 1969-1970 the population had increased to 250 (Carleton and Owre 1975). Carlton (1971) studied the species in the Dade County environment. She estimated that during the first 10 years of the bird's establishment in Dade County, the annual increment of the total population was 30-40 percent. Because the red-whiskered bulbul's native habitat and southeastern Florida have similar climates and because many of southeastern Florida's exotic plants are also from India, the red-whiskered bulbul easily adapted to its new environment (Stoll 1977). In Florida, the red-whiskered bulbul eats the fruits of the Brazilian pepper tree (*Schinus terebinthifolius*), the fig tree (*Ficus* spp.), and jasmine (*Jasminum* spp.) and the drupes and berries of 24 other small exotic plant species that proliferate in residential areas (Carleton and Owre 1975). Many people have also purposely attracted these birds by putting up feeding stations around homes.

Although exotics can become nuisances at any time, the red-whiskered bulbul has not yet become a threat. Robertson and Woolfenden (1992) reported that red-whiskered bulbul populations have spread minimally and are barely surviving. Stoll (1977) believed that the red-whiskered bulbul may be in competition with the mockingbird (*Mimus polyglottos*) because the food habits of the two species are similar. If its populations grow substantially, the red-whiskered bulbul may pose future problems to fruit growers. The only real danger that now exists is the bulbul's diet of Brazilian pepper drupes. The bird may become a major pathway by spreading the seed of the Brazilian pepper in Florida. As the birds fly to new areas, viable seeds from droppings germinate. The red-whiskered bulbul may also intensify the spread of this noxious exotic (Stoll 1977).

Cattle Egret (*Bubulcus ibis*). Although the cattle egret is not typically classified as an aquatic species, it is a nonindigenous species with high visibility. This species belongs to a taxon that is known to peregrinate or migrate (Owre 1973). Because this species may have migrated to the New World and to Florida on its own, it may not be an exotic species. The cattle egret's pathway of introduction is unknown. However, its sudden appearance, increase in numbers, and range expansion soon after it was first observed are similar to those of other exotic species. W.E. Dilley first discovered the cattle egret in the United States near Clewiston, Hendry County, in summer 1941, and on 5 May 1953, G. Chandler and S.A. Grimes found nesting individuals of this species at King's Bar, Lake Okeechobee (Sprunt 1955). In summer, cattle egrets are now common throughout Florida except in the Keys; during winter, the abundance of these birds considerably declines (Robertson and Wolfenden 1992). Unlike most exotic birds, the cattle egret invaded Florida on its own (Owre 1973).

The cattle egret established itself because it can easily adapt its diet to the habitat. This species is most noted for its adaptability and non-competitiveness (Sprunt 1954). Cattle egrets are most typical on pastures where they follow cattle or plows and prey on flushed insects, including insects that are considered pest species and fill empty niches. Although the cattle egret nests in the same colonies and forages on the same grounds as the native herons (Family Ardeidae), its variable diet precludes serious competition with other heron species (Fogarty and Hetrick 1973). Because of its status as an adaptive, non-competitive species, the cattle egret was deliberately introduced to the Seychelles and to the Hawaiian Islands to control flies (Long 1989). However, the cattle egret preys on the eggs of ground-nesting birds in Africa and America (Cunningham 1965). Although the bird is considered a pest by many environmentalists, it consumes many insects and to our knowledge has not created major environmental problems.

Budgerigar (*Melopsittacus undulatus*). The budgerigar, commonly known as the budgie, is indigenous to interior Australia. Budgerigars are popular pets throughout the world but are established only in Florida (Forshaw 1973). This species nested in Pinellas County as early as in the 1950's (Robertson and Woolfenden 1992). It nests at Horseshoe Beach, Dixie County; in Hudson, Pasco County, south to Fort Myers, Lee County (Wenner and Hirth 1984); and in Naples, Collier County. Budgerigar may once have been established around Jacksonville, Duval County, but no further sightings have been made in this area (Robertson and Woolfenden 1992). At one time, a population of budgerigars in St. Petersburg was so large, it was a tourist attraction (Owre 1973). Many sightings were reported elsewhere in the peninsula, in the Keys, and in the panhandle of Florida (Robertson and Woolfenden 1992). Populations of budgerigars peaked at many thousands in the later 1970's and declined in the 1980's (Robertson and Woolfenden 1992). Although the population sizes and the number of locations declined, budgerigars may still be seen throughout southern Florida. They inhabit watercourses, sparsely timbered grasslands, dry scrublands, open plains, and residential areas of southern Florida, and Immelman (1968) believed that they are the most prolific Australian parrot of the United States.

Nonindigenous Aquatic Mammals in Freshwater Systems

At least 28 nonindigenous mammals have been reported in Florida (Tiebout 1983). The only nonindigenous aquatic mammal in Florida is the nutria *(Myocastor coypus.)* Two highly visible, nonindigenous terrestrial species are the nine-banded armadillo (*Dasypus novemcinctus*) and the feral hog (*Sus scrofa*; Table 10). Layne (1984) discussed the distribution and taxonomy of the terrestrial mammals of Florida.

Nutria (*Myocastor coypus*). The nutria is a rodent that is native to temperate Argentina, Bolivia, Chile, Paraguay, and Uruguay in South America (Rue 1967). In South America, the nutria is exploited for its pelt, but in the United States, the quality of the pelt is poor and the meat is unpalatable.

Will Frakes of Elizabeth Lake, California, originally brought this species into the United States in 1899 (Hodgson 1949). The animals were introduced into the wild in the United States in the 1930's when E. A. McIlhenny released six pairs on Avery Island, Louisiana, to start a commercial fur farm. Within 2 years, several individuals escaped from the island, and a viable population established itself in Louisiana (Dozier 1951). In 1940, a hurricane washed the entire colony of 150 nutria off Avery Island into other parts of Louisiana. Since the storm, the nutria population expanded to 1 million individuals in Louisiana (Griffo 1957). The nutria eventually spread throughout Alabama, Georgia, Mississippi, Texas, and--in the early 1950's--Florida through immigration and importation and release of breeders (Anonymous 1955). Already established populations north of Florida easily expanded their range by simply following water courses to the Gulf of Mexico (Tiebout 1983). Individuals that escaped from 20 or more fur farms in the 1950's contributed to the establishment of the nutria in Florida (Griffo 1957). Belfiore (1991) reported that by 1991 the nutria population increased exponentially to more than 10 million individuals. As Tiebout (1983) commented, escape rates may have increased as fur farmers' profits decreased.

Nutrias were released in Blountstown, Palatka, and St. Petersburg for the control of aquatic vegetation (Tiebout 1983). More specifically, Griffo (1957) reported seven records of feral nutrias in North Choctawhatchee Bay, East Choctawhatchee Bay, the mouth of the Apalachicola River, the mouth of the Swannee River, Cedar Keys, Otter Spring Run in Gilchrist County, and the Hillsborough River. In these areas, nutrias do not have natural predators, and they thrive in various polluted runoff canals, ponds, and barnyards of several large commercial dairies in the Brandon area (Brown 1979). Although they consumed large quantities of undesirable aquatic and shoreline vegetation, the nutrias also consumed large amounts of desirable aquatic vegetation and farm crops, competed with muskrats (*Ondatra zibethicus*) and waterfowl, and created extensive tunnels in pond and canal banks. The species gradually expanded its range into central Florida, and eradication was necessary when damage from tunnelling became severe (Brown 1979).

Florida has an abundance of suitable habitat for the nutria, and the nutria's fecundity of 5-8 young/litter and 2-3 litters/year is high. This combination is detrimental to the environment (Tiebout 1983). The nutria's natural South American habitat is composed of vegetation such as saw grass (*Cladium jamaicense*), giant cut-grass (*Zizaniopsis miliacea*), southern bulrush (*Scirpus californicus*), and maidencane (*Panicum hemitomom*; Atwood 1950). These plants are also typical in Florida and point toward the inevitability of a population expansion that has not yet occurred. Although the nutria occurs in the northern two-thirds of the state, including most of the panhandle, the population may be classified as stable to declining (Tiebout 1983). However, in 1959, the state passed Florida Statute 372.98 that labeled the nutria a public nuisance. Consequently, all nutria farmers have to have licenses, the release of animals is prohibited, and cage guidelines are mandated (Tiebout 1983). Smith (1969) described the nutria as an undesirable alien that residents of Florida should eliminate on sight (Tiebout 1983).

The nutria was once expected to be a good biological control agents for unwanted aquatic vegetation (Griffo 1957). However, when it was imported into Texas to control cattails (*Typha* spp.), arrowheads (Family Juncaginaceae), water lilies (Family *Nymphaeaceae*), and other noxious water weeds, it eradicated the targeted plants and everything else in the area. In a short time, the lakes were changed into denuded potholes that were not even suitable habitat for the nutria (Rue 1967). Nutrias also break levees in rice and sugarcane fields by enlarging muskrat burrows around levees or by cutting directly into the levees. The levees break and eventually crops are flooded and destroyed. (Waldo 1958). Nutrias also feed on crops of cabbage, corn, lettuce, and peas (Waldo 1958) and occasionally damage highway bridges and culverts by burrowing around them (Waldo 1958). Nutrias benefit the environment by opening dense stands of vegetation and thereby creating habitat for duck food plants such as millet.

Nurtrias may also be the vectors of wildlife diseases. Waldo (1958) noted that the diseases most commonly associated with the nutria are tuberculosis, false tuberculosis, and septicemia. Diseases associated with an abundance of nutrias and their excretions are parathypiod and parasitic infections. Transmission of the diseases by infected nutrias may harm native species.

The only reported economic impacts that the nutria has had in Florida is the marginal amount of money that can be made from the farming of the nutria for fur and the damage to crops, ornamental shrubs, irrigation dikes, and berms. However, nutria fur has never been a popular commodity in the United States, and profits from the fur have been low. Rue (1967) noted that the only people who can make money from the nutria are those who sell the breeding stock. Furs sold for less than $10/piece on the 1967 market; however, the market is highly variable. In 1943, 436 pelts were harvested; by 1950-1951; 78,422 pelts were harvested; and by 1957, more than a half million pelts were harvested and farmers began to complain about encroachment of the nutria into rice and cane fields (Waldo 1958). In the future, the nutria may become a good source of meat for consumption by humans and animals (Waldo 1958).

Nonindigenous Nonaquatic Mammals of High Visibility

Nine-banded armadillo (*Dasypus novemcinctus*). Since 1922, the nine-banded armadillo has been one of the best studied nonindigenous mammals in Florida (Tiebout 1983). A member of the U.S. Marine Corps, who was stationed at Hileah, Florida, brought a pair of nine-banded armadillos from Texas and released it at the end of his enlistment. In February 1924, a pregnant nine-banded armadillo was killed near the area, indicating that this species was already reproducing in the wild. Another introduction was made in 1922 when Gus Edwards brought a pair of nine-banded armadillos from Texas and placed them in a private zoo in Cocoa, Brevard County. This pair escaped within 2 days and was sighted several months later at a distance of 4 km at Williams Point (Newman 1949). Some residents of Volusia County believe that the original introduction was made near New Smyrna in the early 1930's, and others believe that nine-banded armadillos were introduced into the wild when a circus truck overturned near Titusville in 1936 (Anonymous 1980).

Irrespective of its introduction, an abundant breeding population of nine-banded armadillos was established in the four adjoining counties of Brevard, Flagler, Putnam, and Volusia, and by 1949, the nine-banded armadillo expanded its range to 29 of Florida's 67 counties. In the 1960's, the nine-banded armadillo was introduced to Captiva and Sanibel islands (Layne 1984). Fitch et. al. (1952) reported the nine-banded armadillo occurs in Brevard, Flagler, Indian River, Orange, Osceola, Seminole, St. Johns, St. Lucie, and Volusia counties; in the adjacent parts of Lake, Martin, Okeechobee, Polk, and Putnam counties; and in small communities in Alachua, Broward, De Soto, Hamilton, Hardee, Hendry, Lee, Manatee, Marion, Nassau, Palm Beach, Pasco, and Sumter counties. The trend is a westward expansion into the panhandle by the Floridian population and an eastward expansion by the Texan population (Tiebout 1983). Humphrey (1974) concluded that the armadillo would have arrived in Florida on its own based on the characteristics of the animal and the existence of favorable habitat throughout the southeastern United States. He also believed that the armadillo would eventually spread to Florida from Texas as a result of its ability to survive and the disrupted habitats that humans created.

According to Neill (1952), the preferred habitats of the nine-banded armadillo are the drier areas of slash pine (*Pinus caribaea*) and wire-grass (*Poa compressa*) flatwoods, abandoned fields, rosemary (*Andromeda* sp.) scrub, and stands of turkey-oak (*Quercus catesbaei*)-longleaf pine (*Pinus palustris*), and gardens, cultivated fields, and orange (*Citrus aurantium* and *Citrus sinensis*) orchards. In general, the nine-banded armadillo is most successful in riparian habitats with rich leaf litter (Humphrey 1974). The nine-banded armadillo is an opportunistic species that flourishes in communities that are disrupted by the cutting of forests, grazing of cattle, and production of agricultural crops. The reduction of large carnivores, such as the red wolf (*Canis rufus*), coyote (*Canis latrans*), black bear (*Ursus americanus*), and others and concomitant reduction in predation also promote the spread of the nine-banded armadillo (Fitch et al. 1952).

The degree of competition by the nine-banded armadillo with native species and the extent of the nine-banded armadillo's altering of ecosystem in Florida are unknown. The animal's major food items are insects (78.5%) and miscellaneous invertebrates (19.1%) and includes amphibians and reptiles (1.0%); mammals, birds, and birds' eggs (0.5%); and vegetable matter (0.8%; Bushnell 1952; Nesbitt et al. 1977).

The most important economic benefits from the nine-banded armadillo is its predation on noxious arthropods such as the scarabid beetles that profoundly damage plants (Fitch et. al. 1952). Although it destroys scarabid beetles, the nine-banded armadillo also destroys insectivorous prey, spiders, scorpions, centipedes, small lizards, and amphibians (Fitch et al. 1952) and may therefore partly offset its consumption of beneficial insects. Armadillo burrows also serve as homes for fur bearers. Taber (1945) reported five opossums (*Didelphis virginiana*), five cottontails (*Sylvilagus floridanus*), four cotton rats (*Sigmodon hispidus*), one skunk (*Mephitis mephitis*), two burrowing owls (*Athene cunicularia*), and six nine-banded armadillos in a series of 50 burrows that were excavated in Chambers County, Texas. The harmful actions of nine-banded armadillos are the destruction of quail eggs, destruction of domestic poultry, damage by burrowing, damage to crops, competition with hogs, destruction of pine (*Pinus* sp.) seed, and interference with hunting and livestock handling (Fitch et al. 1952). Other positive impacts of the nine-banded armadillo include the destruction of many insects and other noxious pests, predation of venomous snakes, creation of shelter for other wildlife, cultivation and fertilization of soil, contribution of materials for the curio trade, and a source of human food (Fitch et al. 1952). As a result of their studies, Hall and Kelson (1959) concluded that the armadillo is a "natural and desireable part of the native fauna".

However, other biologists strongly contest that the nine-banded armadillo has harmful consequences for native communities because it is a major cause of leaf-litter and other ecological disturbances. The drying effect of turned-over leaf litter depletes the prey base for other insectivores and therefore reduces the food base for native amphibians and reptiles and for ground-dwelling birds (H.M. Tiebout, Professor, Department of Biology, West Chester University, Pennsylvania, personal communication).

Feral Hog or European Wild Boar (*Sus scrofa*). The domestic pig's current status is domestic, semidomestic, feral, introduced, and immigrant (Tiebout 1983). It has this status because the domestic pig and the European wild boar are classified as the same species and freely interbreed. Any attempt to differentiate wild and domestic stock is futile because of the continuous interbreeding. Hogs were originally introduced into Florida by Spanish explorers more than 400 years ago (Frankenberger and Belden 1976), and in 1912, a wild stock of hogs was introduced for hunters into the mountains of Tennessee and North Carolina (Jones 1959). This wild boar population probably expanded to Florida on its own while other hogs were simultaneously introduced repeatedly by Florida sportsmen (Tiebout 1983). The feral hog population continues to breed with escaped domestic stock, which widens their genetic diversity (Tiebout 1983). Most free-roaming hogs are classified as semi-domesticated because of what is known as "hog claims" or the entitlements of land owners to lay claim to all hogs on their lands (Tiebout 1983). When feral hogs exist in large numbers, they may harm agriculture, forestry, wildlife, and natural ecosystems (Tisdell 1982), primarily because of their habit of rooting while foraging. This behavior may disturb large patches of land (250 m^2 or more). Rooting can destroy understory vegetation and habitat for ground-nesting birds, terrestrial salamander, and other animals and may cause soil erosion (Belden and Pelton

1975). More specifically, rooting disrupts vegetative communities and successional patterns and alters nutrient cycling. Therefore, feral hogs directly and indirectly hurt other wildlife with predation or with alteration of the forest-floor habitat (Tate 1984). Thompson (1977) hypothesized that the wild hog is a notable competitor for food with many wildlife species such as deer (*Odocoileus virginianus*), turkeys (*Meleagris gallopavo*), squirrels (Family sciuridae), and waterfowl (*Anatidae*). An inverse relation between higher predation by snakes where hog populations are low suggests that wild hogs may use snakes as a prey base and therefore reduce predation by snakes (Thompson 1977). Thompson also concluded that the European wild hog is a minor predator of bird eggs and nestlings. Indirect evidence exists that hogs may take injured wildlife such as deer (*Odocoileus virginianus*) and newly dropped fawns (Belden 1990). Wild hogs may also pose a serious threat to the traditional, coastal nesting areas for marine turtles, especially the loggerhead turtle (*Caretta caretta*; Thompson 1977). Feral hogs frequently are in the same areas as domestic sheep and cattle and thus elevate the possibility of transmission of any disease to livestock. Because humans altered the populations of predators on the feral hog, wild hog populations may increase to damaging levels without human intervention (Tisdell 1982). Feral hogs can serve as vectors of diseases and parasites to domestic pigs (Becker et al. 1978; McVicar et al. 1981; Forrester et al. 1982; and Greiner et al. 1982). The hogs are able to smell dead animals, which may carry diseases and parasites and become infected while feeding on the carcasses and subsequently spread diseases and parasites to other species, including domesticated hogs.

Wild hogs are officially regarded as pests, and their eradication is a desirable, if as yet unattainable, goal (Tisdell 1982). However, if feral hogs were eradicated, the landowners but not the hunters would be accommodated (Tisdell 1982). The only minimal benefit from feral hogs is their consumption of the larvae of leaf-eating beetles, and their rooting may promote the regeneration of cypress pines (*Taxodium* spp.; Tisdell 1982).

Although the feral hog does not benefit the environment, it has economic significance (Belden 1990). Because hogs are hunted widely, they are an important source of income and an important source of food. However, cost-benefit analyses are subjective because costs and benefits depend on the current market and on the opinions of the evaluators (Tisdell 1982). "In order to reduce the population of wild hogs, two types of policy measures have been adopted: (a) the declaration of the wild hog as a noxious animal, and (b) the payment of bonuses or royalties on hog snouts" (Tisdell 1982:381). These actions may, however, promote the peoples' preservation of this species for monetary gains.

The feral hog also harms agriculture (Tisdell 1982). It competes with cattle and sheep for grass; damages fences, dams, watering points, and roads; and promotes erosion by its wallowing and digging habits.

Although feral hogs also cause many economic problems, people continue to replenish stocks of hogs because they are a principal game species (Belden 1990). They are in areas such as the Everglades (Everglades Recreational Planning Board 1974) and the Big Cypress Swamp. During a 1980-81 survey, an estimated nearly 21,000 hogs were killed (Belden 1990). The Florida Game and Fresh Water Fish Commission considers wild hogs a valuable natural resource that can supply many days of recreational hunting, although the agency has problems with maintaining populations without restocking (Belden 1990). In the 1960's and 1970's, more than 4,500 hogs were relocated at approximately $39-$86/hog at

1990 prices (Belden and Frankenberger 1977). Another problem has been the miscalculation of restocking that created an overabundance of wild hogs (Belden 1990).

Introductions and Survival of Nonindigenous Species in the Marine Environment

Baltz (1991) estimated that 120 species of marine and euryhaline fishes were introduced around the world. He summarized that most introductions did not establish populations or had deleterious effects or, if they were deliberate, did not achieve the objectives of the responsible parties. Because marine introductions usually cannot be controlled or prevented from spreading, all introductions into marine systems must be carefully evaluated before their implementation (Sindermann 1986). To reduce future problems from introductions, the International Council for the Exploration of the Sea (Sindermann 1992a) developed a code of practice for the introduction of species. The code is generally accepted by European countries but not by New World countries (Sindermann 1992a). Mann (1979) and Sindermann (1993a) summarized the use of exotic species in mariculture.

Pathways of introduction of nonindigenous marine organisms into North American waters were reviewed by Carlton (1985, 1987, 1989, 1992a,c,d). He demonstrated that most significant introductions by humans have been organisms on the outside (fouling species) or on the inside (boring species) of ships, namely, organisms inside vessels in solid ballast such as rocks, sand, and detritus; oysters or other shellfishes and organisms on their shells or in associated sediments and detritus; intentionally released species for fisheries; and larvae, juveniles, or adults of marine organisms in the ballast water of coastal, transoceanic, and interoceanic vessels. Carlton (1985, 1987, 1989, 1992a,c,d) reviewed the relative importance of each of these mechanisms to established introduced mollusks in North America (Carlton 1992b). Another major pathway of introduction is the escape of marine species and their pathogens from mariculture operations in the coastal waters (Kohler 1992).

The recent appearances of the South American fouling bivalves *Mytella* and *Perna* in Florida and Texas suggested that the global increase in ballast-water-mediated invasions (Carlton 1985, 1987) may be a mechanism that will continue to add to the nonindigenous mollusks of the Gulf (Carlton 1992b).

Information on the present ranges of introduced marine or estuarine organisms in North American waters is incomplete, scattered, or completely lacking. A review of the literature revealed introductions of several nonindigenous species into Florida's marine or estuarine waters, not all of which survived. Four exotic fish species of the genus *Tilapia*, three plant species, five invertebrate species, and at least two disease organisms were introduced into Florida's marine waters (Table 11). Some were introduced directly into coastal waters of the state, and some entered the marine or estuarine waters indirectly after they were introduced into freshwater ecosystems and migrated into the coastal waters. Kohler (1992) provided an overview of management principles and objectives for a marine-species introduction policy.

Sindermann (1990a) discussed the effects of principal diseases of marine fishes on wild populations, especially on wild populations of economic significance. Sindermann and Rosenfield (1967) and more recently Sindermann (1990b) discussed the principal diseases of commercially important marine bivalves, molluscs, and crustaceans (including microbial pathogens, parasitic invasions, and tumors). These publications did not provide information about the status of diseases as native or nonindigenous to the United States or Florida. Kern and Rosenfield (1992) discussed shellfish health and protection, and Sindermann (1992b, 1993b) discussed the risks of importing diseases with the importation of nonindigenous marine animals. He reported that the virus IHHNV in shrimp was probably imported from Southeast Asia into aquaculture facilities in Florida. Although other nonindigenous diseases that the authors mentioned may be in Florida waters, we could find no published information that confirmed such presence.

The subject of the diseases of cultured Penaeid shrimp (*Penaeus monodon*) in Asia and in the United States is presented by Brock (1992), Fulks and Main (1992), Lightner (1988), Lightner et al. (1983), 1992a,b), and Lightner and Redman (1990). The introduction of pathogens, especially of nonindigenous viruses, with the introductions of nonindigenous shrimp species is such a threat to Florida's shrimp populations that a major effort is necessary to reduce or eliminate any chances of introducing these injurious organisms. The transfer of stocks the health status of which is unknown may pose a threat to wild populations and could also harm shrimp cultures (Fulks and Main 1992).

To reduce the number of unwanted non-native disease species introduced into marine waters, Sindermann (1993b: 8,c) recommended:

> (1) A substantial reduction in the global dissemination of diseases of aquatic organisms could be attained by the development of native species or species stocks by scientific management and aquaculture practices (including selective breeding and genetic manipulation) as an alternative to introducing nonnative species.
>
> (2) A vigorous international program of marine disease research and control should be developed by the Permanent Commission for the Study of Fish Diseases of the International Office of Epizootics. This intergovernmental veterinary organization, based in Europe, is a logical focus for the kind of coordination that will be required (de Kinkelin et al. 1990). Included would be the development of models for inspection and certification programs, standardized protocols for disease examinations, and the implementation of an effective communication network.
>
> (3) Regional maps should be developed and kept current for each host species, showing the presence and abundance of each disease that affects the species. Movement of infected animals from an area where the disease is present to one where it is absent should be prohibited.

(4) National and regional disease diagnostic centers, with supporting research capabilities, should be established to develop information about species proposed for introduction, or approved for introduction, or introduced accidentally.

(5) Specific pathogen-free stocks of marine fish and shellfish should be identified for aquaculture purposes; these stocks should be used as sources of seed. A program should be developed that is modeled on one developed principally by the U.S. Fish and Wildlife Service and already in use for salmonid hatcheries in the United States.

Sindermann (1993b:page 9,a) outlined a national policy to control the spread of all nonindigenous species. He recommended the following steps:

(1) A clear national policy on introduced species, whether the introductions are accidental or deliberate, should be developed and stated.

(2) A national system of inspection and quarantine, with adequate back-up research capabilities, should be developed and funded.

(3) An effective regulatory regime and an enforcement system to ensure that regulations are not circumvented should be developed.

(4) Proposed introductions should have clearly stated and demonstrated rational bases. Proposals that are without adequate rationale, poorly planned, or unnecessarily risky, should not be approved.

(5) Decisionmakers should be aware of, and sensitive to, the practical, economic, social, and political aspects of introductions, but should evaluate proposals principally on the basis of the available scientific data. Relevant scientific implications and viewpoints include, but are not limited to:

a) Ecological considerations -- including competition, predation, and community characteristics of species (diversity, carrying capacity);

b) Genetic considerations -- including the potential for hybridization, change in gene frequency (genetic diversity), and change or modification in disease or parasite resistance;

c) Behavioral considerations -- including interactions between native and exotic species; and

d) Pathological considerations -- including the potential for unintentional introduction of diseases and parasites.

(6) All proposed introductions should be accompanied by full and adequate procedures and provisions for post-importation (follow-up) monitoring.

Early consideration should also be given to national and international acceptance of a uniform code of practice for movements of nonindigenous marine species. A United States policy on introduced aquatic species and adoption of the precautionary principle proposed by Germany and accepted at the Second International Conference on the Protection of the North Sea in 1987 would be beneficial. That principle requires action to reduce pollution even in the absence of soundly established scientific proof for cause-and-effect relations. The principle could be applied especially for the control of accidental introductions (including pathogens) that clearly are forms of biological pollution.

Nonindigenous Euryhaline Plants

International shipping is probably responsible for the release of three species of nonindigenous plants in Florida (Schardt and Schmitz 1990). Although the original sites of the introductions may have been in marine or estuarine ecosystems, most problems by these plants are now in freshwater ecosystems. The introduced nonindigenous plants are:

Waterlettuce (*Pistia stratiotes* L.). Waterlettuce was first reported by J. W. Bratrum in 1765 (Bartram 1942), and many people now think the plant is native to Florida. There is, however, considerable evidence that the species was introduced by sailing ships from South America early during the colonization of North America. Waterlettuce is now a nuisance species worldwide.

Alligatorweed (*Alternanthera philoxeroides*; Mart. Griseb.). This plant seemingly entered the United States before 1987 as an accidental release from the ballast of sailing ships in Mobile, Alabama (Zeiger 1967). However, Schardt and Schmitz (1990) reported an unsubstantiated report that alligatorweed was present in Florida in 1890 (Weldon 1960). Alligatorweed is a problem species in this country and elsewhere.

Salvinia (*Salvinia minima* Baker). This plant was first collected in Florida during 1928 in the St. Johns River (Long and Lakela 1976). There have been two theories on its pathway of introduction; it was introduced in discharge of spore-contaminated ship ballast at the Port of Jacksonville or discarded as unwanted aquarium plants (Schmitz et al. 1991). It is now a problem species in Florida.

Nonindigenous Euryhaline Invertebrates

Turgeon et al. (1988) listed the number of mollusks that were introduced into the marine waters of North America: nine along the Atlantic Coast and 13 along the Pacific

Coast. The authors provided no additional information on the distributions of the different invertebrates in the United States or the source of their information. Several authors discussed the potential pathways of introduction of mollusks into the United States. Chew (1990) discussed the global introduction of bivalve shellfishes. Futch and Willis (1992) discussed Florida's regulations for the culture of marine species along the Florida coast. The role of cargo ballast water as a vector for introductions of nonindigenous marine species was discussed by Williams et al. (1988).

If it were not for a recent report on the introduction of the edible brown mussel (*Perna perna*) from South America (Hicks and Tunnell 1993), no records of established introduced mollusks in the Gulf of Mexico would be available (Carlton 1992b). The pathway of introduction of this mussel is uncertain. It may have been imported live for sale in the local seafood market or introduced as a fouling organism from the hulls of ships or in the ballast water discharges from the South American vessels that frequently use the nearby harbor. Because the present range of the edible brown mussel is entirely in Texas waters, it will not be further discussed in this publication.

Charru Mussel (*Mytella charruena* d' Or-bigny, 1846). This species, which is native to Venezuela and nonindigenous to Florida, was found fouling the brackish water intake of a power plant near Blount Island on the St. Johns River in 1986 (Lee 1987). The mussel was first noted on filters at the Northside Generator Plant on the St. Johns River. These 2.5 cm-long mussels occurred in substantial numbers when they were discovered and were of considerable concern to the plant manager. Because tankers from Venezuela frequent the port, the mussel may have been brought in by the vessels as a fouling organism. No recent records of this species being taken in Florida waters could be found. It seemingly disappeared by 1987 (Carlton 1992).

Saber or Mexican Crab (*Platychirograpsus spectabilis* de Man 1896). In April 1936, the sabre crab was found in Florida's waters during an ecological study (Marchand 1946) of the Hillsborough River, Hillsborough County, from near the mouth and along 16 km of the river, upstream to Sulphur Springs. The crab inhabited shallow water near logs and rocks, and the largest concentration were at the site called "Old Dam" on the Hillsborough River in Tampa. At night, the crabs come out and feed on algae and diatomaceous mats on the submerged rocks and timbers. The crab was probably introduced into the Hillsborough River during the first few months of World War I in 1915, when the Tampa Box Company imported large cedar logs from Mexico. The trees were cut in Mexico and floated down the rivers to the coast, where they were loaded onto ships and later unloaded in large rafts at the mouth of the Hillsborough River near Tampa and floated upstream to a mill station (Marchand 1946). Inquiries of the employees in the mill revealed that they had observed live crabs under the bark and in the cracks in the logs. After the first observations, none was recorded of them being present for many years. The construction of a dam on the Hillsborough River may have prevented the crabs from moving into warmer freshwater springs during the cold winter months, thereby causing the disappearance or decline of the crab. For nearly 40 years, no new observations were reported until the early 1980's, when Gordon Stevens of Riverview, Florida, found the crab and brought it to the attention of Marthe Kjeer, a Riverview resident (Flinchbaugh 1984). In 1984, Kjeer and Manny Lopez, a Southwest Florida Water Management District employee, exploring the vicinity of Buckhorn Creek, a spring-fed tributary of the Alafia River, found more crabs. The crab was later identified by Dr. Wayne Price, Marine Biology Professor, University of Tampa (Flinchbaugh 1984) as the sabre crab. No additional recent published information could be found on this species, and its present status is unknown.

Benedict's Wharf Crab (*Armases benedicti* Rathbun, 1897). This crab is native to Brazil, Guyana, and Surinam, (Rathbun 1918). It was collected only once at Key West, Florida, in 1918 (Gore 1982). Although the species is presently on Florida's Rare and Endangered Biota List, the status of this species is an endangered species or an exotic species that was introduced into Florida and only survived in the Key West area for a short while before disappearing is questionable.

Indo-West Pacific Samoan Crab (*Scylla serrata*). This crab was purposely introduced into Florida to establish a commercial crab fishery. (D.K. Camp, Florida Marine Research Institute, Department of Environmental Protection, St. Petersburg, Florida, personal communication). The present status of this introduction is unknown.

Jumbo Tiger Shrimp (*Penaeus monodon* (Fabricius, 1798)). This shrimp is a native to southeast Asia, the Philippines, and Australia. It can reach a length of 26.5 cm and a weight of 150 g. It is one of two species of nonindigenous shrimp that were identified as having aquaculture potential in the coastal areas of the southeastern United States.

The jumbo tiger shrimp can survive in freshwater and in estuarine habitats with salinities of 3-35 o/oo and temperatures of 25-33oC. Licop (1988) discussed the required water quality parameter ranges for culture of the tiger shrimp. Freshwater temperatures must be 28-31° C, sea water temperatures must be 24-31° C with a salinity of 28-33ppt. The other requirements for the culture of this species, including spawning, feeding, culture, and disease control were described in detail (Motoh 1981, Anonymous 1988, Solis 1988). The culture of shrimp in the western hemisphere and its status were described in detail (Hanson and Goodwin 1977).

In 1988, the Waddell Mariculture Center, Bluffton, S.C., which was conducting research education and extension services on this species, had an accidental release from its facility into a stream that terminates in coastal waters. The center had imported 200,000 post-larvae from the Hawaii Department of Aquaculture. The number that escaped is unknown, but approximately 1,000 adults were later recaptured by commercial shrimpers along the East Coast of the United States as far south as Cape Canaveral, Florida. The species has not been taken in recent years and is not believed to be established. There is no indication that any nonindigenous diseases were introduced. The winter water temperatures along the northern Florida coasts are believed to be too cold for the survival of the jumbo tiger shrimp.

Pacific White Shrimp (*Penaeus vannamei* Boone). The native range of the Pacific white shrimp extends along the west coasts of North and South America from the Gulf of California to Peru (Perez-Farfante 1988). Nonindigenous shrimp have been used in aquaculture in the southeastern United States, including Florida, Georgia, and South Carolina (Rosenberry 1983). The Pacific white shrimp is the second nonindigenous shrimp species with potential for aquaculture in the southeastern coastal United States.

In 1985, many shrimp farms in South Carolina began importing and stocking postlarvae of the fast growing Pacific white shrimp (Sandifer et al. 1988). The species continued to be the shrimp of choice by these farmers (Wenner and Knott 1992). Sandifer et al. (1988) discussed the intensification of shrimp culture in South Carolina. The growing season for shrimp in South Carolina and in other parts of the southern United States is limited to 5-7 months. United States farmers must maximize production during this period. At one time, the pond culture of penaeid shrimp in South Carolina was sizable with at least 18 different privately owned shrimp farms (Wenner and Knott 1992). The present status and history of marine and freshwater shrimp farming in South Carolina and in Florida was summarized by Hopkins (1991). He stated, however, that there has never been a large-scale marine or freshwater shrimp culture in South Carolina that could be considered an economic success. To prevent the escapement of cultured nonindigenous shrimp into the wild, South Carolina adopted a series of terms and conditions for the culture of penaeid shrimp in coastal waters.

However, specimens of the Pacific shrimp, including sexually mature males, were confirmed as present in the commercial trawl fishery in fall 1986 in the mouth of the North Edisto River,S.C. (South Carolina Wildlife and Marine Resources Department 1990). They were probably escapees from culture facilities there is no evidence that the species is established in the area. To document and track the introduction of nonindigenous shrimp into open-water coastal ecosystems in the future, Wenner and Knott (1992) recommended that monitoring be established in the coastal waters of Georgia and Florida.

The wild-caught native shrimp fishery in Florida during 1987 was valued at $50 million (ex vessel; Karen Steidinger, Florida Department of Natural Resources, personal communication). Any introductions of a nonindigenous species or their diseases that threaten this industry should be carefully evaluated.

Commercial cultivation of shrimp in coastal embayments, ponds, and tanks along Florida's coastline was attempted but proved to be uneconomical because of the winter water temperatures. The culture of shrimp in Florida was conducted in small, densely stocked tanks and ponds with rapid circulation and frequent exchange of seawater and heavy feeding with costly pelleted feed. After a few years, the industry moved to Central and South America (Shireman and Lindberg 1985). In that area, the shrimp are raised in extensive systems in larger ponds; sparse natural populations are brought in with the sea water while filling the ponds. Little supplemental feeding is required. Facilities farther south can also produce as many as 3 crops/year and have reduced labor costs (Shireman and Lindberg 1985). Culture of smaller shrimp for bait in the recreational saltwater fishery may develop in Florida.

Winter water temperatures along the northeastern Florida coast are now considered lethal to the Pacific white shrimp and unsuitable for the culture of this species. Nevertheless, concern that nonindigenous shrimp may become established and adversely affect the native shrimp populations continue. This species seemingly has not been released into Florida waters.

The introduction of any nonindigenous shrimp species into the waters of the United States is of much concern, not only because of possible direct effects on the native species if the nonindigenous organism becomes established in Florida's coastal waters but because of the possible introduction of nonindigenous disease organisms as well. Sindermann (1992b,1993) discussed the risk of importing nonindigenous marine species and their pathogens for either aquaculture or for release into the wild to establish new populations. The incidental spread of pathogens with the intentional transfer of species into new areas is a serious problem. These pathogens may be a threat to cultured species and to native shrimp in the surrounding open waters. Several shrimp species in aquaculture in the Southeast carry several disease-causing pathogens (red disease, cramp tail disease), and various bacterial, fungal, and viral infections). These diseases have been spread outside their native ranges and pose a threat to hatcheries and any open waters where the species escape or the effluent is allowed to enter. The virus IHHNV, Infectious Hypodermal and Hematopoietic Necrosis virus, is of particular concern (Rosenberry 1983; Lightner et al. 1989). The Pacific white shrimp is a known carrier of IHHNV and increases the concern for native shrimp populations that may become infected if the virus is introduced. Lightner et al (1989) discussed the concerns about the spread of viruses (IHHN, MBV, and HPV) to native wild penaeid stocks by releases from culture facilities.

Nonindigenous Euryhaline Fishes

The four species of *Tilapia* were first introduced into marine waters when they were released or escaped from fish farms into freshwater and migrated downstream into coastal waters (Southeastern Biological Science Center, National Biological Survey, Gainesville, Fl., unpublished records) The one possible exception could be the introduction of the blackchin tilapia on the east coast of Florida that may have escaped from the reflection pond in front of the Civic Center in Satellite Beach, Florida, where it was used as an algae control agent (Dial and Wainright 1983).

Blue Tilapia (*Tilapia aurea*). This species invaded the coastal waters of Tampa Bay and Boca Ciega Bay near St. Petersburg in southern Pinellas County, Florida, in 1978 (Courtenay and Hensley 1979a). Hensley first learned of the observation or collections of specimens in the Bayboro Harbor area in January and February 1976 and collected some specimens from Salt Creek in 1978. The population in the western Tampa Bay probably entered the bay from Lake Maggiore, St. Petersburg, where blue tilapia had been established for many years. The introduction into Lake Maggiore was probably the result of escape or release from a nearby aquaculture and subsequent migration downstream. The blue tilapia has been nesting in the saline waters of Tampa Bay (Courtenay et al. 1986). Loftus (1986) reported that this species existed in the estuarine waters of the Everglades National Park.

Blackchin Tilapia (*Tilapia melanotheron*). This species is native from Senegal to Gabon in West Africa. It was imported into the United States by tropical fish dealers and sold as a popular tropical aquarium fish (Axelrod and Schultz 1955). There was some early confusion about the correct identification of this species (probable synonyms include *Tilapia macrocephala* (Bleeker) and *T. heudeloti* (Aronson 1949)). The early established populations of *Tilapia* along the east coast of Tampa Bay probably consisted of only *T. melanotheron*. The introduction of this species was probably an escape or accidental release from a fish farm in the mid-1950's. The present distribution of this species on the west coast of Florida extends from the Alafia River southward along the east shore of Tampa Bay to Cockroach Bay, Manatee County (Springer and Finucane 1963; Finucane and Rinckey 1964; Buntz and Manooch 1969b; Lachner et al. 1970; Courtenay et al. 1974).

The blackchin tilapia was first caught in Hillsborough Bay in late summer 1959 in a gillnet set by mullet fishermen between Mangrove Point and the Alafia River (Springer and Finucane 1963). In 1962, one commercial fish dealer sold 1,589 or 2,043 kg of tilapia from the west coast population. The most consistent collecting sites was near Dug Creek that received drainage from a fish farm (Finucane and Rinckey 1964). Springer and Finucane (1963) reported hearing that one tropical fish farm went out of business and dumped its entire fish stock into a local stream (Springer and Finucane 1963). This one action could be responsible for many of the exotic fish species that are established in the Tampa Bay area.

In 1962, regular sampling was initiated in the area as part of the East Gulf Estuarine Program on Tampa Bay (Finucane and Rinckey 1964). An ecological and life history study of the fishes was conducted. At that time, the distribution of the blackchin tilapia extended from the Alafia River to Mangrove Point along the eastern shore of the Upper Tampa and Hillsborough bays. More recent sampling indicated the species migrated up the freshwater streams such as the Alafia River. In this river, it migrated upstream into the headwaters, Lithia Springs, where it and the blue tilapia became a dominant species, replacing many native species (personal observation). Springer and Finucane (1963) stated that this species was well established in the Little Manatee River system in Ruskin.

On the east coast of Florida, the first collection of the blackchin tilapia was in the Indian River system in 1980 near Satellite Beach, Brevard County (Dial and Wainright 1983). The species is now well established in Brevard County, in the estuary, in canals near Satellite Beach, and in the Indian and Bananna rivers from Merritt Island southward to Canova Beach, a distance of 27 km (Dial and Wainright 1983). The species was abundant in shallow estuarine waters, coastal lagoons, and canal systems (Dial and Wainright 1983) where it prefers quiet backwater habitats with aquatic vegetation and mucky, organic substrate (Jennings and Williams 1992).

Whether the establishment of this species on the east coast of Florida was the result of released fishes from local fish farms, transplanted fishes by commercial fishermen from the west coast of Florida to establish a fishery, released fishes by anglers for bait, or escaped fishes from the Satellite Beach reflection pool in front of the Civic Center is not known (Jennings and Williams 1992). The distribution of the species on the east coast of Florida in August 1990 was from Cocoa Beach to just south of the Indian Harbor Beach, Brevard County. The southern edge of the range is presently near Vero Beach.

The temperature tolerance of this species depends on the ambient water temperature before the species is subject to the colder water temperature, the rate of temperature change, the length of exposure, and the salinity (Snelson and Bradley 1978; Snodgrass 1991). Stauffer et al. (1984) found the lower lethal temperature was 15°C. Shafland and Pestrak (1982) found it was 10.3°C, whereas Jennings (1991) reported that death of the blackchin tilapia occurred at 10°C. Shafland and Pestrak (1982) and later Jennings (1991) concluded that the northern expansion of the blackchin tilapia above the Indian River system is limited by cold water temperature in winter but that southern expansion of its range is probable because of the absence of physical barriers. Similar to the blackchin tilapia population on the west coast of Florida, the east coast population can be expected to expand inland as the population expands to the south. Its impact on the invaded marine, estuarine, and freshwater ecosystems is unknown but could be significant. The native habitat of the blackchin tilapia in Africa is in brackish lagoons and estuaries. The species can tolerate salinities to at least 100 ppt and produced viable offspring in salinities from 0 to at least 35 ppt. (Jennings and Williams 1992). In closed lagoons, it acclimates to hypersaline conditions (Pauley 1976).

Temperature tolerance tests at different salinities indicated that the blackchin tilapia does not survive the winter water temperature north of its present range except for short periods of time during mild winters (Jennings 1991). Populations of this species that find a source of warm water such as a warm spring or power plant effluent can overwinter every year.

Along the east coast of Florida, this species is taken by cast netting, gillnetting, and hook and line and has entered the commercial fishery (Dial and Wainright 1983). However, the value of the present fishery for this species is unknown. No studies have been conducted to determine the impact on the native marine, estuarine, or freshwater ecosystems as the species spreads southward.

Mozambique Tilapia (*Tilapia mossambica*; Peters). This species is established in the saline parts of the Bananna River near Cocoa Beach, Brevard County (Dial and Wainright 1983), and in brackish water areas of southeastern Florida. The populations in Brevard County probably originated from escaped or released fishes from fish farms or aquarium dumps (Courtenay et al. 1974; Dial and Wainright 1983). One population was probably the result of a developer's release to control plants (Courtenay et al. 1984). No ecological or life history studies have been conducted to determine the species' actual or potential impacts on the receiving ecosystems.

Spotted Tilapia (*Tilapia mariae*; Boulenger). This species is established throughout most of eastern and central Dade County northward into southern Broward County (Hogg 1974; Courtenay and Hensley 1979b, 1980; Courtenay 1984). Hogg (1974, 1976 a,b) reported that the fish was accidentally or intentionally released by fish farms. The origin of the estuarine populations was the downstream movement of fishes from freshwater into brackish water. Information about the impact of this species on native populations or about the potential range of this species is not available. Cold winter temperatures without a source of warm-water refuge stop the fishes' expansion northward, but no barriers impede its spread to the south. In freshwater, the spotted tilapia successfully competes against smaller native fishes. It has spread throughout Broward County and into the Everglades.

Regulations for the Import of Fishes, Wildlife, Plants, and Insects

Nuisance-Plant Regulations

The federal laws and regulations for the control of introductions of plants were recently summarized and discussed (Campbell 1993; U.S. Congress 1993). In 1974, Animal and Plant Health Inspection Service of the U.S. Department of Agriculture was given the responsibility of administering the Federal Noxious Weed Act of 1974 (Public Law 93-629 - Jan. 3, 1975; 7 U.S.C.A.2801 et seq. 21 USC 111 et seq.). This responsibility included the identification of actual or potential noxious weeds, prevention of entry into the United States, early detection, and eradication of incipient infestations. "Noxious weed" was defined as "any living stage (including but not limited to, seeds and reproductive parts) of any parasitic or other plant of a kind, or subdivision of a kind, that is of foreign origin, is new to or not widely prevalent in the United States, and can directly or indirectly injure crops, other useful plants, livestock, or poultry or other interests of agriculture, including irrigation, or navigation or the fish or wildlife resources of the United States or the public health" (Part 360.100 Definitions, Section 32). The Department was given the responsibility of controlling the importation of weeds, but it does not monitor the interstate shipment of the commercially sold plants (Schmitz 1990). The act also designated 15 aquatic plant species as noxious weeds. Plant shipments from other countries are first inspected at an U. S. Department of Agriculture inspection station for agricultural pests and plants that are listed as federally designated noxious weeds. All federally designated noxious-weed species that are intentionally or accidentally imported are destroyed.

The Florida Department of Natural Resources has an agreement with plant inspection stations of the U. S. Department of Agriculture in Miami and in New York, where most tropical plants enter the continental United States, to monitor plant shipments for species listed on the list of prohibited aquatic plants in Florida.

The number of nonindigenous plant species is greater on the list of prohibited aquatic plants in Florida than on the federal list because the state of Florida believes that without control, a larger number of such plants could invade and infest southern Florida's unique semi-tropical waterways (Joyce 1991). All species on the state list are either seized or destroyed (Joyce 1991). The federal interception of the introduction of harmful plants was outlined by Williams (1980).

In 1969, the Florida State Legislature enacted a state statute (Section 403.271) that prohibited the importation, transportation, and cultivation of aquatic plants without a permit from the Department of Pollution Control (now the Florida Department of the Environmental Regulation). Jubinsky (1991) discussed Florida's rules and regulations for aquaculture plant management. In 1973, the controlling authority was transferred to the Florida Department of

Natural Resources Bureau of Aquatic Plant Research and Control (now the Bureau of Aquatic Plant Management; Goldsby et al. 1976).

In 1970 the state legislature turned its attention to the organization of the state's aquatic-plant control program. Under Chapter 372.925 FS (now 369.20 FS), the legislature enacted the Florida Aquatic-Weed Control Act in 1970. The Florida Weed Control Act of 1970 designated the Florida Department of Natural Resources as the lead agency in aquatic-plant control. In the same year, the Department of Natural Resources was given authority to regulate the importation and transportation of aquatic plants in an attempt to limit the importation of new problem species into the state (403.271 FS). In response to this directive, the Department of Natural Resources created the Bureau of Aquatic Plant Research and Control (now known as the Bureau of Aquatic Plant Management) to direct the control, eradication, and regulation of noxious aquatic weeds and to direct related research and planning (Joyce 1991).

Chapter 403.088 FS allows the temporary reduction of water quality of the treated waters (to control nuisance weeds) if the application was performed pursuant to a permit by the Department of Natural Resources and applicable pesticide laws. This statute also required the Department of Natural Resources and the Department of Environmental Regulation to enter an interagency agreement for the establishment of procedures for program approval and provisions for public health, welfare, safety, and environmental factors. These requirements resulted in the establishment of several interagency agreements and the promulgation of Chapter 16c-20, FAC, for the permitting of aquatic plant control in Florida in 1977 under the Florida Game and Freshwater Fisheries Commission (Joyce 1991).

In 1972, rules and regulations were established, and a comprehensive list of prohibited aquatic and wetland plants was developed by the Florida Department of Natural Resources to prevent the introduction of new, potentially noxious weed species. The Federal Department of Natural Resources established a prohibited plant list that consists of several species from 18 different genera. Chapter 16C-52, Florida Administrative Code, specifies the regulations aquatic plant collection, importation, transportation, cultivation, possession, and retail sales. The chapter provides for an annual permitting of persons who are involved in the use of aquatic plants for business purposes and scientific research.

Past inspections of permit holders by the department resulted in the seizure or eradication of several federally designated noxious-weed species. The major requirements of the regulatory program are as follows:

1. Prohibited aquatic plant species may not be collected, imported, transported, cultivated, or sold unless permitted by the Florida Department of Natural Resources, Tallahassee.

2. Exotic aquatic plant species cannot be planted in the state's waterways.

3. Permittees are required to notify the Bureau of Aquatic Plant Management with a complete botanical listing of species received within seven days after importing plants from abroad (out of state and foreign importations).

4. Permittees who cultivate aquatic plants must have secure and adequate quarantine facilities to avoid accidental introductions of exotic plants into adjacent waterways.

5. All permitted wholesale and culturing facilities, and retail outlets are subject to inspection.

6. Violations can result in the suspension or revocation of the permit, or a misdemeanor charge of the second degree.

In 1973, the controlling authority was transferred to the Bureau of Aquatic Plant Research and Control--now the Bureau of Aquatic Plant Management--of the Department of Natural Resources.

In 1974, the authority of the Department of Natural Resources was expanded by Chapter 372.932 FS and

> gave the department supervision of all aquatic-plant control to "guide, approve, review, coordinate and disperse aquatic plant control funds" in each water management district. This law also designated areas of state responsibility and mechanisms of funding and defined the concept of maintenance control of nonindigenous (exotic) aquatic plants as a method of control "in that control techniques are used in a coordinated manner on a continuous basis in order to maintain the plant population at the lowest feasible level as determined by the department - (Joyce, 1991, Page 6).

The authority of entering cost-sharing agreements with the U.S. Army Corps of Engineers under the Federal Aquatic Plant Control Program was transferred from the Florida Game and Freshwater Fish Commission to the Department of Natural Resources at this time; however, the actual transfer of the contract did not occur until a later date (Joyce 1991). Goldsby et al. (1976) described the permitting of Florida's aquaria-plant wholesalers, the training course for plant inspectors, and the enforcement of the Florida regulations in the industry.

In 1984, legislation modified 403.271 to authorize the permitting and inspection of all persons involved in the aquatic plant business. A violation could result in a charge with a second-degree misdemeanor.

Although Florida's rules and regulations for aquatic plant-importation, transportation, cultivation, possession, and retail sales have prevented permit holders from introducing new exotic aquatic plants into the state's waterways, the growing of plant species elsewhere and shipment of plants from another state by U.S. Mail or by commercial freight carrier into Florida cannot be regulated. The U. S. Department of Agriculture has the authority (Section 2803(a), Federal Noxious Weed Act) to stop the interstate spread of federally designated noxious weeds but fails to use it. The U.S. Department of Agriculture must properly administer the Federal Noxious Weed Act of 1974 or Florida and other states will be recipients of new exotic aquatic plant infestations (Schmitz 1990). Westbrooks (1990) discussed the interstate transfer and sale of aquatic federally designated noxious weeds. In a later publication, he (Westbrooks 1993) outlined the federal and state regulations, policies, and enforcement to exclude and eradicate the federally designated noxious weeds. A draft model ordinance was developed for the control of introductions of pest plants by municipalities and counties in southern Florida (South Florida Exotic Pest Plant Council 1985).

Regulations for the Control of Fishes and Wildlife

Campbell (1993) and the U.S. Congress, Office of Technological Assessment (1993), summarized the present-day frustration with the failure of the many federal and state laws and regulations to control the continued introductions of nonindigenous nuisance species. Most people think it is not practical to stop the importation of nonindigenous species into the United States, and at present a system to stop introductions of nuisance species into the nation's open waters does not exist. As long as the importation of such species is profitable, loopholes and inconsistencies in regulations prevent stopping the invasion. Because not enough is known about native ecosystems and about the life histories of nonindigenous species and their potential to become nuisances, the potential impacts of these invaders cannot be predicted. The mystic of introducing a new species, the inability to know the final impacts, the ongoing changes from other factors, and the lack of time and resources to examine the potential impacts of nonindigenous species before introductions makes the stopping of future introductions an impossible task.

Anonymous (1992) and Cambell (1993) summarize the federal regulations for the control of the import, export, sale, purchase, possession or transportation of nonindigenous species. The Lacey Act Amendments of 1981 (16U.S.C.A.667 et seq.,18U.S.C.A.42 et seq.), the Nonindigenous Aquatic Nuisance Prevention and Control Act of 1990,as amended (16U.S.C.A. 4701 et seq., 18U.S.C.A. 42), and the Federal Noxious Weed Act of 1974(7 U.S.C.A. 2801 et seq.) provide most of the authority. People et al. (1992) discussed the program and statutory basis for the U.S. Fish and Wildlife Service programs and policies for the control of nonindigenous species. Stanley et al. (1991:page 165) concluded that a "Rigorous review of all exotic introductions and consultations of all concerned jurisdictions and user groups should precede any planned introduction." Shelton (1986) summarized the procedures that should be followed before a nonindigenous species is introduced and cultured in an area where it is not already established. Brown (1979) discussed the federal role in regulating exotic species in mariculture. Recent publications by Campbell (1993) and by the U.S. Congress (1993) discussed the many federal and state regulations and laws for the reduction of introductions and their ineffectiveness in stopping harmful introductions.

All importers are required to file Form 3-177, *Declaration of Importation of Fish and Wildlife*, for each shipment at authorized ports of entry (Ramsey 1985). Ramsey (1985) described the importation of fishes into the United States, the practices by the shippers and importers, and the resulting problems for the inspectors. Clugston (1986) and Kohler (1986a,b) discussed the strategies that should be followed to reduce the risks of introductions of any aquatic organisms. Kohler and Courtenay (1986a,b) outlined the history of the attempts to develop guidelines and protocols for the evaluation of a nonindigenous species before its purposeful introduction and the steps for federal and state regulations. Welcomme (1986) discussed the reasons for the trade of exotic species are traded between nations and summarized the control of unwise introductions. In a more recent publication, Welcomme (1988) provided a detailed listing of the worldwide movement of exotic species. Only few introduced organisms met expectations; most failed to survive or became harmful. Myers (1947) and Chamberlain (1947) were among the first professional fishery personnel in this country who expressed concern about the introductions of exotic fish species into the United States and expressed concern about the exportation of native species to foreign lands without a thorough evaluation of the reasons for the transfers and the environments to which the species were introduced. In 1977, President Carter signed Executive Order 11987 that restricted the import and export of exotic plants or animals by federal agencies without an evaluation of potential impacts on the receiving ecosystems. Regulations in support of that order were never completed.

The regulations for introductions of nonindigenous species into Florida and related management were presented by Shafland (1991). He provided a summary of Florida's constitution, statutes, and rules for the importation, sale, use, or release of any nonindigenous fish. He also identified the ten groups of fishes on the restricted list that can be legally possessed only with a permit from the Florida Game and Freshwater Fish Commission. A list of a group of 12 prohibited nonindigenous species, including the green sunfish (*Lepomis cyanellus*) that is native to the United States was included. Only under maximum security and with strong justification can possession of species on this list be permitted into Florida. Regulations for the use of grass carp *(Ctenopharyngodon idella)* are outlined and usually require the use of sterile triploid grass carp.

A model for state regulations concerning the holding of wild and exotic animals was developed by the Southeastern Cooperative Wildlife Disease Study (1985) to serve as a national standard for controling animals in captivity. The model's purpose was to prevent the escape or release of environmental injurious species, the mistreatment of said animals, to ensure the safety of humans, and the prevention of the introduction of harmful exotic diseases or parasites.

Regulations for the Use of Insects as Biological Control Agents

Klingman and Coulson (1983) outlined the guidelines for the introduction of insects as biological control agents of nuisance plants. A more up-to-date discussion of the protocols for the evaluation of these insects before release was discussed by Coulson and Soper (1989). Westbrooks (1993) described the six action levels by the Animal and Plant Health Inspection Service that is responsible for preventing the entry and establishment of designated foreign pests to the United States. These steps include:

Prevention - Certain products entering the U.S. must be certified as pest free.

Preclearance - Inspection before shipment to the U.S.

Exclusion - Inspection and treatment before entry

Detection - Early detection of infestations

Containment - Established rules and procedures to stop the spread

Eradication - Means to eradicate infestations

The effectiveness of the regulations is challenged by many, including the industries that depend on the importation of nonindigenous species and the personnel that must enforce the regulations (Westbrooks 1993).

Frank and McCoy (1993:page 38) commented:

> It is interesting to note that acting under the Plant Pest Act of 1912 and Plant Quarantine Act of 1957, U. S. Department of Agriculture agricultural inspectors have for decades tried to exclude phytophagous insects (plant pests) from entry into the USA, yet the U. S. Department of Agriculture has encouraged, and itself has taken part in, importation of exotic plants as ornamentals. This incongruity is explicable in terms of trade: sales of exotic terrestrial plants (by the nursery trade), exotic aquatic plants (by the aquarium trade), and exotic animals, especially vertebrates, but also mollusks and arthropods (by the pet trade) provide a profit to importers. Our laws make it acceptable to import potential pests if a profit is made, but not to import worthless (i.e., unsalable) potential pests. We are not aware of anything in the laws that requires importers to pay for the control of imported organisms that have become pests, nor even to pay the cost of research toward finding means of control of such pests, although it strikes us as fair that they should do so.

Campbell (1993) summarized the legislation for the control of the introductions of exotic species into the United States and the major issues in the control of introductions.

A complete analysis of the Florida regulations about the importation and movement of arthropods was made by Denmark and Porter (1973). They emphasized that the applications to import insects, millipedes, mites, scorpions, spiders, ticks, snails, and protozoan malaria parasites were received and evaluated by a committee of state and federal agencies.

Conclusions

The successful evaluation of the introduction of exotic insects as biological control agents for aquatic nuisance plants by the Health Inspection Service of the U. S. Department of Agriculture is evidence that with adequate facilities, staffing, and funding, pre-introduction studies can be accomplished and can permit the beneficial use of exotics without harm to other species or to the environment. The success rate of U. S. Department of Agriculture to prevent or reduce the rate of introduction of harmful exotic species also demonstrated that methods are available to control and prevent the introduction of harmful species. The National Fishery Research Center of the U. S. Fish and Wildlife Service in Gainesville, Florida, was carefully designed to conduct research on nonindigenous aquatic species to avoid premature release of test organisms (McCann 1984, Peoples et al. 1992). However, the center failed to receive adequate staffing and funding to conduct such research. With appropriate support, the center may have been able to prevent the introductions of the rudd (*Scardinius erythrophthalmus*), the zebra mussel (*Dreissena polymorpha*), the spiny water flea (*Bythotrephes cederstroemi*), and other aquatic pest species, and the enormous environmental and economic costs to the Nation's ecosystems that now require a major commitment of resources could have been avoided.

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TABLES

Table 1. Number of Recorded Pathogens from Nonindigenous Plants in the Aquarium Trade in Florida[a].

Family	Species	Common Name	Number
Acanthaceae	*Hygrophila augustifolia* R. Br. *H. difformis* (L.f.) Blume *H. stricta* (Vahl) Nees	 Water Wysteria Java Temple Plant	1 1 4
Alismataceae	*Echinodorus brevipedicellatus* (O.Kuntze) Boch	Amazon Sword Plant	5
Aponogetonaceae	*Aponogeton ulvaceus* Bak.		1
Araceae	*Anubias lanceolata* N.E. Br. *A. nama* Eng. *Cryptocoryne* sp.	Water Aspidistra Water-Trumpet	3 2 5
Nymphaeaceae	*Victoria amazonica* (Poepp.) 3.Dec.Sowerby	Amazon Water Lily	3

[a]from Alfieri et al. 1994.

Table 2. Introduced Nonindigenous Diseases and Parasites in Florida.

	Common Name	Source	Affected Species	Status	Method of Transfer	Reference
PROTOZOA						
Dermocystidium koi		Japan to U.S.	carp			Migaki et al. 1981
Ichthyophthirius multifiliis	Ich	Asia to U.S.	many fishes		cosmopolit an	Hoffman & Schubert 1984
Mitraspora cyprini			fish	PE		Hoffman 1981a, b
Myxosoma cerebralis	whirling disease	Central Europe to U.S.	Salmonidae	NE	alive and frozen	
Oodinium pillularis		unknown	many fishes	PE	Cosmopoli tan	Reichenbach-Klin ke 1960
Pleistophora hyphessobryconis			many fish	PE		Hoffman Case no. s78-209A
Protopalin symphysodonis		Bangkok to U.S.	many fishes	PE		Hoffman & Schubert 1984
Sphaerospora carassii		Europe to U.S.	common carp & grass carp	PE		Hoffman 1981
Spironucleus elegans			South American ciclids	PE		Molnar 1982

Trichodina reticulata		Asia to U.S.	goldfish	PE	skin of fish	Hoffman 1970
Trichodinella subtilis		Asia to U.S.	goldfish	PE	gills of fish	Lom & Hoffman 1964
Trichodinella epizootica		Asia to Europe to U.S.	goldfish	PE	gills of fish	Hoffman & Schubert 1984
TREMATODA: MONOGENEA	gill and skin flukes					
Anacanthorus anacanthorus		South America to U.S.	redbellied piranha	PE	gills of fish	Mizelle & Price 1965
Anacanthorus brevis		Brazil to U.S.	Brycon melanopterus		gills of fish	Mizelle & Kritsky 1969a
Archidiplectanu archidiplectanum		western Africa to U.S.	Gnathonemus petersi		gills	Hoffman & Schubert 1984
Cichlidogyrus sp.		Africa to U.S.	Mozambique tilapia	*	gills of fish	Hoffman 1970
Cleidodiscus amazonensis	gill fluke	South America to U.S.	piranha		gills of fish	Mizele & Price 1965
Dactylogyrus anachoratus		Asia to U.S.	goldfish	PE		Price & Mizelle 1984
Dactylogyrus extensus		Europe to U.S.	carp	PE	gills of fish	Paperna 1964
Dactylogyrus vastator		Asia to U.S.	goldfish	PE	gills	Price & Mizelle 1964

Dactylogyrus wegeneri		Asia to Europe & U.S.	goldfish	PE		
Dactylogyrus minutus		Europe & central Asia to U.S.	common carp			
Dactylogyrus baueri		Japan to U.S.	goldfish		gills	Rogers 1967
Gyrodactylus cyprini	skin fluke	to North America	carp	PE		Rogers 1967
Gyrodactylus elegans	skin fluke	Asia to U.S.	goldfish	PE		Malmberg 1962
Heteronocleidus gracilis		India to California	Colisa labiosa		gills	Hoffman & Schubert 1984
Longihaptor longihaptor		Brazil to U.S.	Cichla ocellaris		gills	Hoffman & Schubert 1984
Pseudacolpenteron pavlovskyi		Asia to U.S.	carp	PE		
Trianchoratus acleithrium		Malaysia to U.S.	Helostoma rudolfi		gills	Mizelle & Kritsky 1969a
Urocleidoides amazonensis		Brazil to U.S.	Phractocephal us hemibiopterus		gills	Mizelle & Kritsky 1969a
Urocleidoides catus		Brazil to U.S.	Phractocephal us hemibiopterus		gills	Mizelle & Kritsky 1969a
Urocleidoides reticulatus		Trinidad to California	guppies	PE		Mitchell, pers. comm

Urocleidus crescentis & others		South America to U.S.	redbreasted pirhna			Mizelle & Price 1965
TREMATODA: DIGENEA						
Bolbophorus confusus	Eurasian strigeid trematode	Europe to U.S.	Stray European pelican	NE		Hoffman & Schubert 1984
Cryptocotyle lingua	marine blackspot	E. Atlantic to E. coast U.S.	European snail			Sindermann & Farrin 1962
CESTODA						
Bothriocephalus opsarichthydis		E. to Midwest to State of Washington	many fish	PE	microcrust aceans	Hoffman & Schubert 1984
NEMATODA						
Philometra sanguinea		Japan to U.S.	goldfish	PE		Hoffman 1970
Camallanus cotti		Japan , Malaysia, Europe to U.S.	many fish	PE		Hoffman 1970
COPEPODA						
Argulus japonicus		Africa, Israel , New Zeleand, U.S.	goldfish & common carp	PE		Cressey 1978
Lernaea cyprinacea	anchorworm	Africa, Asia, Europe, Israel,etc	goldfish?	PE		Hoffman 1970

ISOPODA						
Artystone trysibia		Columbia to U.S.	many fish			Hoffman Case no. H77-1
Lironeca symmetrica		South America to U.S.	many fish	PE		Herwig 1976
ACANTHOCEPHALA						
Polyacanthorhynchus kenyensis		S. America to N. America	tilapia	PE		Schmidt & Canaris 1967

PE=probably established; E=established; NE=not established

Major references other than those listed above are Hoffman 1970; Hoffman and Schubert 1984.

Table 3. Frequency of Diseases and Parasites in Fishes and in Their Carrying Waters from Southeast Asia, South America, and from Domestic Production Facilities in Florida.[1]

Source of Fishes	Southeast Asia (Singapore, Hong Kong, Bangkok, Taiwan)	S. America (Columbia, Brazil, Peru, Guyana)	Florida
# families of examined fishes	16	9	5
# fish genera	24	21	14
# fish species	31	29	24
# examined lots[2]	67	55	80
% bacteremic when rec'd at lab	68	30	10
% fishes with parasites	61	67	68

[1] Data from Gratzek et al. 1976; Shotts et al. 1976; Shotts and Gratzek 1984.
[2] Each lot contained about 50 specimens.

Table 4. Introduced Nonindigenous Aquatic Plants in Florida.

Family	Scientific Name	Common Name	Status	Reference
Hydrocharitaceae	*Hydrilla verticillata*	hydrilla	E	Schmitz et al. 1993; Schmitz et al. 1991
Poaceae	*Panicum repens*	torpedo grass	E	Hodges & Jacobs 1981
Araceae	*Pistia stratiotes*	water lettuce	E	Sharma 1984; Dray et al. 1988
Amaranthaceae	*Alternanthera philoxeroides*	alligator weed	E	Zieger 1967; Coulson 1977
Salvinaceae	*Salvinia minima*	common salvinia	E	Long & Lakela 1976
Haloragaceae	*Myriophyllum spicatum*	Eurasian watermilfoil	E	Blackburn & Weldon 1967
Pontedariaceae	*Eichhornia crassipes*	water hyacinth	E	Schmitz et al. 1993
	Eichhornia azurea	anchored waterhyacinth	NT	
Araceae	*Colocasia esculenta*	taro	E	Greenwell 1947
Poaceae	*Brachiaria mutica*	para-grass	E	Sainty & Jacobs 1981
Najadaceae	*Najas minor*	brittle naiad	E	Schmitz 1991
	Najas ancistrocarpa	water nymph	E	Godfrey & Wooten 1979; Schardt & Schmitz 1990
Hydrocharitaceae	*Egeria densa*	egeria	E	Cook & Uri-Konig 1984

Acanthaceae	*Hygrophila polysperma*	hygrophilla	E	Les & Wunderlin 1981
Haloragaceae	*Myriophyllum aquaticum*	parrotsfeather	E	Nelson & Couch 1985
Scrophulariaceae	*Limnophila sessiliflora*	limnophila	E	Mahler 1980
Ceratopteridaceae	*Ceratopteris thalictroides*	water sprite	E	Rataj & Horeman 1977
Poaceae	*Pennisetum purpueum*	napier grass	E	
Brassicaceae	*Nasturtium officinale*	watercress	E	Rollins 1978
Convolvulaceae	*Ipomoea aquatica*	water spinach	E	Ochse 1951; Edie & Ho 1969
*Mytaceae	*Melaleuca quinquenervia*	melaleuca	E	Morton 1976; Ewel 1986
*Convolvulaceae	*Casuarina* sp.	Australian pine	E	Morton 1980
*	*Mimosa pigra*	catclaw mimosa	E	Hall 1985
*Hydrocharitacea	*Schinus terebinthifolius*	Brazilian pepper	E	Ewel 1978; Bennett & Habeck 1991

E=established, *=semi-aquatic
Major reference besides those listed above is Schardt and Schmitz 1990.

Table 5. Introduced Nonindigenous Mollusks in the United States and in Florida.

Family	Scientific Name	Common Name	Status	Reference
Mytilidae	*Geukensia demissa*	ribbed mussel	A,P,I	
Ostreidae	*Crassostrea gigas*	Pacific oyster	P	
	Crassostrea virginica	eastern oyster	A,P,I	
	Ostrea edulis	edible oyster	A,I	
Sphaeriidae	*Pisidium amnicum*	greater European pea clam	F,I	
	Pisidium henslowanum	Henslow pea clam	F,I	
	Pisidium supinum	humpback pea clam	F,I	
	Pisidium corneum	European fingernail clam	F,I	
Semelidae	*Theora lubrica*	Asian semele	P	
Corbiculidae	*Corbicula fluminea*	Asian clam	F,I, *	Corner 1986
Veneridae	*Gemma gemma*	amehyst gemclam	A,P,I	
	Mercenaria mercenaria	northern quahog	A,P,I	
	Tapes philippinarum	Japanese littleneck	P,I	
Helicinidae	*Alcadia striata*	striate drop	T,I	

Viviparidae	*Cipangopaludina chinensis malleata*	chinese mystery snail	F,I	Clench & Fuller 1965; Burch & Tottenham 1980
	Cipangopaludina japenica	Japanese mystery snail	F,I	Clench & Fuller 1965; Burch & Tottenham 1980
Pilidae	*Marisa cornuarietis*	giant rams-horn	F,I, *	Hunt 1958; Hale 1964
	Pomacea bridgesi	Brazilian apple snail	F,I, *	Clench 1966
Thiaridae	*Melanoides tuberculatus*	red-rim melania	F,I, *	Roessla & Tabb 1977; Clench 1967
	Melanoides turricula	faune melania	F,I, *	Thompson 1984
	Tarebia granifera	thiarid snail	F,I, *	Abbott 1950
Potamididae	*Batillaria zonalis*	Japanese false cerith	P,I	
Hyponicidae	*Sabia conica*		P,I	
Calyptraeidae	*Crepidula convexa*	convex slippersnail	A,P,I	
	Crepidula formicata	common Atlantic slippersnail	A,P,I	
Muricidae	*Urosalpinx cinerea*	atlantic oyster drill	A,P,I	
Melongenidae	*Busycotypus canaliculatus*	channeled whelk	F,I,**	
Nassariidae	*Ilyanassa obsoleta*	eastern mud snail	A,P,I	
	Nassarius fraterculus	Japanese nassa	P,I	
Lymnaeidae	*Radix auricularia*	big ear radix	F,I	

Physidae	*Physa skinneri*	glass physa	F,I	
Planorbidae	*Biomphalaria glabrata*	bloodfluke planorb	F,I	
	Drepanotrema aeruginosum	rusty rams-horn	F,I	
	Drepanotrema cimex	ridged rams-horn	F,I	
	Drepanotrema kermatoides	crested rams-horn	F,I	
Carychiidae	*Carychium minimum*	herald snail	T,I	
Achatinidae	*Achatina fulica*	giant African snail	T,I, *	Roessler et al. 1977
?	*Mytella charruana*	charru mussel	2)	Lachner et al. 1970

I=not native to U.S.; A=established Atlantic Coast of U.S.; P=established Pacific coast of U.S.; F=established in freshwater; T=terrestrial; *=established in Florida; ** native to Florida,introduced to Pacific coast; 1)=modified from Turgeon 1988; 2)=see text.

Table 6. Nonindigenous Aquatic Insects that were introduced or immigrated into Florida.

Family	Scientific Name	Common Name	Pathway of Introduction	Status	Reference
Chrysomelidae	*Microtheca ochroloma*		IM-watercress	E	Chamberlin & Tippins 1948
Chironomidae	*Goeldichironomus amazonicus*		IM- aquatic plants	E	Wirth 1979
Culicidae	*Aedes albopictus*	Asian tiger mosquito	IM-tires	E	O'Meara et al. 1991, 1992
	Aedes bahamensis		IM-tires	E	O'Meara et al. 1989; Parfume et al. 1988
Pyralidae	*Parapoynx diminutalis*		IM& BC hydrilla	E	del Fosse et al. 1976; Buckingham & Habeck 1990
Aeshinidae	*Coryphaeschna adnexa*	blue-faced darner	IM	E	Dunkle 1989
Lestidae	*Lestes spumarius*	Antillen spreadwing	IM	E	Dunkle 1989
Libellulidae	*Crocothemis servilia*	scarlet skimmer;Asiatic dragonfly	IM	E	Paulson et al. 1988
	Erythemis plebeja	black pondhawk	IM	E	Dunkle 1989

	Micrathyria aequalis	spottailed skimmer	IM	E	Dunkle 1989
	Micrathyria didyma	three-striped skimmer	IM	E	Dunkle 1989
	Aedes aegypti	yellow fever mosquito	IM-shipping	E	Skiles 1989; Frank 1981
*Culicidae	*Toxorhynchites amboinensis*		BC-A aegypti	NE	Frank & McCoy 1993
*	*Toxorhynchites splendens*		BC- A aegypti	NE	Frank & McCoy 1993
*Curculionidae	*Neohydronomus affinis*		BC- water lettuce	E	Dray et al. 1990
*Noctuidae	*Spodoptera pectinicornis*		BC- water lettuce	US	AD 1986,1987, 1988; Buckingham & Habeck 1990
*Chrysomelidae	*Agasicles hygrophila*	alligatorweed flea beetle	BC- alligatorweed	E	Center et al. 1991
*Phlaeothripidae	*Amynothrips andersoni*	alligatorweed thrips	BC- alligatorweed	E	Center et al. 1991
*Pyralidae	*Vogtia malloi*	alligatorweed stem borer	BC- alligatorweed	E	Center et al. 1991
*Curculionidae	*Eubrychius* sp.		BC- watermilfoil	T	AD 1991

*	*Phytobius leucogaster*		BC-alligatorweed	NE	Buckingham & Habeck 1990; AD 1978, 1979
*Pyralidae	*Acentria ephemerella*		BC-alligatorweed	T	AD 1975, 1976, 1978
*	*Parapoynx stratiotata*		BC-alligatorweed	T	AD 1975, 1976; BIRL 1992
*Curculionidae	*Bagous affinis*		BC-hydrilla	NE	Buckingham & Habeck 1990
*	*Bagous dilgiri*		BC-hydrilla	T	AD 1983; Bennett & Buckingham 1991
*	*Bagous laevigatus*		BC-hydrilla	T	AD 1983, 1986
*	*Bagous vicinus*		BC- hydrilla	T	AD 1983; Bennett & Buckingham 1982
*	*Bagous hydrillae*		BC-hydrilla	US	AD 1988, 1991; Center 1992
*Chironomidae	*Polypedilum dewulfi*		BC-hydrilla	L	AD 1990
*	*Polypedilum wittae*		BC-hydrilla	L	Frank & McCoy 1993
*Ephydridae	*Hydrellia balciunasi*		BC-hydrilla	E	AD 1988, 1989, 1991

*	*Hydrellia pakistanae*		BC- hydrilla	E	Buckingham 1988; Buckingham 1988; Buckingham & Okrah 1993
*	*Hydrellia sarahae*		BC-hydrilla	US	AD 1990
*Curculionidae	*Neochetina bruchi*	weevil	BC-waterhyacinth	E	Charudattan 1986
*	*Neochetina eichhorniae*	weevil	BC-waterhyacinth	E	Charudattan 1986
*	*Acigona infusella*		BC-waterhyacinth	L	AD 1974, 1975
*Pyralidae	*Sameodes albiguttalis*		BC-waterhyacinth	E	Charudattan 1986; Center & Durden 1984
	Orthogalumna terebrantis	oribatid mite	IM-waterhyacinth	E	Buckingham & Habeck 1990
*Hypomycetes	*Cercospora rodmanii*	weevil	BC-waterhyacinth	US	Conway & Freeman 1977; Center et al. 1991
*Curculionidae	*Oxyops vitiosa*	weevil	BC-melaleuca	US	Leist 1993
Formicidae	*Solenopsis invicta*	red imported fire ant	IM	E	Davidson & Stone 1989
Bibionidae	*Plecia nearctica*	love bug	IM	E	Peckham 1977

E=established; NE=not established; BC=biological control agent; IM=immigrated; L=loss during evaluation; T=study terminated; US=presently under study; *=biological control agent Major references other than those listed above are Frank & McCoy 1992, 1993; Stoetzel 1989.

Table 7. Introduced nonindigenous fishes in Florida.

Family	Scientific Name	Common Name	Status	Reference
Cyprinidae	*Barbodes schwanefeldi*	tinfoil barb	NE	
	Carassius auratus	goldfish	NE	DeKay 1842; Courtenay & Hensley 1980
	Ctenopharyngodon idella	grass carp	NE	Berg 1949; Connor et al 1980
	Cyprinus carpio	common carp	E	Berg 1949; DeKay 1842
	Danio melabaricus	Malabar danio	NE	
	Danio rerio	zebra danio	NE	
	Hypophthalmicthys molitrix	silver carp	NT	Courtenay & Williams 1992
	Hypophyhalmichthys nobilis	bighead carp	NE	Jennings 1988; Shelton & Smitherman 1984
	Labeo chrysophekadion	black sharkminnow	NE	
	Pimephales promelas	fathead minnow	LE,T	Carter Gilbert, pers. comm. 1993
	Puntius conchonius	rosy barb	NE	
	Puntius gelius	dwarf barb	NE	
	Puntius tetrazona	tiger barb	NE	
Cobitidae	*Misgurnus anguillicaudatus*	oriental weatherfish	LE	Berg 1949; St. Amant & Hoover 1969
Characidae	*Colossoma* sp.	pacu	NE	

	Colossoma macropomum	tambaqui,pacs	NE	
	Gymnocorymbus ternetzi	black tetra	NE	
	Hoplias malabaricus	trahira	ER	
	Leporinus fasciatus	banded leporinus	NE	
	Metynnis sp.		NE	
	Piaractus brachypomus	pirapatinga	NE	
Characidae	*Pygocentrus nattereri*	red piranha	ER	FGFWFC, pers. comm.
	Serrasalmus humeralis = S. rhombeus	pirambeba	ER	Shafland 1991
Characidae	*Serrasalmus rhombeus*	redeye piranha	NE	Shafland & Foote 1979; Moe 1964
Clariidae	*Clarias batrachus*	walking catfish	E*	Courtenay 1978, 1979a, 1979b
Loricariidae	*Hypostomus* sp.	suckermouth catfish	NE	Courtenay et. al. 1974; Burgess 1958
	Pterygoplichthys multiradiatus	sailfin catfish	E*	Courtenay 1986
Doradidae	*Platydoras costatus*	Raphael catfish	NE	
	Pseudodoras niger	ripsaw catfish	NE	
	Pterodoras granulosus	granulated catfish	NE	
Pimelodidae	*Phractocephalus hemiliopterus*	redtail catfish	NE	
Callichthyidae	*Callichthys callichthys*	cascarudo	NE	

	Corydoras sp.	Corydoras	NE	
	Belonesox belizanus	pike killifish	E*	Belshe 1961; Miley 1978
	Poecilia mexicana	shortfin molly	NT	Courtenay 1973; Courtenay et al. 1974
	Poecilia reticulata	guppy	NE	Pers. comm., R. Robbins
	Xiphophorus helleri	green swordtail	LE	Dial & Wainright 1983
	Xiphophorus maculatus	southern platyfish	LE	Courtenay et al. 1974; Dial & Wainright 1983
	Xiphophorus variatus	variable platyfish	LE	Courtenay et al. 1974; Burgess et al. 1977
Cichlidae	*Aequidens pulcher*	blue acara	NE	
	Astronotus ocellatus	oscar	E*	Courtenay et al. 1974; Hogg 1974
	Cichla ocellaris	peacock bass	E*	Shafland 1993
	Cichla temensis	speckled pavon	NE	Ogilvie 1966; Chapman 1989
	Cichlasoma bimaculatum	black acara	E*	Rivas 1965
	Cichlasoma citrinellum	midas cichlid	LE	Anderson et al. 1984
	Cichlasoma meeki	firemouth cichlid	E	Courtenay 1980
	Cichlasoma cyanoguttatum	Rio Grande perch	LE,T	Courtenay 1974
	Cichlasoma octofasciatum	Jack Dempsey	LE	Shafland1982; Courtenay 1974
	Cichlasoma urophthalmus	Mayan cichlid	E*	Miller 1966; Loftus 1987

	Cichlasoma nigrofasciatum	convict cichlid	NE	Rivas 1965
	Cichlasoma beani	green guapote	NE	
	Cichlasoma salvini	yellowbelly cichlid	LE, ER	Shafland 1991
	Cichlasoma trimaculatum	threespot cichlid	NE	
	Geophagus brasiliensis	pearl eartheater	NE	
	Geophagus surinamensis	redstriped eartheater	LE	Metzger & Shafland 1984; Axelrod et al. 1980
	Hemichromis bimaculatus	African jewelfish	E*	Courtenay 1974; Courtenay & Robins 1973
	Labeotropheus sp.		NE	
	Pterophyllum scalare	freshwater angelfish	NE	
	Tilapia aurea	blue tilapia	E*	Foote 1977
	Tilapia mariae	spotted tilapia	E*	Hogg 1974, 1976a, b
	Tilapia melanotheron	blackchin tilapia	E*	Springer & Finucane 1963
	Tilapia mossambica	Mozambique tilapia	LE	Dial & Wainright 1984
	Tilapia zilli	redbelly tilapia	NE, ER	Courtenay et al. 1980; Shafland 1991
	Tilapia melanopleura	congo tilapia	NE	Courtenay & Stauffer 1990
	Tilapia nilotica	Nile tilapia	LE	

	Tilapia sparrmani	banded tilapia	NE	
Anabantidae	*Anabas testudineus*	climbing perch	NE	
	Betta splendens	Siamese fighting fish	NE	
	Colisa labiosa	thicklip gourami	NE	
	Colisa lalia	dwarf gourami	NE	
	Ctenopoma nigropannosum	twospot ctenopoma	NE	
	Helostoma temmincki	kissing gourami	NE	
	Macropodus opercularis	paradise fish	NE	
	Trichogaster leeri	pearl gourami	NE	
	Trichogaster trichopterus	threespot gourami	NE	
	Trichopsis vittata	croaking gourami	LE	
Ictaluridae	*Pylodictis olivaris*	fathead catfish	E,T*	FGFWC, pers. comm.
Moronidae	*Morone chrysops*	white bass	E,T*	Lee et al. 1980
Centrarchidae	*Lepomis humilis*	orangespotted sunfish	LE,T	Gilbert, pers. comm.
	Poxomis annularis	white crappie	E,T	Lee et al. 1980
Percidae	*Perca flavescens*	yellow perch	E,T	Lee et al. 1980
	Stizostedion canadense	sauger	NE,T	Yerger & Beecher 1975
	Stizostedion vitreum	walleye	NE,T	Yerger and Suttkus 1962

E=established; NE=collected, but not established; LE=locally established; NT=not taken from wild; T=transplant; ER=eradicated; *=expanding population

Major references other than those listed above are Courtenay et a.l. 1984, 1986, 1991; Shafland 1986.

Table 8. Introduced Nonindigenous Herpetofauna in Florida.

Family	Scientific Name	Common Name	Status	Reference
*Bufonidae	*Bufo marinus*	marine toad	E	Krakauer 1968; 1970; Wilson & Porras 1983
*Hylidae	*Osteopilus septentrionalis*	Cuban treefrog	E	Austin 1973; Wilson & Porras 1983
*Crocodylidae	*Caiman crocodylus*	brown caiman	E	Ellis 1980
*Emydidae	*Trachemys scripta elegans*	red-eared turtle	E,T	King & Krakauer 1966; Carr 1940
Leptodactylidae	*Eleutherodactylus planirostris planirostris*	greenhouse frog	E	Smith & Kohler 1978; King & Krakauer 1966
	Eleutherodactylus coqui	Puerto Rican coqui	E	Ashton & Ashton 1990
Gekkonidae	*Gekko gekko*	tokay gecko	E	Smith & Kohler 1978; King & Krakauer 1966
	Gonatodes albogularis	yellow-headed gecko	E,D	Smith & Kohler 1978; King & Krakauer 1966
	Hemidactylus garnotii	Indo-Pacific gecko	E	Smith & Kohler 1978; King & Krakauer 1966
	Hemidactylus mabouia	common house gecko	E	King & Krakauer 1966
	Hemidactylus turcicus	mediterranean gecko	E	Smith & Kohler 1978; King & Krakauer 1966
	Sphaerodactylus argus argus	ocellated gecko	U	Smith & Kohler 1978; King & Krakauer 1966

	Sphaerodactylus elegans	ashy gecko	E	King & Krakauer 1966
Iguanidae	*Iguana iguana*	green iguana	E	Smith & Kohler 1978; King & Krakauer 1966
	Ctenosaura pectinata	spiny-tailed iguana	E	Smith & Kohler 1978
Corytophanidae	*Basiliscus vittatus*	brown basilisk	E	Ashton & Ashton 1990
Tropiduridae	*Leiocephalus carinatus*	northern curly-tailed lizard	E	Ashton & Ashton 1990
Phrynosomatidae	*Phrynosoma cornutum*	Texas horned lizard	E	King & Krakauer 1966; Carr & Goin 1955
Polychridae	*Anolis sagrei sagrei*	brown anole	E	Ashton & Ashton 1990
	Anolis sagrei ordinatus	Bahamian brown anole	R	Ashton & Ashton 1990
	Anolis distichus floridanus	Florida bark anole	E	Ashton & Ashton 1990
	Anolis distichus dominicensis	green bark anole	R	Ashton & Ashton 1990
	Anolis equestris	Cuban knight anole	E	King & Krakauer 1966
	Anolis garmani	Jamaican giant anole	E	Ashton & Ashton 1990
	Anolis cybotes	large-headed anole	E	Ashton & Ashton 1990
	Anolis cristatellus	Puerto Rican crested anole	E	Ashton & Ashton 1990
Teiidae	*Ameiva ameiva*	South American giant ameiva	E	Smith & Kohler 1978

	Cnemidophorus lemniscatus	rainbow whiptail	E	Ashton & Ashton 1990
Typhlopidae	*Ramphotyphlops braminus*	braminy blind snake	E	Smith & Kohler 1978

E=established; U=unknown; D=declining; *=aquatic; T=transplant; R=reported to exist
Major reference other than those listed above are Ashton and Ashton 1990, 1988.

Table 9. Introduced Nonindigenous Birds in Florida.

Family	Scientific Name	Common Name	Status	Reference
*Anatidae	*Cairina moschata*	muscovy duck	E	Hutt 1967
	Cygnus olor	mute swan	NE	Esch 1993
	Cyngus atratus	black swan	NE	Todd 1979
*Cathartidae	*Phoenicopterus ruber*	greater flamingo	E, N	del Hoyo 1992
*Threskiornit hida	*Eudocimus ruber*	scarlet ibis	E,N	Quincy 1977
*Anatinae	*Anas b. bahamensis*	Bahama pintail	N,NE	Evans 1960
Pycnonotidae	*Pycnonotus jocosus*	red-whiskered bulbul	E	Stoll 1977
Ardeidae	*Bubulcus ibis*	cattle egret	E	Sprunt 1954
Platycercinae	*Melopsittacus undulatus*	budgerigar	E	Forshaw 1973
Columbidae	*Columba livia*	rock dove	E	Goodwin 1967
Columbidae	*Streptopelia decaocto*	Eurasian collared dove	E,I	Goodwin 1967; Smith 1987
Columbidae	*Zenaida asiatica*	white winged dove	E,N	Goodwin 1967; Saunders 1980

Arinae	*Myiopsitta monachus*	monk parakeet	E	Forshaw 1973
Arinae	*Brotogeris versicolurus*	canary-winged parakeet	E	Forshaw 1973; Owre 1973
Icterinae	*Icterus pectoralis*	spot-breasted oriole	E	Owre 1973
Fringillidae	*Carpodacus mexicanus*	house finch	E,I	Terres 1980
Passerinae	*Passer domesticus*	house sparrow	E	Long 1989

E=established; N=occurred naturally; I=introduced by humans near Florida & established itself into Florida; NE=not established; D=declining; *=aquatic

Major reference other than those listed above is Robertson & Wolfenden 1992.

Table 10. Introduced Nonindigenous Mammals in Florida.

Family	Scientific Name	Common Name	Status	Reference
*Capromyidae	*Myocastor coypus*	nutria	E	Griffo 1957
Xenarthra	*Dasypus novemcinctus*	armadillo	E	Fitch et al. 1952
Suidae	*Sus scrofa*	feral hog	E	Belden, 1990; Mayer & Brisbin 1991
Sciuridae	*Sciurus aureogaster*	Mexican red-bellied squirrell	E	Brown 1969
Muridae	*Rattus rattus*	black rat	E	Layne 1974
	Rattus norvegicus	Norway rat	E	Stevenson 1976
	Mus musculus	house mouse	E	Layne 1974
Leporidae	*Lepus claifornicus*	black-tailed jackrabbit	E	Layne 1974
Felidae	*Felis yagouroundi*	jaguarundi	E	Fowler 1981
	Felis catus	domestic cat	E	Tiebout 1983
Canidae	*Canis familiaris*	domestic dog	E	Tiebout 1983
	Vulpes vulpes	red fox	E	Layne 1974
	Canis latrans	coyote	E	Cunningham & Dunford 1970
Cervidae	*Cervus unicolor*	sambar deer	E	Stevenson 1976

	Axis axis	axis deer	E	Allen & Neill 1954
Felidae	*Felis onca*	jaguar	NE	Tiebout 1983
	Felis pardalis	ocelot	NE	Tiebout 1983
	Felis pardus	leopard	NE	Tiebout 1983
	Profelis aurata	golden cat	NE	Tiebout 1983
Leporidae	*Oryctolagus cuniculus*	European rabbit	NE	Tiebout 1983
Homidae	*Ateles* sp.	spider monkey	NE	Tiebout 1983
	Nasua sp.	coati	NE	Tiebout 1983
	Bassariscus astutus	ringtail cat	NE	Tiebout 1983
Sciuridae	*Cynnomys* sp.	prairie dog	NE	Tiebout 1983

E=established; NE=not established; *=aquatic

Major reference other than those listed above is Tiebout 1983.

Table 11 . Introduced Nonindigenous Aquatic Species in Marine Waters of Florida.

Class	Scientific Name	Common Name	Status	Mode of Introduction	Reference
FISH	*Tilapia aurea*	blue tilapia	E	FGFWFC & individuals	Courtenay & Hensley 1979; Courtenay et al. 1984
	Tilapia melanotheron	black chin tilapia	E	fish farm & individuals	Springer & Finucane 1963; Dial & Wainright 1983
	Tilapia mossambica	Mozambique tilapia	E	fish farm	Courtenay 1984; Dial & Wainright 1983
	Tilapia mariae	spotted tilapia	E	fish farm	Courtenay & Hensley 1979, 1980; Hogg 19776
PLANTS	*Pistia stratiotes*	water lettuce	E	ballast water	Schardt & Schmitz 1990
	Alternanthera philoxeroides	alligator weed	E	ballast water	Schardt & Schmitz 1990
	Salvinia molesta	salvinia	E		Schmitz et al. 1991
INVERTEBR ATES	*Mytella charruena*	charru mussel	NE	ships	Turgeon et al. 1988
	Platychirograpous typicus	saber or mexican crab	E	ships ballast	Marchand 1946; Flinchbaugh 1984
	Sesarma (Holometopus) *benedicti*	Benedict's wharf crab	NE		Gore 1982

	Scylla serrata	Indo-west Pacific Samoan crab	NE	commercial fishermen	Camp, pers. comm. to McCann
	Penaeus monodon	jumbo tiger shrimp	NE	fish farm	Wenner 1992; Shireman & Lindberg 1985

E=established; NE=not established
individual=public; fish farm=fish culture facility

Figures

Figure 1. Counties of Florida.

Figure 2. Public Lakes and Rivers in which Hydrilla (*Hydrilla verticillata*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 3. Public Lakes and Rivers in Florida in which Torpedograss (*Panicum repens*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 4. Public Lakes and Rivers in Florida in which Waterlettuce (*Pistia stratiotes*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 5. Public Lakes and Rivers in Florida in which Alligatorweed (*Alternanthera philoxeroides*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 6. Public Lakes and Rivers in Florida in which Salvinia (*Salvinia minima*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 7. Public Lakes and Rivers in Florida in which Eurasian Watermilfoil (*Myriophyllum spicatum*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 8. Public Lakes and Rivers in Florida in which Waterhyacinth (*Eichhornia crassipes*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 9. Public Lakes and Rivers in Florida in which Taro (*Colocasia esculenta*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 10. Public Lakes and Rivers in Florida in which Paragrass (*Brachiaria mutica*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 11. Public Lakes and Rivers in Florida in which Exotic Naiads (*Najas* sp.) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 12. Public Lakes and Rivers in Florida in which Egeria (*Egeria densa*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 13. Public Lakes and Rivers in Florida in which Hygrophila (*Hygrophila*

polysperma) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 14. Public Lakes and Rivers in Florida in which Parrotfeather (*Myriophyllum aquaticum*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 15. Public Lakes and Rivers in Florida in which Limnophila (*Limnophila sessiliflora*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 16. Public Lakes and Rivers in Florida in which Water Sprite (*Ceratopteris thalictroides*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 17. Public Lakes and Rivers in Florida in which Napier Grass (*Pennisetum purpureum*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 18. Public Lakes and Rivers in Florida in which Watercress (*Nasturtium officinale*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

Figure 19. Public Lakes and Rivers in Florida in which Water Spinach (*Ipomoea aquatica*) was reported during 1990 (computer scanned from Schardt and Schmitz 1990).

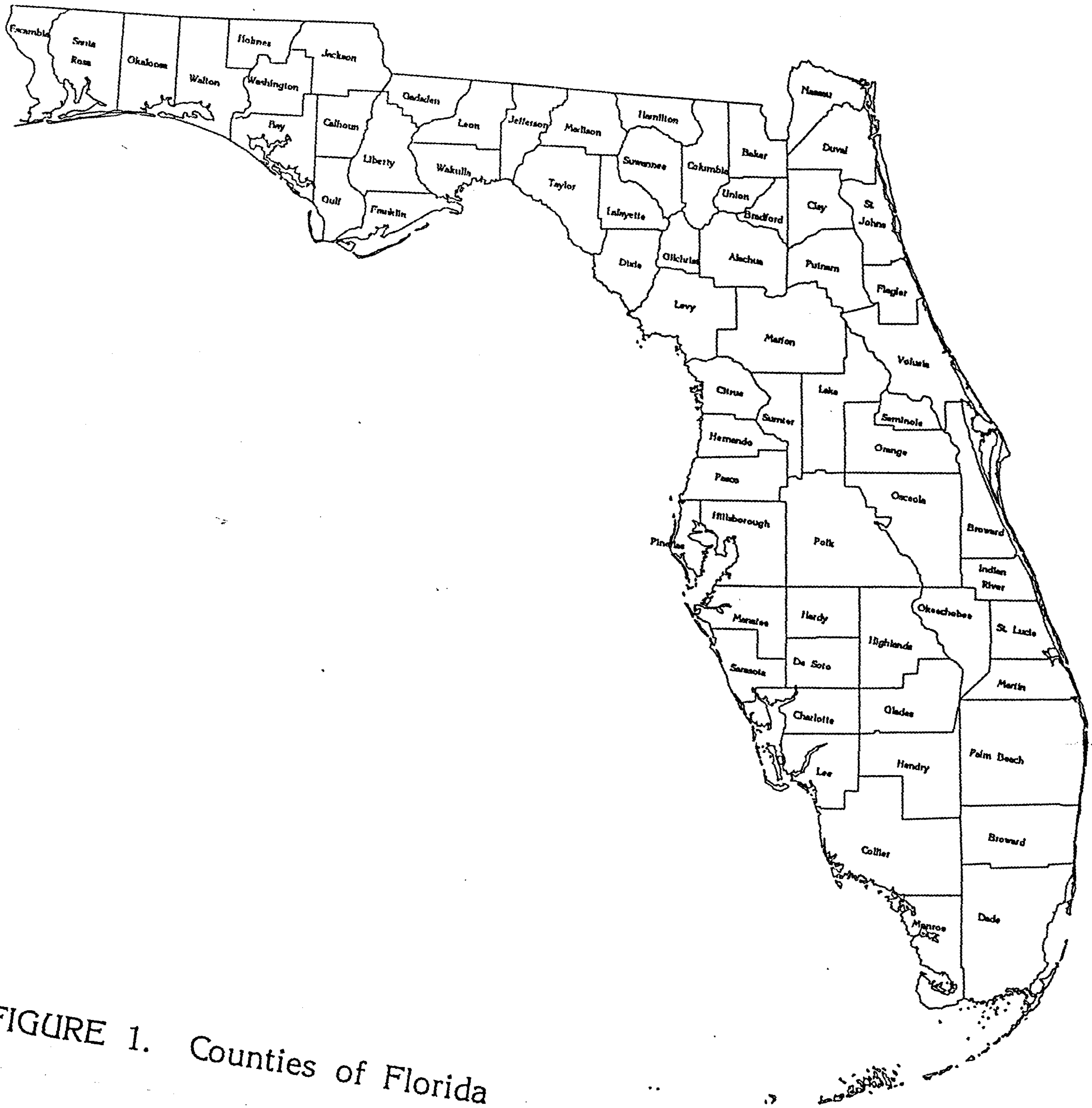

FIGURE 1. Counties of Florida

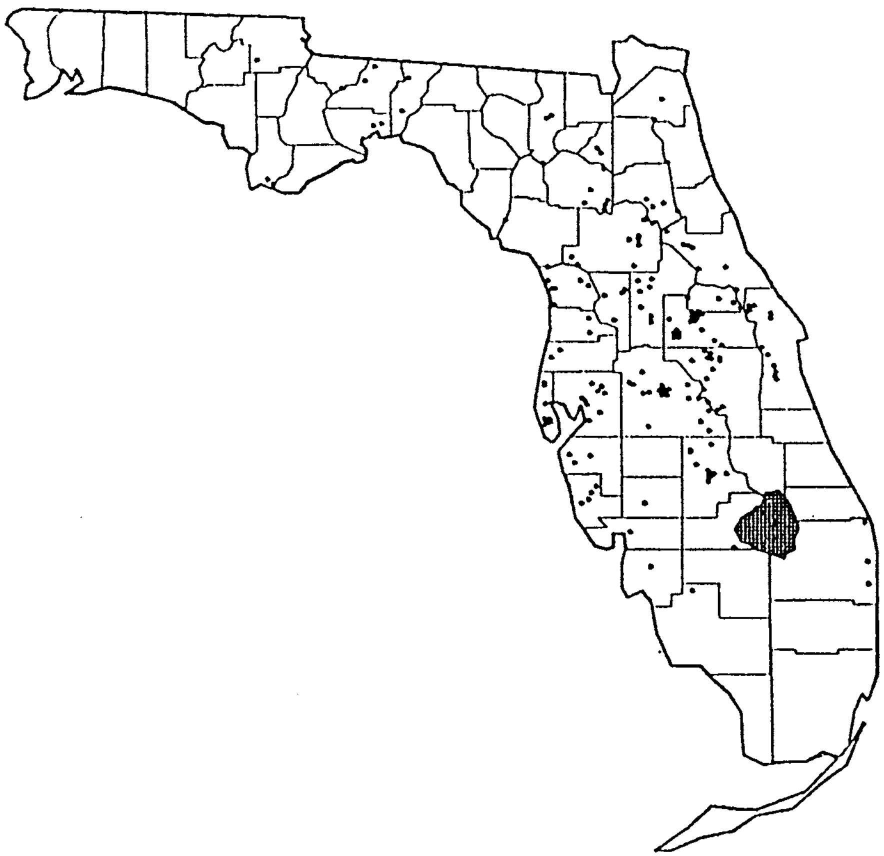

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Figure 2: Public Lakes and Rivers in Which Hydrilla Was Reported During 1990

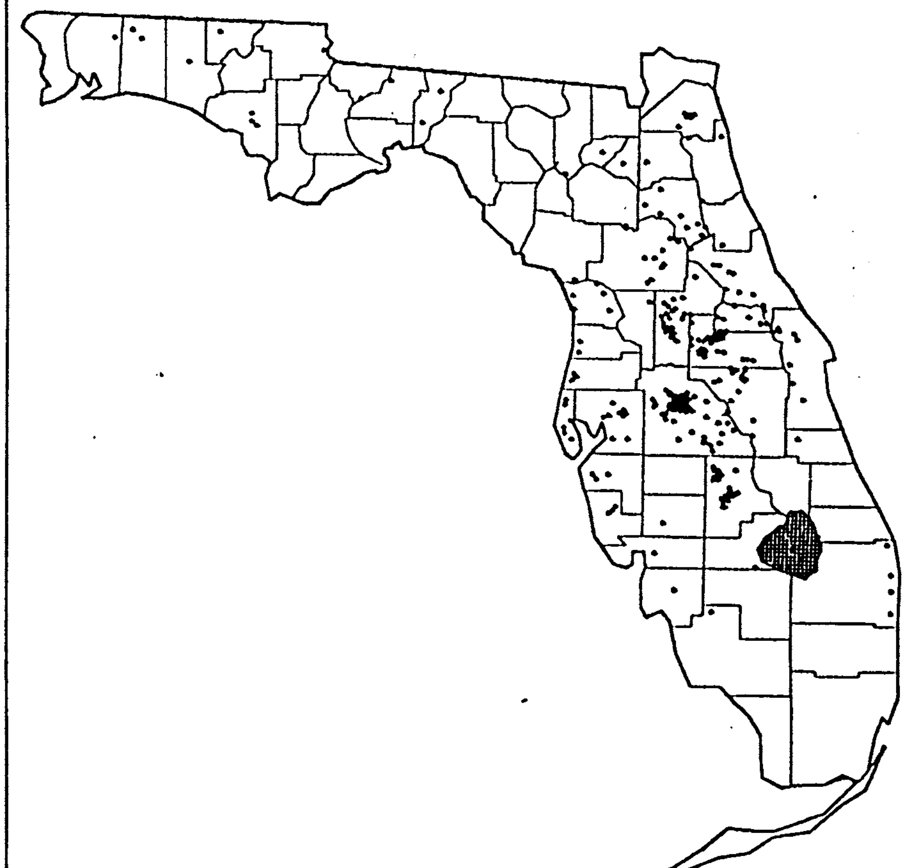

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Figure 3: Public Lakes and Rivers in Which Torpedograss Was Reported During 1990

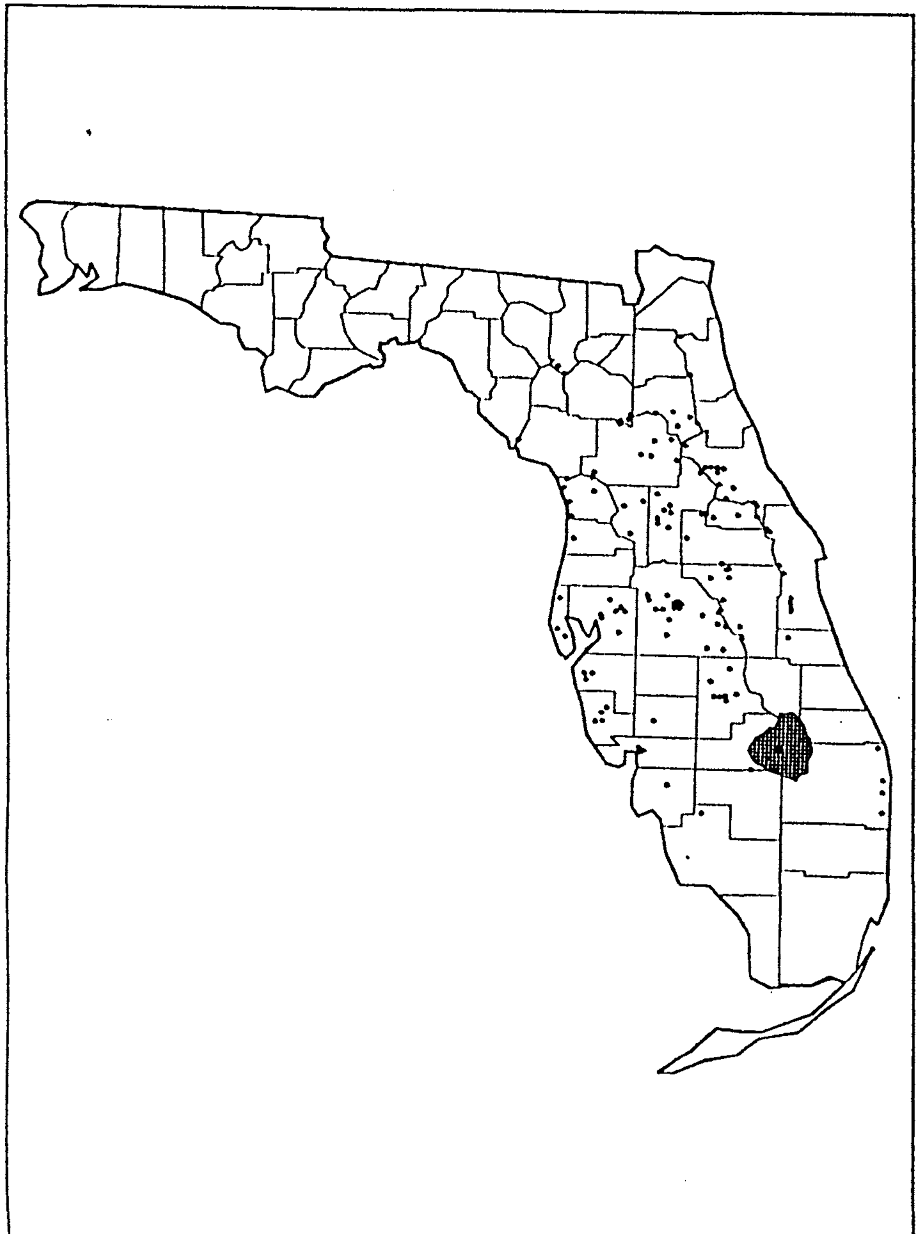

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Figure 4: Public Lakes and Rivers in Which Waterlettuce Was Reported During 1990

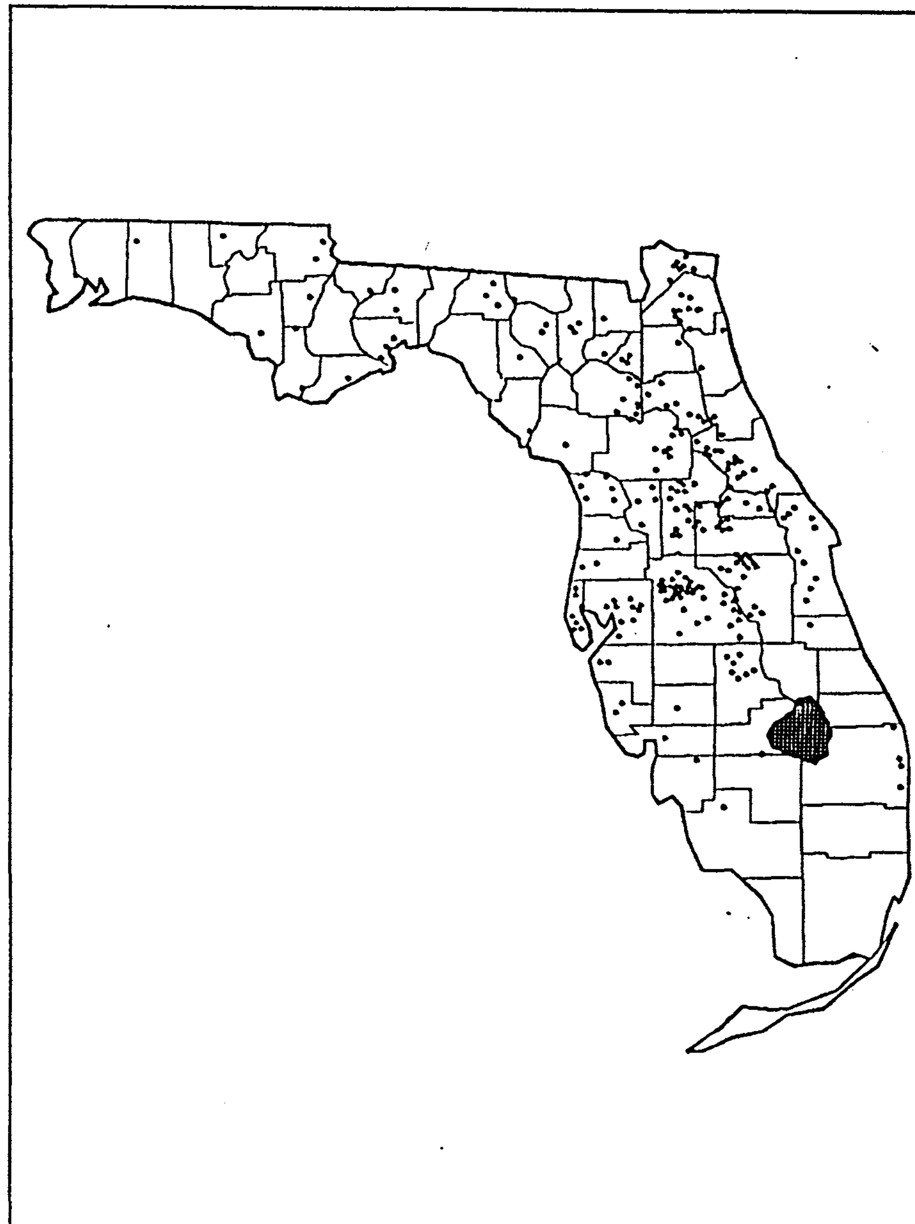

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Figure 5: Public Lakes and Rivers in Which Alligatorweed Was Reported During 1990

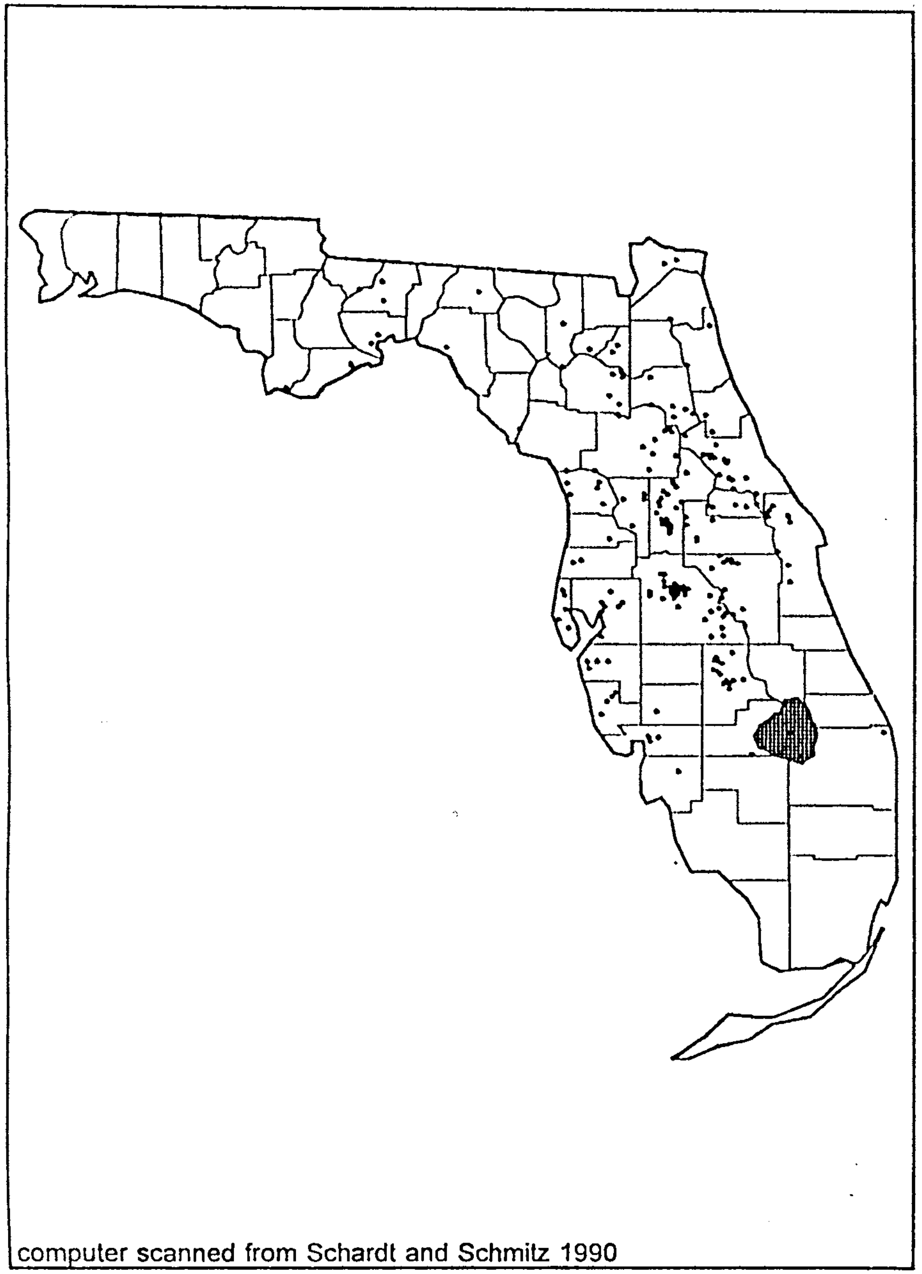

Figure 6: Public Lakes and Rivers in Which Salvinia Was Reported During 1990

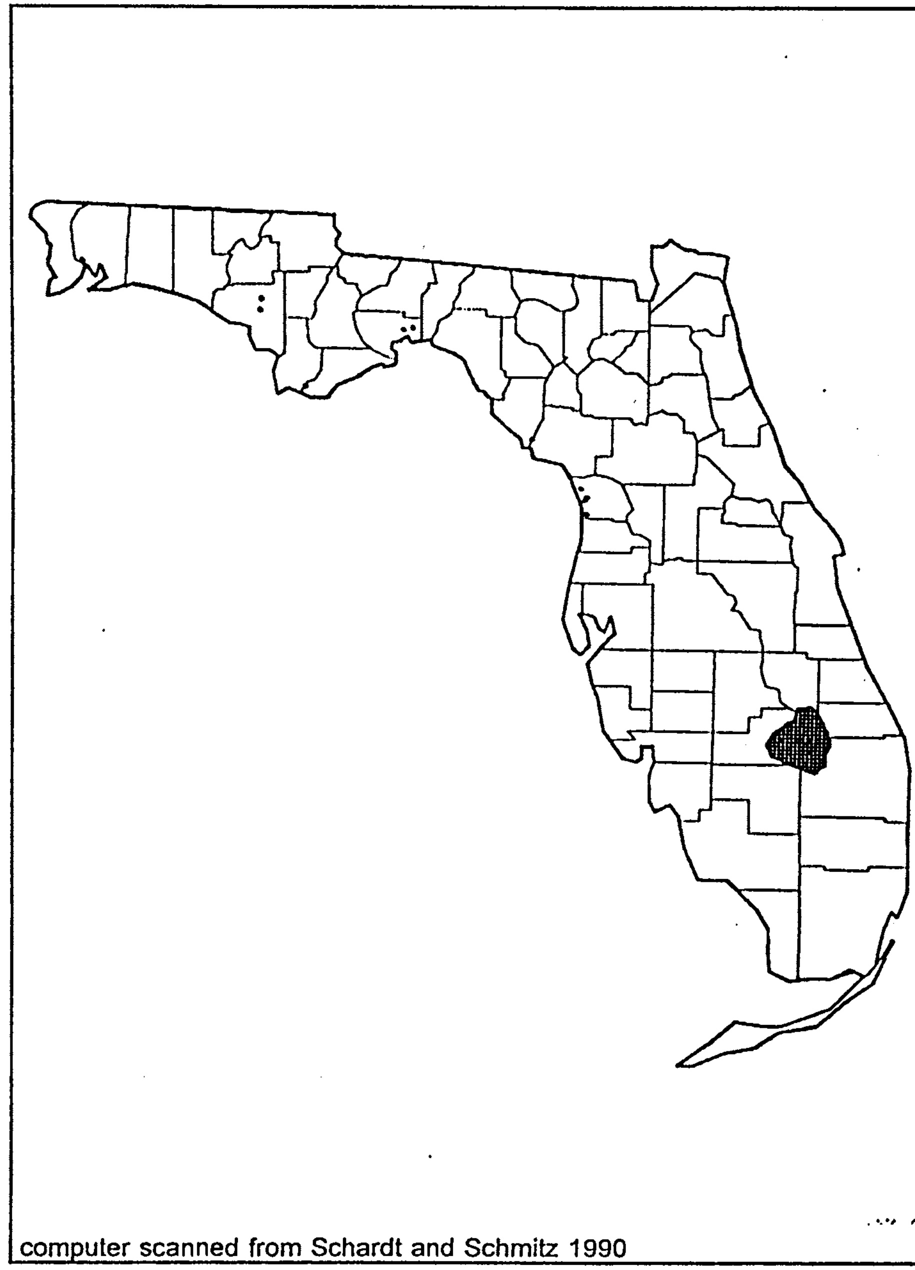

Figure 7: Public Lakes and Rivers in Which Eurasian Watermilfoil Was Reported During 1990

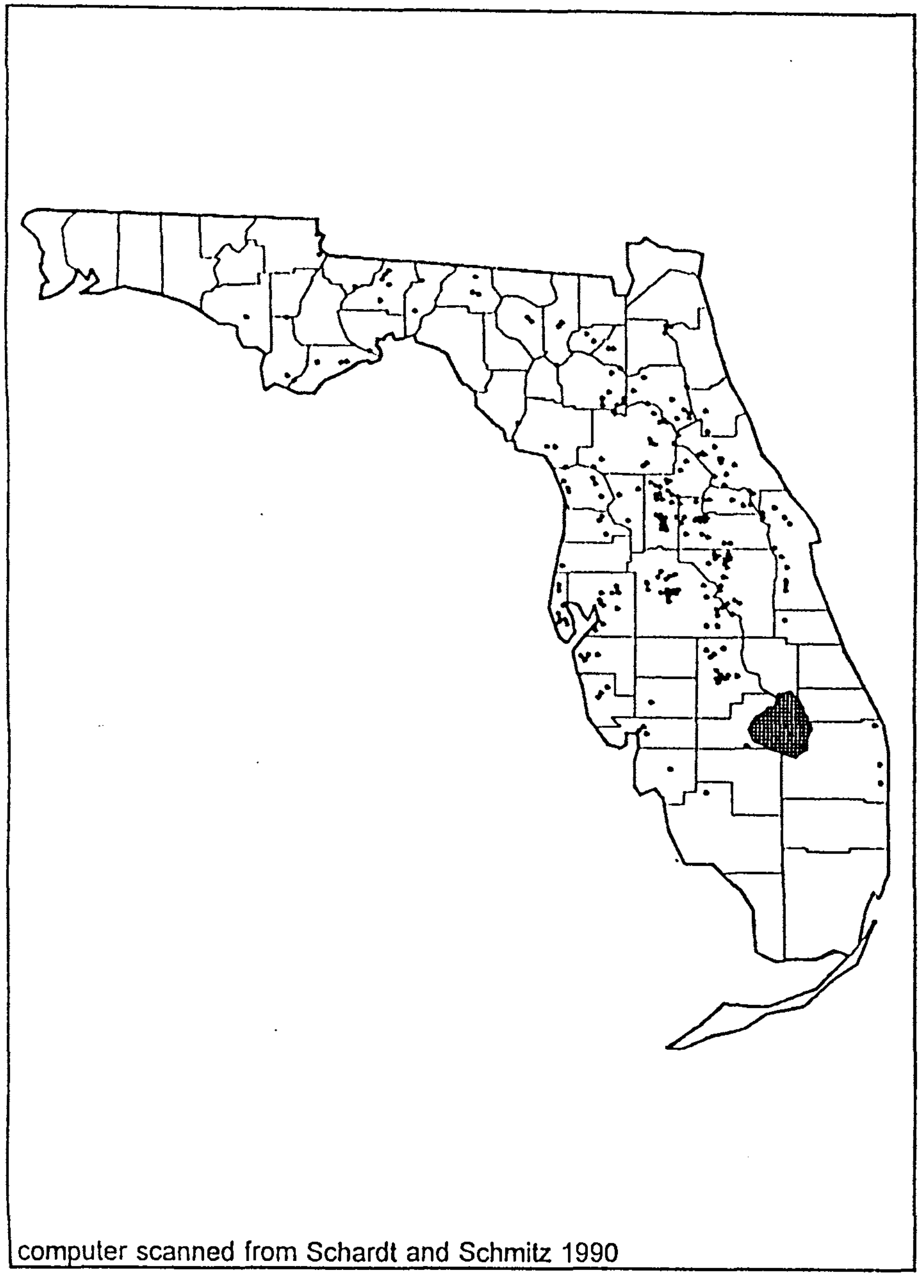

Figure 8: Public Lakes and Rivers in Which Waterhyacinth Was Reported During 1990

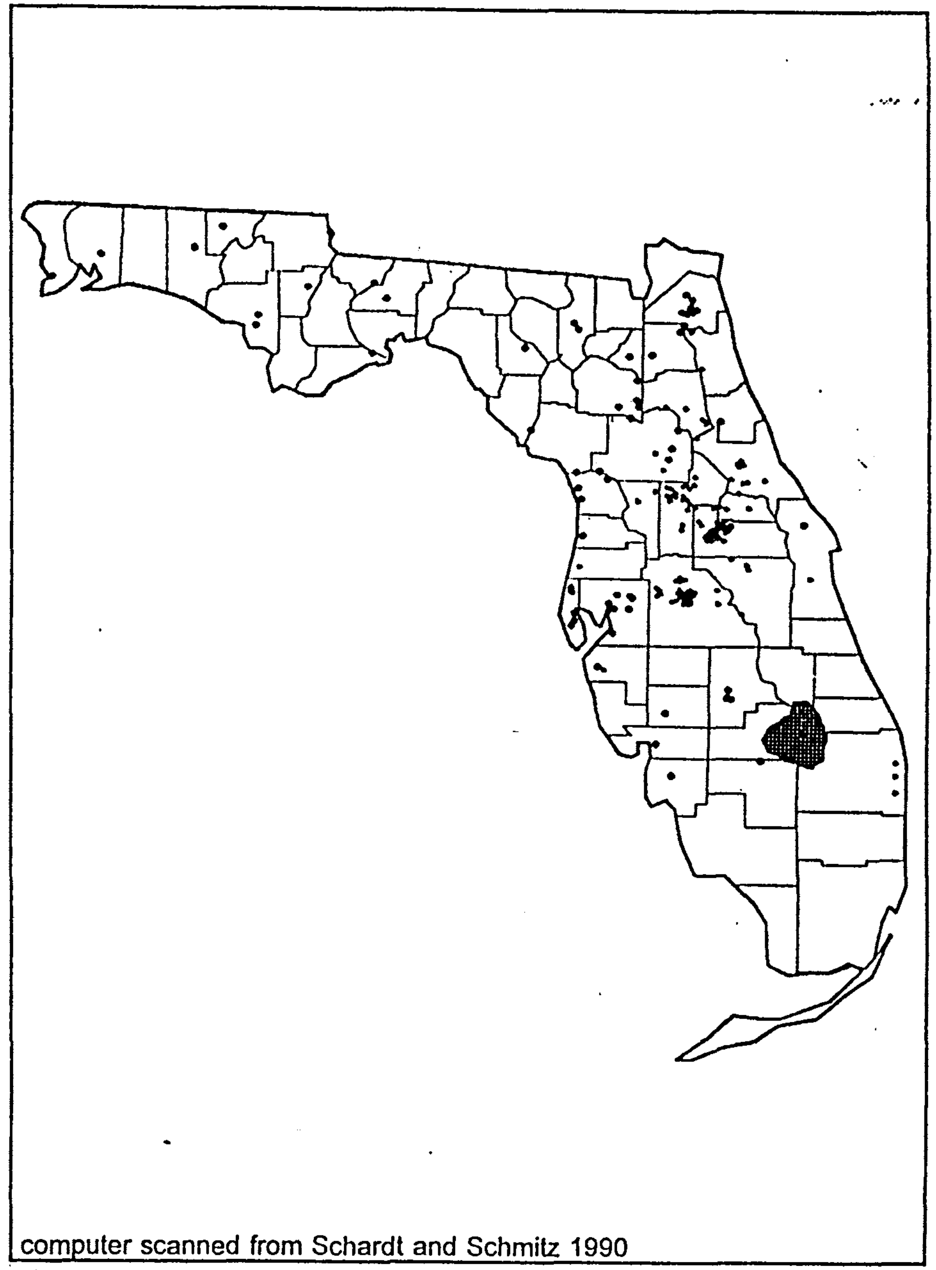

Figure 9: Public Lakes and Rivers in Which Taro Was Reported During 1990

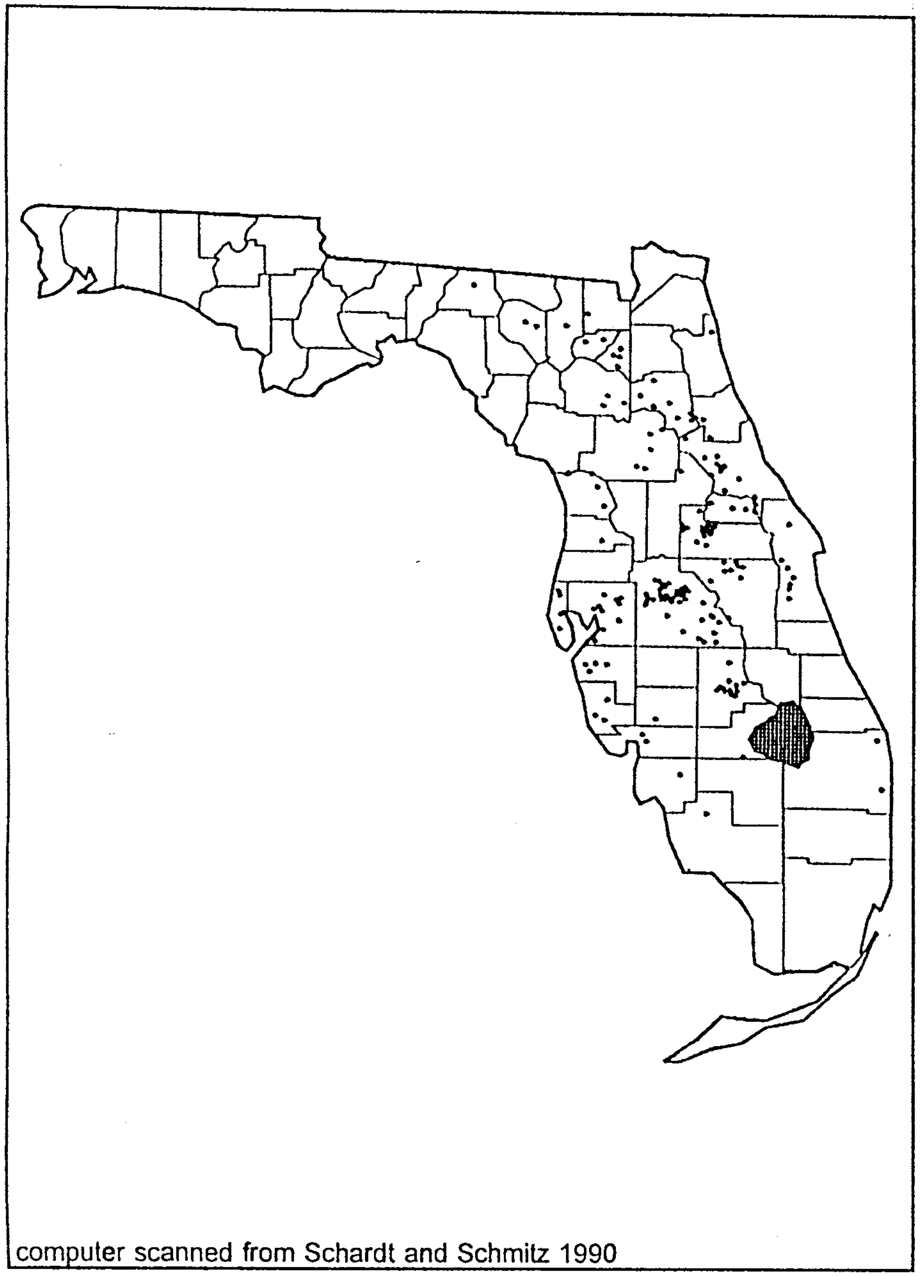

Figure 10: Public Lakes and Rivers in Which Paragrass Was Reported During 1990

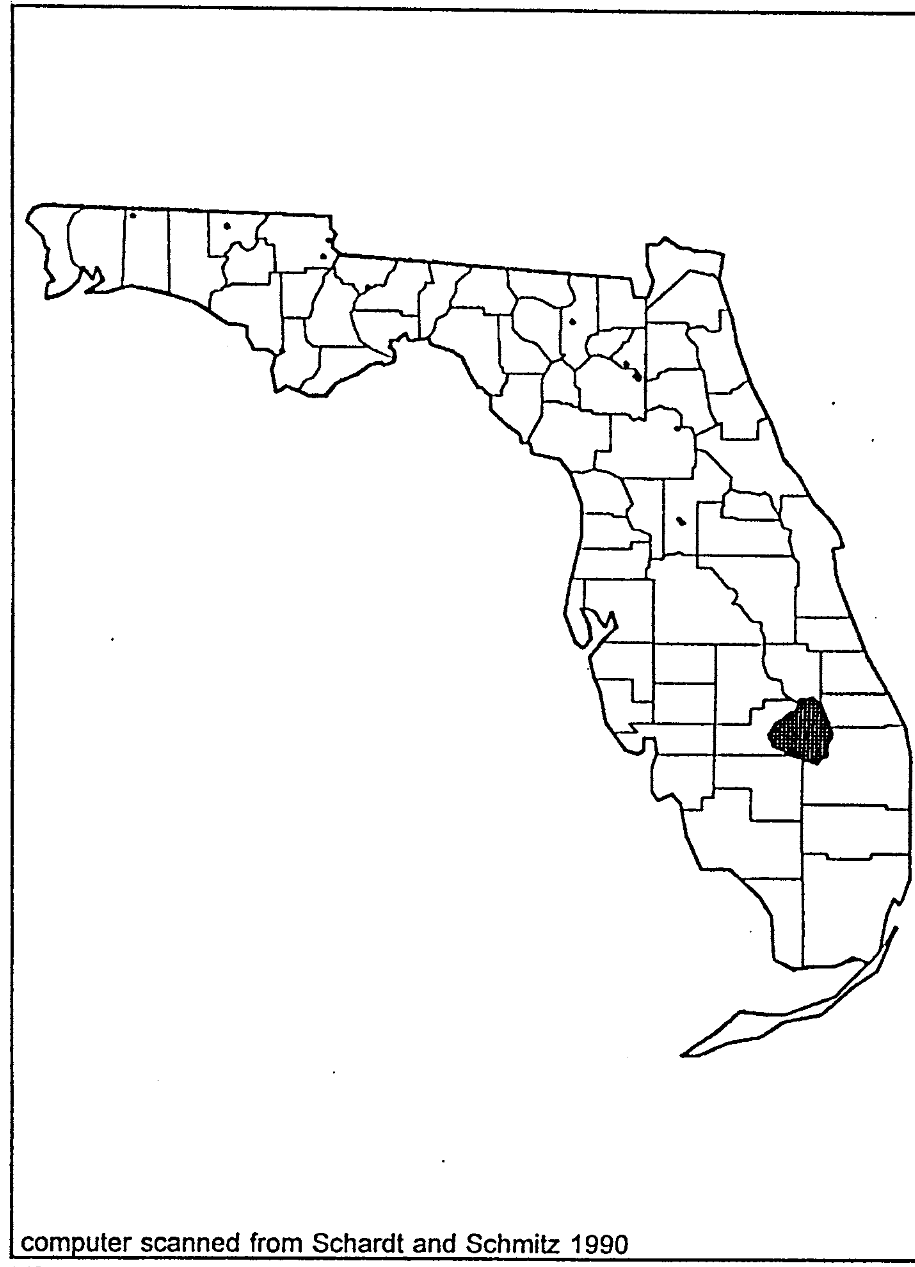

Figure 11: Public Lakes and Rivers in Which Exotic Naiads Were Reported During 1990

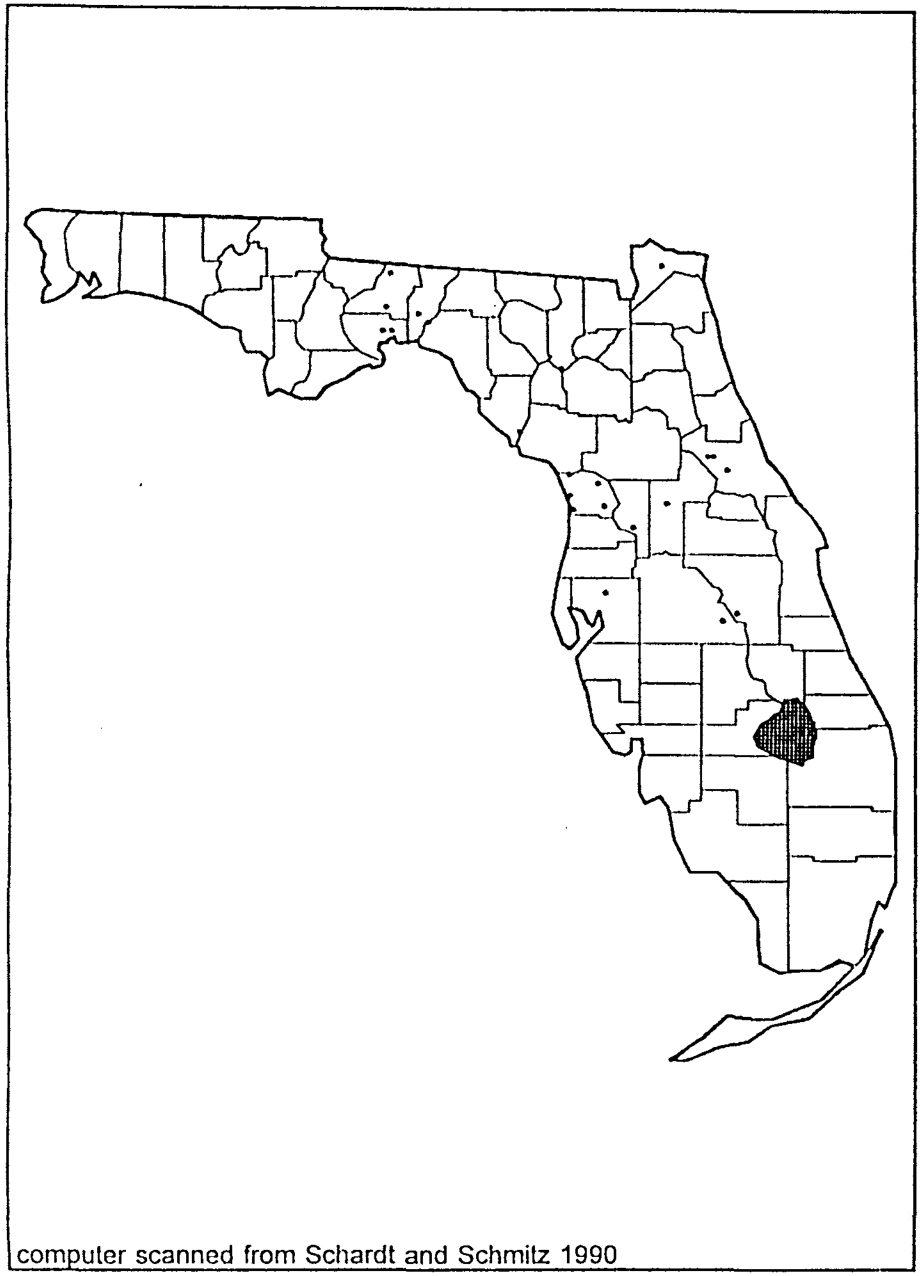

Figure 12: Public Lakes and Rivers in Which Egeria Was Reported During 1990

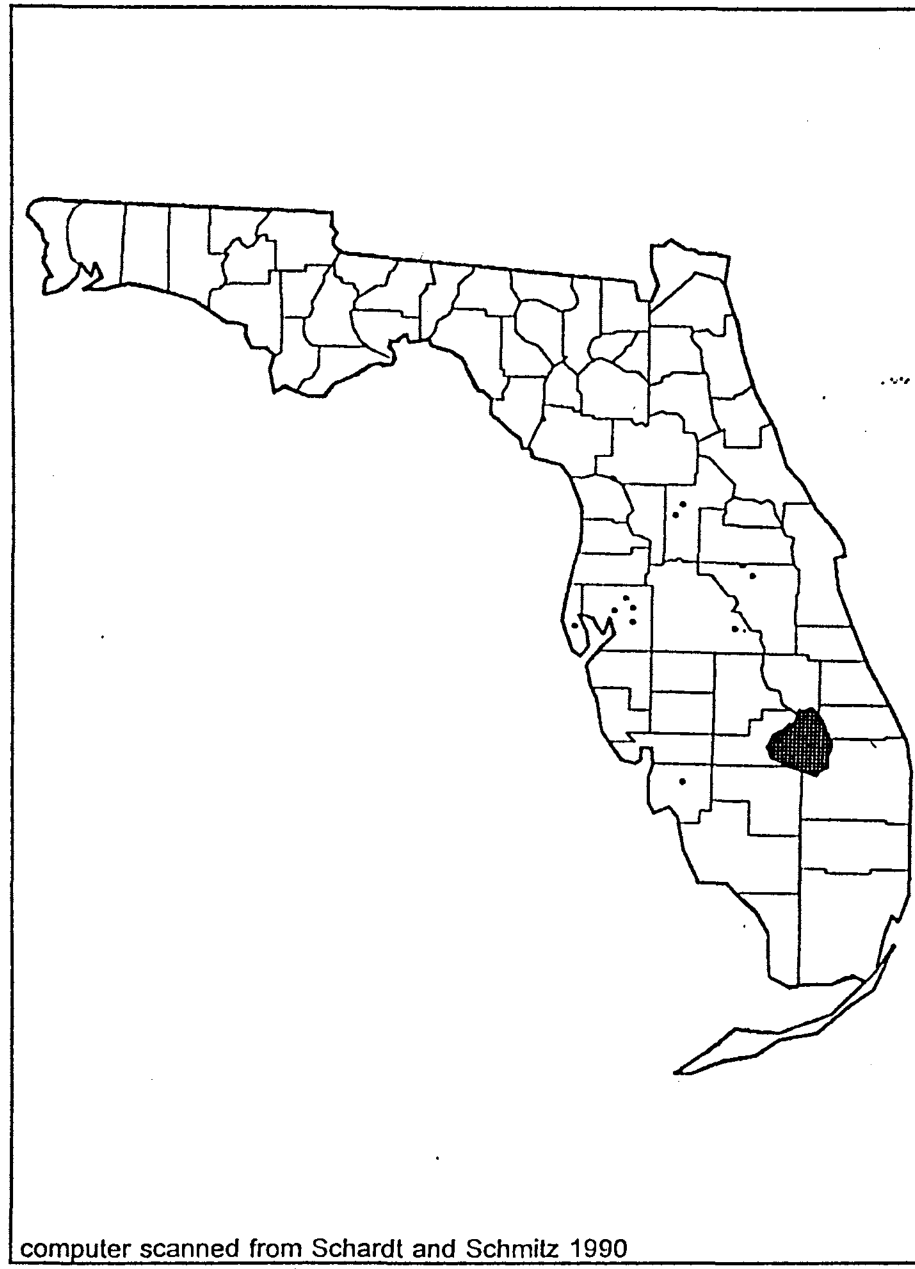

Figure 13: Public Lakes and Rivers in Which Hygrophila Was Reported During 1990

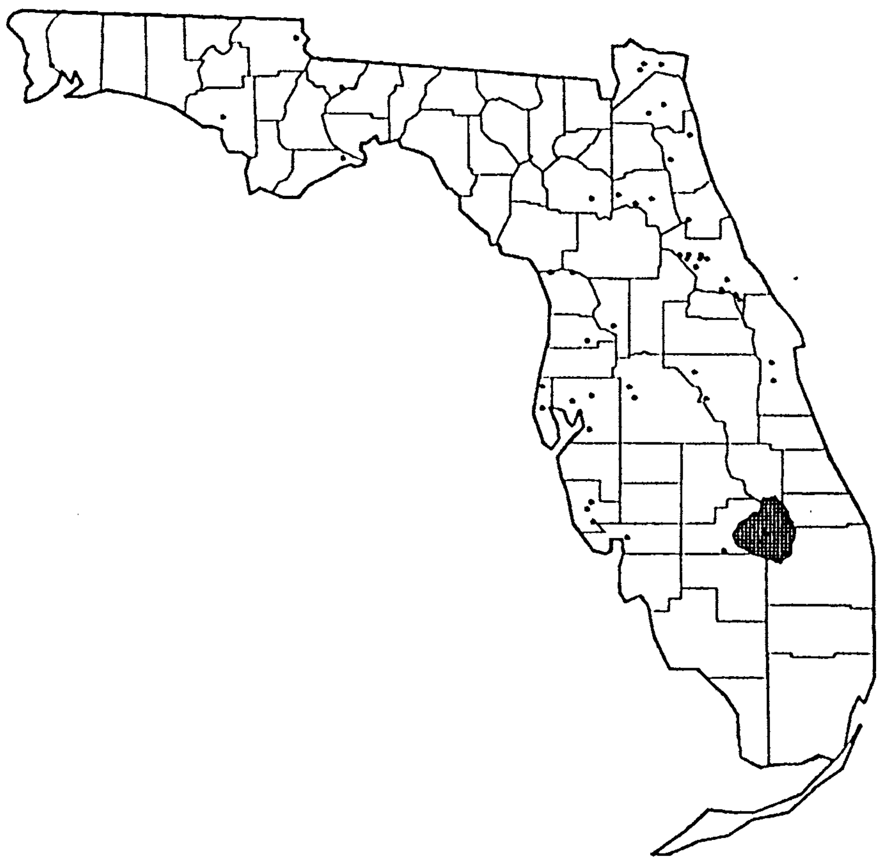

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Figure 14: Public Lakes and Rivers in Which Parrot-feather Was Reported During 1990

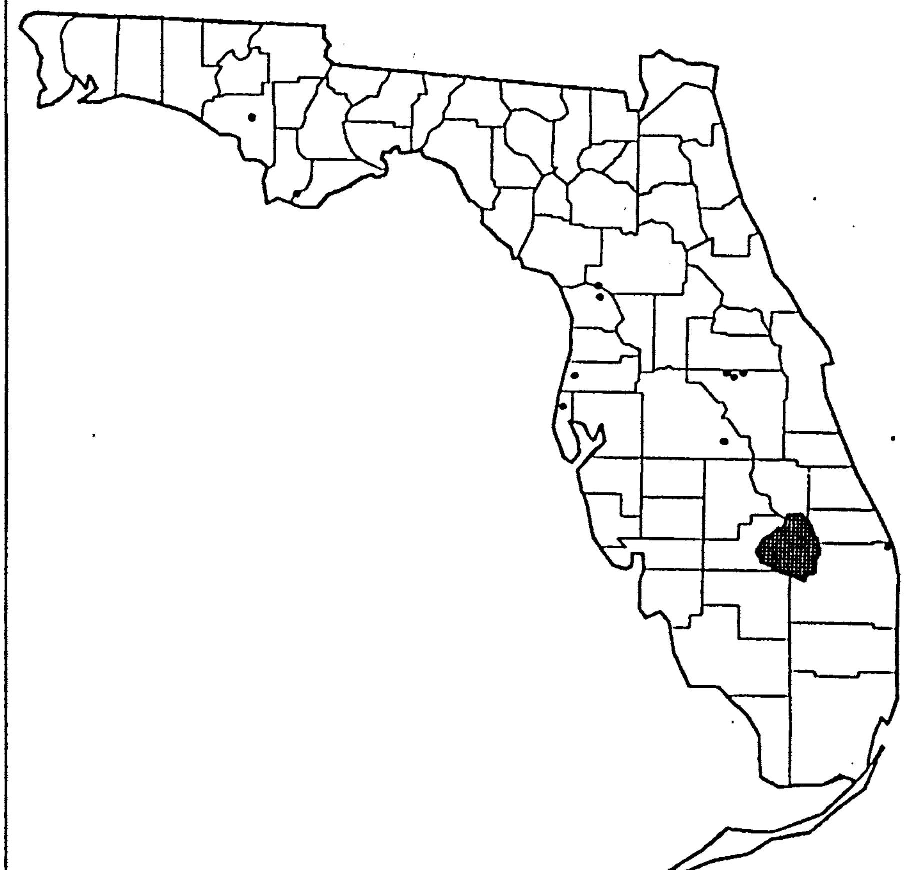

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Figure 15: Public Lakes and Rivers in Which Limnophila Was Reported During 1990

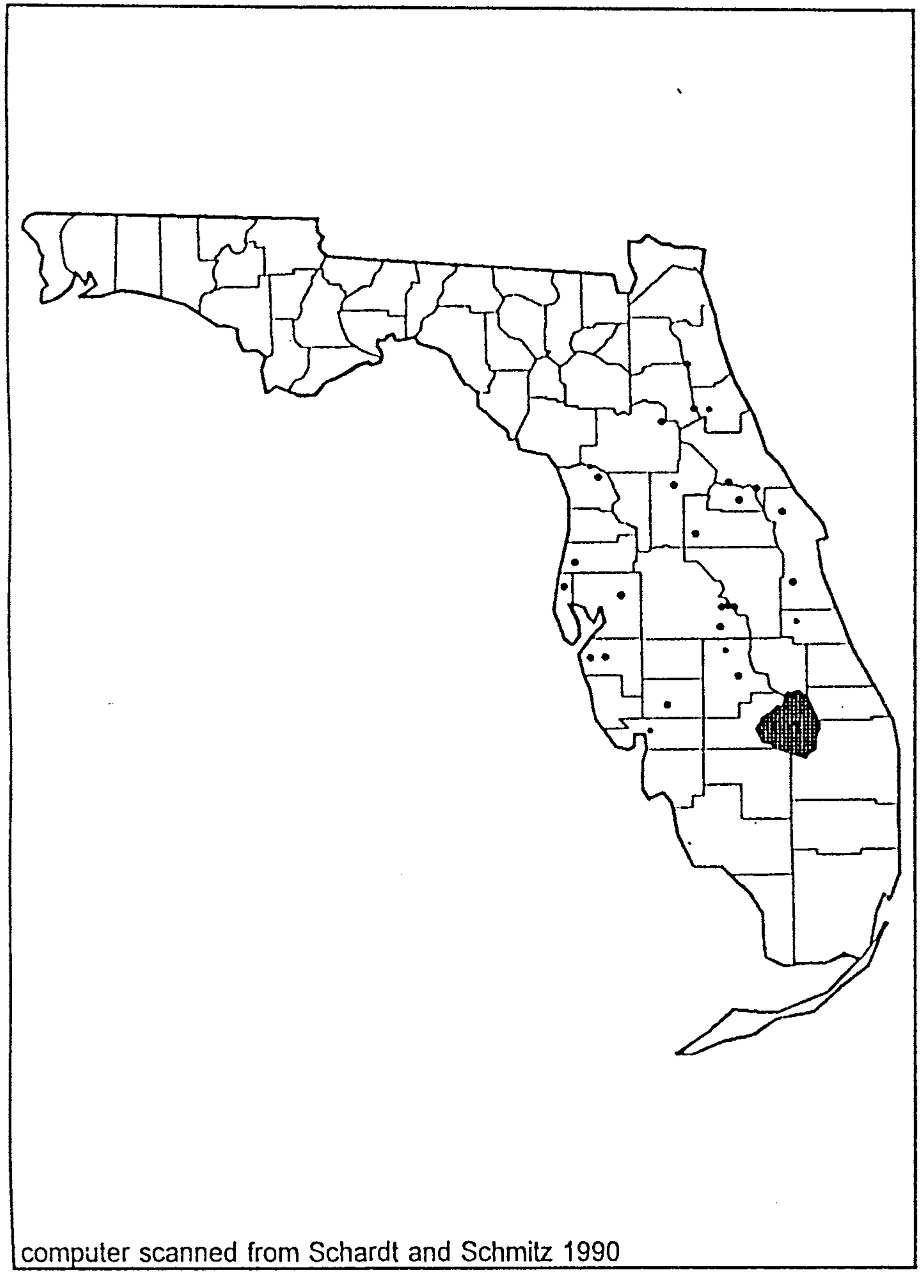

Figure 16: Public Lakes and Rivers in Which Water Sprite Was Reported During 1990

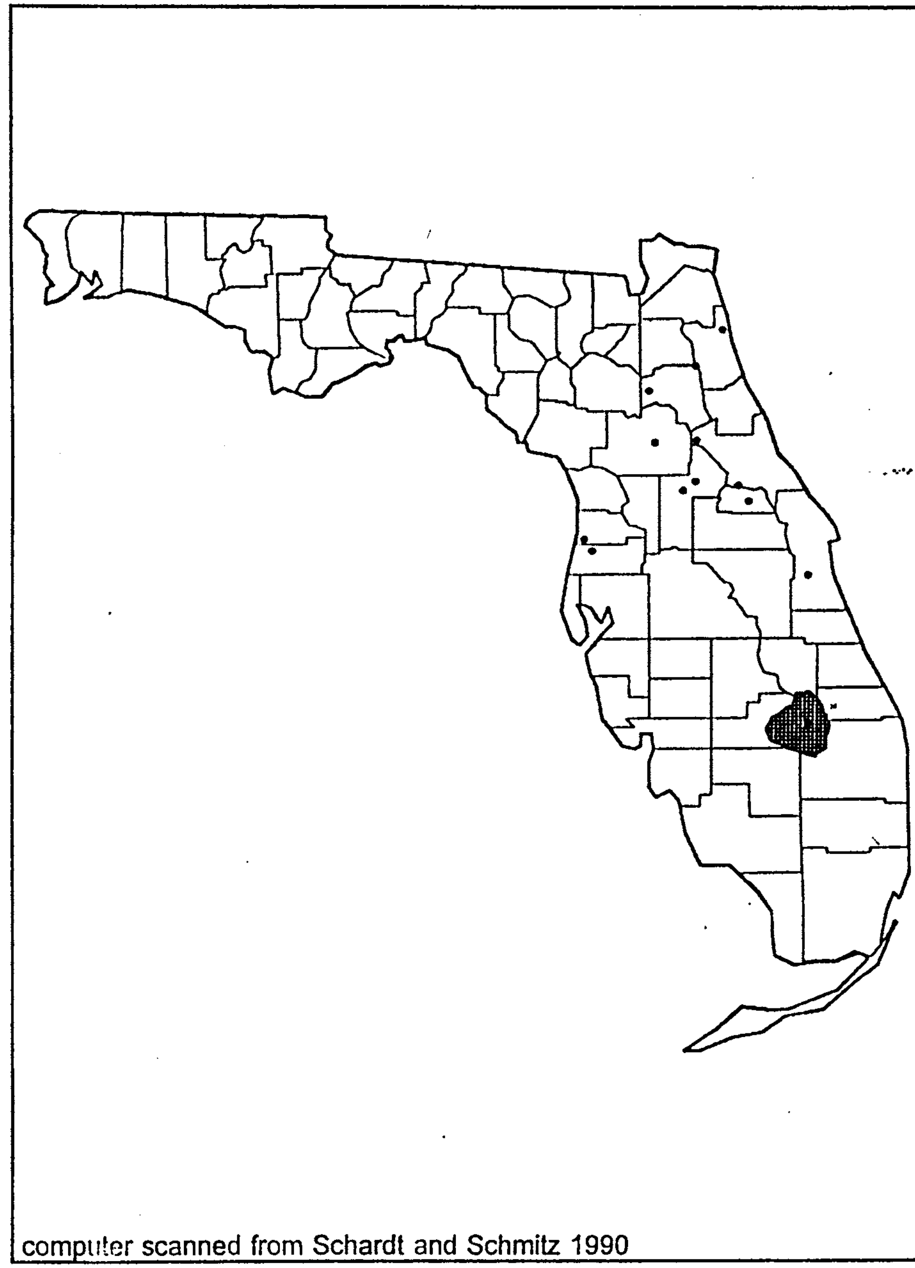

Figure 17: Public Lakes and Rivers in Which Napier Grass Was Reported During 1990

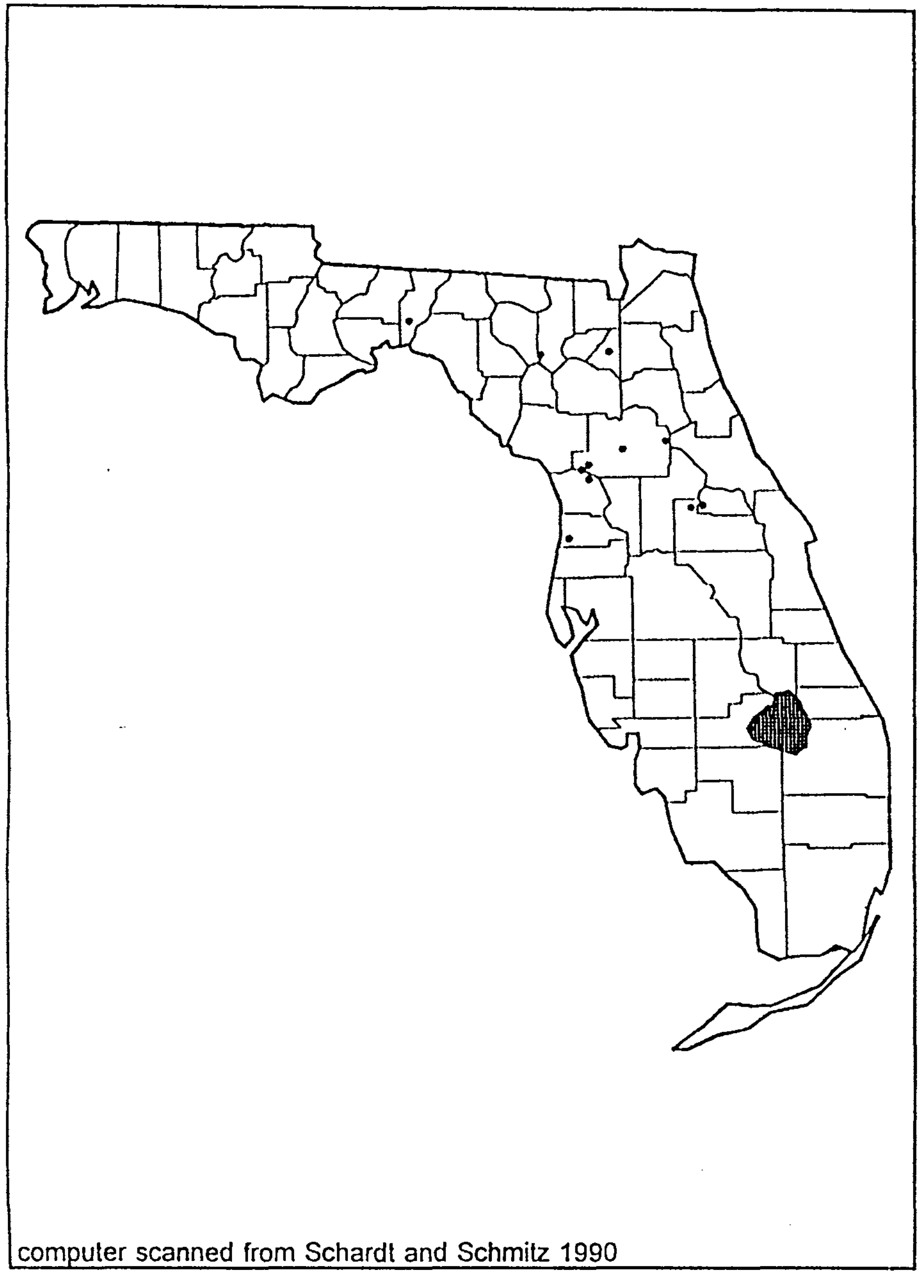

Figure 18: Public Lakes and Rivers in Which Watercress Was Reported During 1990

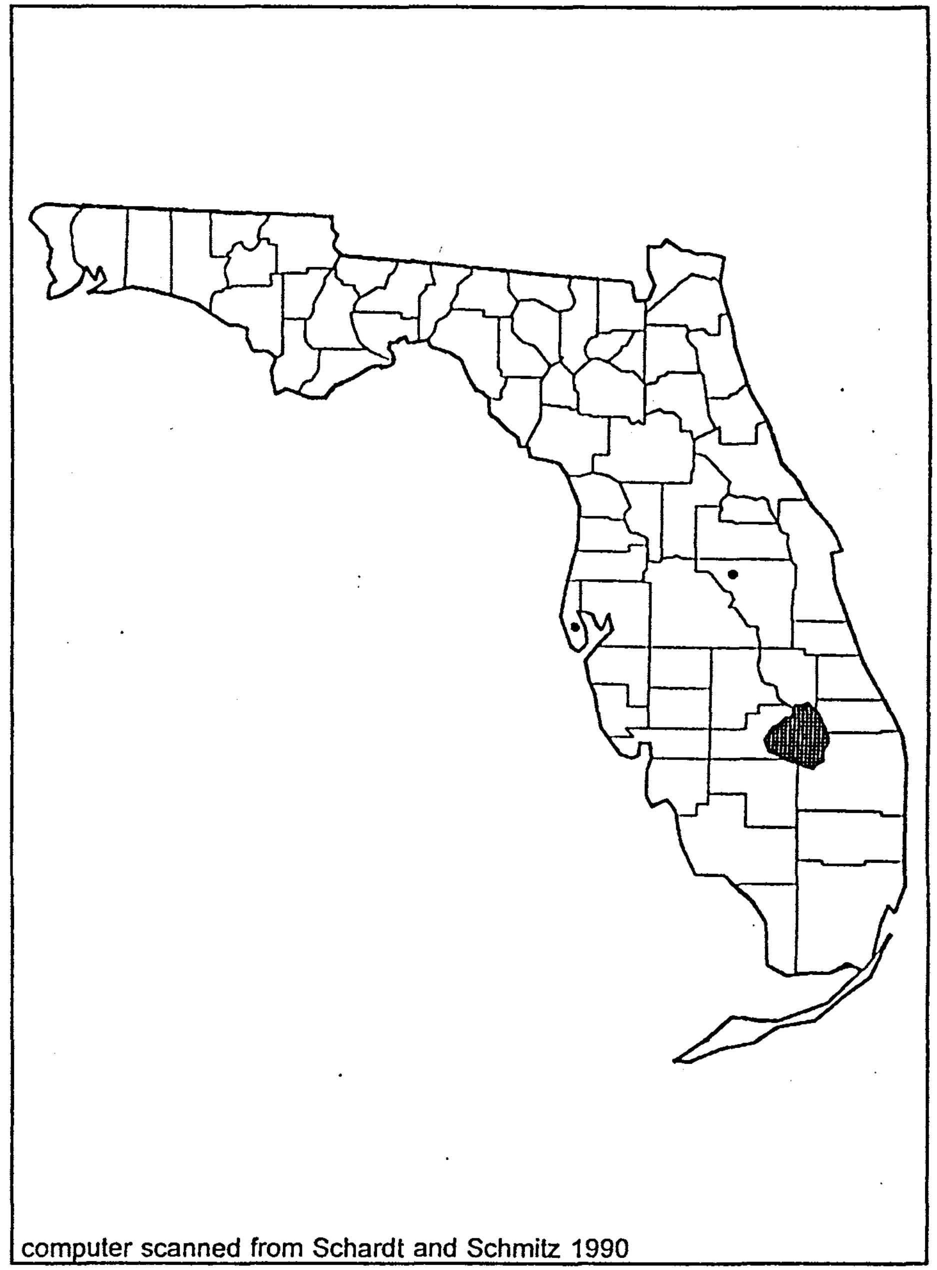

Figure 19: Public Lakes and Rivers in Which Water Spinach Was Reported During 1990

Cited Literature

* Unpublished work

Abbott, R. T. 1950. Snail invaders. Natural History 59:80-85.

Abbott, R. T. 1952. A study of an intermediate snail host (*Thira granifera*) of the Oriental lung fluke (*Paragonimus*). Proceedings of the United States National Museum 102(3292):71-116.

Abbott, R. T. 1975. American seashells. 2nd ed. Van Nostrand-Reinhold, New York. 633 pp.

Abele, L. G. 1974. Taxonomy, distribution and ecology of the genus *Sesame* (Crustacea, Decapoda, Grapsidae) in eastern North America, with special reference to Florida. American Midland Naturalist 90:375-386.

Abele, L. G. 1992. A review of the grapsid crab genus *Sesarma* (Crustacea: Decapoda: Grapsidae) in America with the description of a new genus. Smithsonian Contributions to Zoology 527. iii + 60 pp.

Adams, C. M. 1986. Aquaculture in Florida: general economic considerations. Florida Cooperative Extension Service, University of Florida, Gainesville, Fla. Sea Grant Extension Bulletin No.9. 17 pp.

Agami, M., and K. R. Reddy. 1990. Competition for space between *Eichhornia crassipes* (Mart.) Solms and *Pistia stratiotes* L. culured in nutrient-enriched water. Aquatic Botany 38:195-208.

Ahmed, A. T. A. 1973. Morphology and life history of *Mitraspora cyprini* Fujita, parasitic in the kidney of goldfish. Journal of Medical Science Biology 26:87-101.

Ahmed, A. T. A. 1974. Kidney enlargement disease of goldfish in Japan. Japanese Journal of Zoology 17:37-65.

Akbay, K. S., J. W. Wooten, and F. G. Howell. 1988. Simulation model of waterhyacinth and its biocontrol control agents; Report 1. First-generation model. Unpublished report, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms. 75 pp.

*Aldridge, F. J., and J. V. Shireman. 1987. Fish parasites and diseases and their treatment. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville. 14 pp.

Alexander, T. R. 1964. Feeding behavior of *Bufo marinus*. Herpetologica 20:255-259.

*Alfieri, Jr., S. A., K. R. Langdon, J. W. Kimbrough, N. E. El-Gholl, and C. Wehlburg. 1994. Diseases and disorders of plants in Florida. Unpublished report, Florida Department of Agriculture and Conservation Services, Gainesville. 1114 pp.

Allen, A. W. 1980. *Cyprinus carpio* Linnaeus. Page 152 in D. S. Lee, C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer, Jr., editors. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, North Carolina. 854 pp.

Allen, E. R., and Neill, W. T. 1953. The treefrog, *Hyla septentrionalis*, in Florida. Copeia 1953:127-128.

Allen, R. P. 1954. A report on the flamingo. Audubon 55:210-13, 224.

Allen, R. P. 1956. The flamingoes: their life history and survival, with spedial references to the American and West Indian flamingo (*Phoenicopterus ruber*). Research Report No. 5. National Audubon Society, New York. 285 pp.

Allen, R. and W.T. Neill. 1954. The Florida deer. Florida Wildlife 7(9):21,37.

Allen, S. K. J., and R. J. Wattendorf. 1987. The triploid grass carp: status and management implications. Fisheries 12(4):20-24.

American Fisheries Society. 1973. Position statement on exotic aquatic organisms' introductions. Transactions of the American Fisheries Society 102:268-269.

American Ornithologists' Union. 1983. Check-list of North American birds. American Ornithologists' Union, Washington, D.C. 877 pp.

*Anderson, R. S. 1981. Food habits of selected non-native fishes: stomach contents. Unpublished report, Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, Boca Raton. 16 pp.

*Anderson, R. S. 1982. Food habits of selected non-native fishes: stomach contents. Unpublished report, Non-Native Fish Research Laboratory, Florida Game and Fresh Water Fish Commission, Boca Raton. 22 pp.

Anderson, R. S., R. J. Metzger, and P. L. Shafland. 1984. Establishment of Midas cichlid, *Cichlasoma citrinellum*, in Florida. Florida Scientist 47:263-267.

Anderson, W. 1975. Temperature of Florida streams. U.S. Geological Survey and Bureau of Geology, Florida Department of Natural Resources, Tallahassee. 1 page map.

Andres, L. A., and F. D. Bennett. 1975. Biological control of aquatic weeds. Annual Review of Entomology 20:31-45.

Anonymous. 1896. Clogged by hyacinths: navigation on the St. John's, Florida, seriously obstructed. The New York Sun, September 20, 1896.

Anonymous. 1955. Roving rodent. Florida Wildlife 8(9):10.

*Anonymous. 1971. Economic damage caused by aquatic weeds. Unpublished report, Office of Science and Technology, U.S. Agency for International Development, Washington, D.C. 13 pp.

Anonymous. 1976. Making aquatic weeds useful: some perspectives for developing countries. Pages 127-129 in Report of an Ad Hoc Panel of the Advisory Committee on Technology Innovation, Board on Science and Technology for International Development, Commission on International Relations, National Academy of Sciences. Washington, D.C. 175 p.

Anonymous. 1979. United Nations study of tropical fish trade. Pet Age, February and April.

*Anonymous. 1980. Southern hospitality or the exotic invasion of Florida. Unpublished report, Florida Atlantic University, Boca Raton. 11 pp.

Anonymous. 1988. Biology and culture of *Penaeus monodon*. Southeast Asian Fisheries Development Center. Tigbauan, Iloilo, Philippines. 178 pp.

Anonymous. 1992. Digest of federal resource laws of interest to the U.S. Fish and Wildlife Service. U.S. Fish and Wildlife Service, Washington, D.C. 105 pp.

*Anonymous. 1992. TRAFFIC (USA). Unpublished report, World Wildlife Fund, Washington, D.C. September. 2 pp.

Anonymous. 1993. Exotic Pest Plants Council's 1993 list of invasive species. Florida Department of Natural Resources, Research Management Notes 5(3):27-32.

*Aquaculture Program. 1991. Florida aquatic plant locator: a listing of sources of Florida aquatic plants for the aquarium, garden pool, restoration project or salad. Unpublished report, Florida Department of Agriculture and Consumer Services, Tallahassee. 85 pp.

Aronson, L. R. 1949. An analysis of reproductive behaviour in the mouth-breeding Cichlid fish, *Tilapia macrocephala* (Bleecker). Zoologica 34:133-158.

Ashton, R. E., Jr., and P. S. Ashton. 1988. Handbook of reptiles and amphibians of Florida. Part III: the amphibians. Windward Publishing, Miami, Fla. 191 pp.

Ashton, R. E., Jr., and P. S. Ashton. 1991. Handbook of reptiles and amphibians of Florida. Part two: lizards, turtles and crocodilians. Windward Publishing, Miami, Fla. 191 pp.

Attionu, R. H. 1976. Some effects of water lettuce (*Pistia stratiotes*, L.) on its habitat.

Hydrobiologia 50:245-254.

Atwood, E.L. 1950. Life history studies of nutria, or coypu, in coastal Louisiana. Journal of Wildlife Management 14:249-265.

Austin, D. F. 1973. Range expansion of the Cuban tree frog in Florida. Florida Naturalist 46(4): 28.

Austin, D. F. 1975. Exotics. Florida Naturalist 48(3):2-5.

Austin, D. F. 1978. Exotic plants and their effects in southeastern Florida. Environmental Conservation 5(1):25-34.

Austin, D. F., and A. Schwartz. 1975. Another exotic amphibian in Florida. *Eleutherodactylus coqui*. Copeia 1975:188.

Avault, Jr., J. W., R. O. Smitherman, and E. W. Shell. 1968. Evaluation of eight species of fish for aquatic weed control. Pages 109-122 in Proceedings of the world symposium on warm-water pond fish culture. FAO Fisheries Report 44, 5:Vii/E-3.

Axelrod, H. R. 1971. The aquarium fish industry-1971. Tropical Fish Hobbyist Publications, Jersey City, N.J. 7 pp.

Axelrod, H. R. 1973. Tropical aquarium fishes as laboratory animals. Transaction of the American Fisheries Society 102:249-250.

Axelrod, H. R., C. W. Emmons, W. E. Burgess, N. Pronek, and G. S. Axelrod. 1980. Exotic tropical fishes. Tropical Fish Hobbyist Publications, Neptune, N.J. 1302 pp.

Axelrod, H. R., and L. P. Schultz. 1955. Handbook of tropical aquarium fishes. McGraw-Hill Book Co., New York. 718 pp.

*Babcock, S. C. 1974. The haul seine program and Lake Parker study. Unpublished report, Florida Game and Fresh Water Fish Commission. Tallahassee. 26 pp.

*Babcock, S., and P. Chapman. 1973. Description and status of the commercial fishery for blue tilapia in Polk County with recommendations to the Commission on methods of obtaining additional revenue from this fishery. Unpublished report, Florida Game and Fresh Water Fish Commission. Tallahassee. 35 pp.

Bailey, H. H. 1924. The armadillo in Florida and how it reached there. Journal of Mammalogy 5:264.

Bain, M. B. 1993. Assessing impacts of introduced aquatic species: grass carp in large systems.

Environmental Management 17:211-224.

Baird, S. F. 1879. The carp. Pages 40-44 in Report of the commissioner. Report of the United States Fish Commission for 1876-77. U.S. Government Printing Office, Washington, D.C.

Bajaj, Y. P. S., and M. S. Dhanju. 1980. Regeneration of plants from cultures of napier grass (*Pennisetum purpureum*). Plant Science Letters 20:343-345.

Baker, H. B. 1930. The mollusca collected by the University of Michigan-Williamson expedition in Venezuela. Part VI. Occasional Papers, Museum of Zoology, University of Michigan 210:1-94.

Balciunas, J. K., and T. D. Center. 1991. Biological control of *Melaleuca quinquenervia*: prospects and conflicts. Pages 1-22 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colarado. NPS/NREVER/NRTR-91/06.

Balon, E. K. 1974. Domestication of the carp *Cyprinus carpio* L. Life Sciences Miscellaneous Publications, Royal Ontario Museum. 37 pp.

Baltz, D. M. 1991. Introduced fish in marine systems and inland seas. Biological Conservation 56:151-177.

Barbour, T. 1931. Another introduced frog in North America. Copeia 1931:140.

Barkley, F. A. 1944. *Schinus* L. Brittonbia 5:160-198.

*Barko, J. W., R. M. Smart, D. C. Hardin, and M. S. Mathews. 1980. Growth and metabolism of three introduced, submersed plant species in relation to the influences of temperatures and light. Unpublished report, US Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms. Technical Report A-80-1. Washington DC. 46 pp.

*Barkuloo, J. M. 1964. Experimental stocking of *Tilapia* sp. Final Completion Report for Florida Dingell-Johnson Proj. No. F-14-R-4, Job 1-D. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee, Fla. 3 pp.

Barlow, G. W. 1974. Contrasts in social behavior between central American cichlid fishes and coral-reef surgeon fishes. American Zoologist 14:9-34.

Barlow, G. W. 1976. The Midas cichlid in Nicaragua. Pages 333-358 in T. B. Thorsen, editor. Investigations of the ichthyofauna of Nicaraguan lakes. University of Nebraska, Lincoln.

*Barnett, B. S. 1972. The freshwater fishes of the Hillsborough River drainage, Florida. M.S. thesis, University of South Florida, Tampa.

Barnett, B. S., and R. W. Schneider. 1974. Fish populations in dense, submersed plant communities. Hyacinth Control Journal 12:12-14.

Bartram, J. 1942. Diary of a journey through the Carolinas, Georgia, and Florida from July l, 1765 to April 10, 1766. Annotated by Francis Harper. Transactions of the American Philosophy Society 33:i-iv, 1-120 + pls. I-XXII.

*Bass, D. G., Jr., and V. G. Hitt. 1974a. Ecological distribution of the introduced Asiatic clam, *Corbicula manilensis*, in Florida. Unpublished report, Florida Game and Fresh Water Fish Commission, Lake City. 32 pp.

*Bass, D. G., Jr., and V. G. Hitt. 1974b. Utilization of the Asiatic clam, *Corbicula manilensis*, by game fishes in Florida. Unplublished report, Florida Game and Fresh Water Fish Commission, Lake City. 7 pp.

Bates, M. 1956. Man as an agent in the spread of organisms. Pages 788-804 in W. L. Thomas, Jr., editor. Man's role in changing the face of the Earth. University of Chicago Press, Chicago. 1193 pp.

Bates, M. 1964. Man in nature. 2nd ed. Prentice-Hall, Englewood Cliffs, New Jersey. 176 pp. + illustrations.

Bauer, O. N., and G. L. Hoffman. 1976. Helminth range extension by translocation of fish. Pages 163-172 in L. A. Page, editor. Wildlife diseases. Proceedings of the 3rd international wildlife disease conference. Plenum Press, New York.

Bauer, O. N., and Y. A. Strelkov. 1972. The effect of acclimatization and transportation on fish parasite fauna. Izvestia WNIORCh 80:123-131.

Becker, H. M., R. C. Belden, T. Breault, M. J. Burridge, W. B. Frankenberger, and P. Nicoletti. 1978. Brucellosis in feral swine in Florida. Journal of American Veterinarians Association 173:1181-1182.

Begley, B. W. 1979. Taro in Hawaii. Oriental Publishing Company, Honolulu. 29 pp.

Begum, A., M. A. Baskar, and M. Nasiruddin. 1985. Studies on the life history of *Crocothemis servilia* Drury (Anisoptera: Libellulidae). Dheka University Studies B33(1):137-143.

*Belden, R. C. 1990. Wild hog stocking: a discussion of issues. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 19 pp.

Belden, R. C., and W. B. Frankenberger. 1977. Management of feral hogs in Florida - past, present, and future. Pages 5-10 in G. W. Wood, editor. Research and management of wild hog populations. Proceedings of a symposium. Pelle W. Baruch Forest Science Institution, Clemson University, Georgetown, S.C.

Belden, R. C., and M. R. Pelton. 1975. European wild hog rooting in the mountains of east Tennessee. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 29:665-671.

Belfiore, N. M. 1991. The bottleneck effect in nutria: accumulation of genetic variability under favorable conditions. M.S. thesis, University of Florida, Gainesville. 33pp.

Belleville, B. 1981. Large effort with small fish builds valuable Florida tropical industry. Aquaculture Magazine. 7(4):12-17.

Belsche, J. F. 1961. Observations of an introduced tropical fish (*Belonesox belizanus*) in southern Florida. M.S. thesis, University of Miami, Coral Gables, Florida. 71 pp.

Bennett, C. A., and G. R. Buckingham. 1991. Laboratory biologies of *Bagous affinis* and *B. laevigatus* (Coleoptera: Curculionidae) attacking tubers of *Hydrilla verticillata* (Hydrocharitaceae). Annals of the Entomology Society of America 84:420-428.

Bennett, F. D., Crestana, L., Habeck, D. H., and E. Berti- Filho. 1988. Brazilian peppertree-prospects for biological control. Pages 293-295. in E. S. Delfosse, editor. Proceedings of the VII international symposium on biological control of weeds, Rome, Italy. 491 pp.

Bennett, F. D., and D. H. Habeck. 1991. Brazilian peppertree - prospects for biological control in Florida. Pages 23-30 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06.

Berg, L. S. 1949a. Freshwater fishes of the U.S.S.R. and adjacent countries. Vol. 2. Academy of Sciences of the U.S.S.R. Zoological Institute. Guide to the fauna of the U.S.S.R. 29. 1964 translation by Israel program for scientific translations. 496 pp.

Bertholdt, W. 1958. Your aquarium needs *Myriophyllum*: plant of delicate beauty. Aquarium Journal 29:106-107.

Beumer, J. P. 1980. Hydrology and fish diversity of a North Queensland tropical stream. Australian Journal of Ecology 5:159-186.

*Beneficial Insect Introduction Research Laboratory, (BIRL). 1992. Shipment to the state of Florida. A computer printout from a data base (BIRLDATA) of records of beneficial insects shipped from the Beneficial Insect Introduction Research Laboratory. Unpublished report, U.S. Department of Agriculture, Newark, Delaware.

Blackburn, R. D., D. L. Sutton, and T. Taylor. 1971. Biological control of aquatic weeds. Journal of Irrigation and Drainage Division, American Society of Civil Engineers 97:421-432.

Blackburn, R. D., T. M. Taylor, and D. L. Sutton. 1971. Temperature tolerance and necessary stocking rates of *Marisa cornuarietis* L. for aquatic weed control. Proceedings of the European Weed Research Committee. 3rd international symposium on aquatic weeds 3:79-86.

Blackburn, R. D., and L. W. Weldon. 1967. Eurasian watermilfoil - Florida's new underwater menace. Hyacinth Control Journal 6:15-18.

Blackburn, R. D., and L. W. Weldon. 1967. Preliminary evaluation of several herbicides on elodea in south Florida. Proceedings of the 29th Southern Weed Science Society. Raleigh, NC. 20:298.

Blackburn, R. D., L. W. Weldon, R. R. Yeo, and T. M. Tayor. 1969. Identification and distribution of certain similar-appearing submersed aquatic weeds in Florida. Hyacinth Control Journal 8(1):17-21.

Bogart, D. B. 1949. The effects of aquatic weeds on flow in Everglades canals. Proceedings of the Soil Science Society 9:32-52.

Bogel, K., and M. Abdussalam. 1976. International movement of wild animals in relation to the dissemination of zoonoses. Pages 107-112 in L.A. Page, editor. Wildlife diseases. Proceedings of the 3rd international wildlife disease conference. Plenum Press, New York.

Bond, W. J., and M. J. Roberts. 1978. The colonization of Cabora Bassa, Mozambique, a new man-made lake, by floating aquatic macrophytes. Hydrobiologia 60:243-259.

Bondy, C. 1962. The scarlet ibis in Florida. Florida Naturalist 35:87.

Boozer, A. C., and P. E. Mirkes. 1979. Observations on the fingernail clam, *Musculium partumeium* (Pisidiidae), and its association with the introduced Asiatic clam, *Corbicula fluminea*. Nautilus 93:73-83.

Boozer, D., 1973. Tropical fish farming. The American Fish Farmer 4(8):4-5.

Bowes, G., A. S. Holaday, and W. T. Haller. 1979. Seasonal variation in the biomass, tuber density and photosynthetic metabolism of hydrilla in three Florida lakes. Journal of Aquatic Plant Management 15:32-35.

Bowes, G., T. K. Van, L. A. Garrard, and W. T. Haller. 1977. Adaption to low light levels by hydrilla. Journal of Aquatic Plant Management 15:32-35.

*Bown, T. A., C. Lyman, and P. P. Rotar. 1966. Paragrass or California grass. Unpublished report, Cooperative Extension Service, University of Hawaii, Honolulu, 2 pp.

Braga, R. A. 1954. Alimentacao de pirambeba, *Serrasalmus rhombeus* (L., 1766) Lacepede, 1803, no acude Lima Campos, Ico, Ceara (Ostariophisi, Charicidae, Serrasalminae). English Summary, Brazilian Biological Review. 14:477-492.

Braithewaite, R. W., W. M. Lonsdale, and J. A. Estbergs. 1989. Alien vegetation and native biota in tropical Australia: the spread and impact of *Mimosa pigra*. Biological Conservation 48:189-210.

Britton, J. C., editor. 1979. Proceedings the first international *Corbicula* symposium. Unpublished report, Texas Christian University Research Foundation, Fort Worth. 313 pp.

Britton, J. C., and B. Morton. 1979. *Corbicula* in North America: the evidence reviewed and evaluated. Pages 249-287 in J. C. Britton, editor. Proceedings of the first international *Corbicula* symposium. Unpublished report, Texas Christian University Research Foundation, Fort Worth.

Britton, J. C., and R. S. Prezant, editors. 1986. Proceedings of the second international *Corbicula* symposium. Special edition 2, American Malacological Bulletin. 238 pp.

Brock, J. A. 1992. Current diagnostic methods for agents and diseases of farmed marine shrimp. Part II. Pages 209-232 in W. Fulks and K. L. Main, editors. Diseases of cultured penaeid shrimp in Asia and the United States. The Oceanic Institute, Honolulu.

Brookfield, C. M., and O. Griswold. 1956. An exotic new oriole settles in Florida. National Geographic Magazine 109:260-264.

Brown, J. L., and N. R. Spencer. 1973. *Vogtia malloi*, a newly introduced phycitine moth (Lepidoptera: Pyralidae) to control alligatorweed. Environmental Entomology 2:519-523.

Brown, K. M. 1991. Mollusca: Gastropoda. Pages 285-314 in J. H. Thorp and A. P. Covich, editors. Ecology and classification of North American freshwater invertebrates. Academic Press, New York.

Brown, L.N. 1969. Exotic squirrel in Florida. Florida Wildlife 23:4-5.

*Brown, L. N. 1974. Breeding biology of the nutria (*Myocaster coypus*) in the Tampa Bay area, Florida. Unpublished report, Abstract papers of the 54th annual meeting of the American Society of Mammalogists.

*Brown, L. N. 1979. The Mexican gray squirrel and nutria in Florida. Unpublished report, Presented at the Florida exotic non-native species conference, Boca Raton.

Brown, R. V. 1982. The state perspective of the imported fire ant. Pages 36-39 in S. L. Battenfield, editor. Proceedings of the symposium on the imported fire ant. Unpublished report of the Inter-Society Consortium for Plant Protection. Atlanta, Georgia.

Brown, W. Y. 1979. The federal role in regulating species introductions into the United States. Pages 258-264 in R. Mann,, editor. Exotic species in mariculture. MIT press, Cambridge, Mass. 363 pp.

Bruner, M. C., and T. R. Batterson. 1984. The effect of three sediment types on tuber production in hydrilla (*Hydrilla verticillata* L.F. Royle). Journal of Aquatic Plant Management 22:95-97.

Brunner, G. 1949. Fische als Bazillentrager. Vom Vasser 17:9-15.

Bruton, M. N., and R. E. Boltt. 1975. Aspects of the biology of *Tilapia mossambica* Peters (Pisces: Cichlidae) in a natural freshwater lake (Lake Sibaya, South Africa). Journal of Fish Biology 7:423-445.

Buchannan, T. M. 1971. The reproductive ecology of the Rio Grande cichlid, *Cichlasoma cyanoguttatum* (Baird and Girard). Ph.D. dissertation, University of Texas, Austin. 242 pp.

Buckingham, G. R. 1988. Reunion in Florida-hydrilla, a weevil, and a fly. Aquatics 10:19-25.

Buckingham, G. R., and C. A. Bennett. 1981. The laboratory biology and behavior of *Litodactylus leucogaster*, a ceutorhynchine weevil that feeds on watermilfoils. Annals of the Entomology Society of America 74:451-458.

Buckingham, G. R., and C. A. Bennett. 1989. Laboratory host range of *Parapoynx diminutalis* (Lepidoptera: Pyralidae), an Asian aquatic moth adventive in Florida and Panama on *Hydrilla verticillata* (Hydrocharitaceae). Environmental Entomology 18:526-530.

Buckingham, G. R., D. Boucias, and R. F. Theriot. 1983. Reintroduction of the alligatorweed flea beetle (*Agasicles hygrophila* Selman and Vogt) into the United States from Argentina. Journal of Aquatic Plant Management 21:101-102.

Buckingham, Gary R., and Dale H. Habeck. 1990. Aquatic weeds. Pages 167-173, 184 in D. H. Habeck, F. D. Bennett, and J. H. Frank, editors. Classical Biological Control in the Southern United States. Southern Cooperative Series Bulletin No. 355.

Buckingham, G. R., and E. A. Okrah. 1993. Biological and host range studies with two species of *Hydrellia* (Diptera: Ephydridae) that feed on hydrilla. Unpublished report. U.S. Army Corps of Engineers, Waterways Experiment Station. Vicksburg, Ms. Technical Report A-93-7 58pp.

Buckow, E. 1969. Exotics: new threat to U.S. waters. Field and Stream, May:16-28.

Buker, G. E. 1982. Engineers vs. Florida's green menace. The Florida Historical Quarterly April:413-427.

Bullock, G. 1964. Pseudomonadales as fish pathogens. Developments in Industrial Microbiology

5:101-106.

Buntz, J., and P. Chapman. 1971. Fish population survey and comparison of Lake Lena and Hancock. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 22 pp.

Buntz, J., and C.S. Manooch III. 1969a. *Tilapia aurea* (Steindachner), a rapidly spreading exotic in south central Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 22:495-501.

*Buntz, J., and C. S. Manooch, III. 1969b. A brief summary of the cichlids in the south Florida region. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 3 pp.

Burch, J. B. 1982. North American freshwater snails: identification keys, generic synonymy, supplemental notes, glossary, references and index. Transactions of the POETS Society 4:217-363.

Burch, J. B., and J. L. Tottenham. 1980a. North American freshwater snails. Transactions of the POETS Society 1(3):33-80.

Burch, J. B., and J. L. Tottenham. 1980b. North American freshwater snails: species list, ranges, and illustrations. Transactions of the POETS Society 1(3):81-215.

Burch, J. Q. 1944. Check list of west American mollusks. Minutes Conch. Club. Southern California 38:18.

Buren, W. F., G. E. Allen, W. H. Whitcomb, F. E. Lennartz, and R. N. Williams. 1974. Zoogeography of the imported fire ants. Journal of the New York Entomology Society 82:113-124.

Burgess, E. J. 1958. The fishes of Six-Mile Creek, Hillsborough County, Florida, with particular reference to the presence of exotic species. Proceedings of the Annual Conference of the Southeastern Association Game and Fish Commissioners 12:1-8.

Burgess, G. H., C. R. Gilbert, V. Gillory, and D. C. Taphorn. 1977. Distributimnal notes on some north Florida freshwater fishes. Florida Science 40(1):33-41.

Burkhead, N. M., and J. D. Williams. 1990. Research on the Okaloosa darter focuses on competition and habitat use. Endangered Species Technical Bulletin 15(11):5-6.

*Burkhead, R. R. 1991. *Melaleuca* control in Big Cypress National Preserve. Pages 63-68 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. Unpublished report, National Park Service, Denver, Colardo. NPS/NREVER/NRTR-91/06.

Bushnell, R., III. 1952. The place of the armadillo in Florida wildlife communities. M.S. thesis, Stetson University, Deland, Fla. 55 pp.

Bussing, W. A. 1966. New species and records of Costa Rican freshwater fishes with a tentative list of species. Revista de Biologia Tropicale 14:205-249.

Bykhovskaya-Pavlovskaya, I. E. 1962. Key to the parasites of freshwater fish of the U.S.S.R. 1964 English translation, U.S. Department of Commerce, Office of Technical Service, Springfield, Va. Publication TT64-11040. 919 pp.

Caldwell, D. K., L. H. Ogren, and L. Giovannoli. 1959. Systematic and ecological notes on some fishes collected in the vicinity of Tortuguero on the Caribbean coast of Costa Rica. Revista de Biologia Tropicale 7:7-33.

Callahan, Phillip S., and Harold A. Denmark. 1973. Attraction of the "love bug," *Plecia nearctica* (Diptera: Bibionidae) to UV irradiated automobile exhaust fumes. The Florida Entomologist 56(2):113-119.

Campbell, F. T. 1993. Legal avenues for controlling exotics. Pages 243-250 in B. N. McKnight, editor, 1993. Biological pollution: the control and impact of invasive exotic species. Indiana Academy of Science. Indianapolis. 261 pp.

Canfield, D. E., Jr., Maceina, M. J., and Shireman, J. V. 1983. Effects of hydrilla and grass carp on water quality in a Florida lake. Water Resources Bulletin 19:773-778.

Carleton, A. R. 1971. Studies on a population of the red-whiskered bulbul *Pycnonotus jocosus* (Linnaeus) in Dade County, Florida. Unpublished M.S. thesis, University of Miami, Coral Gables, Florida.

Carleton, A. R., and O. T. Owre. 1975. The red-whiskered bulbul in Florida: 1960-71. Auk 92:40-57.

Carlton, J. T. 1985. Transoceanic and interoceanic dispersal of coastal marine organisms: the biology of ballast water. Ocean and Marine Biology Annual Review 23:313-371.

Carlton, J. T. 1987. Mechanisms and patterns of transoceanic marine biological invasion in the Pacific Ocean. Bulletin of Marine Science 41:467-499.

Carlton, J. T. 1989. Man's role in changing the face of the ocean: biological invasions and implications for conservation of near-shore environments. Conservation Biology. 3:265-273.

Carlton, J. T. 1990. The introduced marine and estuarine mollusks of North America: an end-of-the-century perspective on four centuries of human-mediated introductions. Proceedings of the National Shellfisheries Association 8:465.

Carlton, J. T. 1992a. The dispersal of living organisms into aquatic ecosystems: the mechanisms of dispersal as mediated by aquaculture and fisheries activities. Pages 13-45 in A. Rosenfield and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems. The University of Maryland, College Park. 471 pp.

Carlton, J. T. 1992b. Introduced marine and estuarine mollusks of North America: An end-of-20th-century perspective. Journal of Shellfish Research 11:489-505.

*Carlton, J. T. 1992c. Marine species introductions by ship's ballast water: An overview. Pages 23-29 in M. R. DeVoe, editor. Proceedings of the conferences and workshop: introductions and transfers of marine species: achieving a balance between economic development and resource protection. Unpublished report, South Carolina Sea Grant Consortium, Charleston.

Carlton, J. T. 1992d. Overview of the issues concerning marine species introductions and transfers. Pages 65-67 in M. R. DeVoe, editor. Proceedings of the conferences and workshop: introductions and transfers of marine species: achieving a balance between economic development and resource protection. South Carolina Sea Grant Consortium, Charleston.

Carlton, J. T., and J. B. Geller. 1992. Ecological roulette: the global transport of nonindigenous marine organism. Science. 261(July 2, 1993):78-82.

Carr, A. F., Jr. 1940. A contribution to the herpetology of Florida. University of Florida Publications, Biological Science Service 3:1-118.

Carr, A. F., Jr., and C. J. Goin. 1955. Guide to the reptiles, amphibians, and fresh-water fishes of Florida. University of Florida Press, pp. i-ix + 1-341.

Cassani, J. R. 1986. Arthropods on Brazilian peppertree (*Schinus terebinthifolius*) (Anacardiaceae), in South Florida. Florida Entomologist 69:184-196.

Cassani, J. R., T. W. Miller, and M. L. Beach. 1981. Biological control of aquatic weeds in southwest Florida. Journal of Aquatic Plant Management 19:49-50.

Center, T. D. 1982. The waterhyacinth weevils: *Neochetina eichhorniae* and *N. bruchi*. Aquatics 4(2):8-19.

Center, T. D. 1984. Dispersal and variation in infestation intensities of waterhyacinth moth, *Sameodes albiguttalis* (Lepidoptera: Pyralidae), populations in peninsular Florida. Environmental Entomology 13:482-91.

*Center, T. D. 1992. Release and field colonization of new biological control agents of *Hydrilla verticillata*. Pages 205-221 in Proceedings of the 26th annual meeting of the Aquatic Plant Control Research Program. Miscellaneous Paper A-89-1. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms.

*Center, T. D., and J. K. Balciunas. 1988. Insect enemies of *Melaleuca*: what role should they play in management? Pages 1-16 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06. Unpublished abstract.

Center, T. D., R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker. 1991. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06. 387 pp.

*Center, T. D., and F. A. Dray, Jr. 1986. *Melaleuca quinquenervia*, a serious threat to South Florida wetlands: a review of taxonomy, biology, harmful and beneficial values and potential for biological control. Unpublished report, U.S. Department of Agriculture, Fort Lauderdale, Florida. 21 pp.

Center, T. D., and W. C. Durden. 1981. Release and establishment of *Sameodes albiguttalis* for the biological control of waterhyacinth. Environmental Entomology 10:75-80.

Center, T. D., and W. C. Durden. 1986. Variation in waterhyacinth/weevil interactions resulting from temporal differences in weed control efforts. Journal of Aquatic Plant Management 24:28-38.

Center, T. D., and Kipker, R. L. 1991. First record in Florida of *Acanthoscelides quadridentatus* (Coleoptera: Bruchidae), a potential biological control agent of *Mimosa pigra*. Florida Entomologist 74:159-162.

Center, T. D., and N. D. Spencer. 1981. The phenology and growth of waterhyacinth (*Eichhornia crassipes* (Mart.) Solms) in a eutrophic North-Central Florida lake. Aquatic Botany 10:1-32.

*Center, T., D. L. Sutton, V. A. Ramey, and K. A. Langeland. 1991. Other methods of aquatic plant management. Pages 61-67 in K. A. Langeland, editor. Aquatic pest control applicator training manual. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville.

Chadwick, M. J., and M. Obeid. 1966. A comparative study of the growth of *Eichhornia crassipes* (Solms) and *Pistia stratiotes* L. in water culture. Journal of Ecology 54:563-575.

*Chamberlain, E. B. 1960. Florida waterfowl populations habitat and management. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee, Florida. Technical Bulletin No. 7. 62pp.

Chamberlain, T. K. 1947. There is no universal pond fish. Progressive Fish Culturist 9:78-81.

Chamberlin, F. S., and H. H. Tippins. 1948. *Microthecaochroloma*, an introduced pest of crucifers. Journal of Economic Entomology 41:979-980.

Chandrasena, J. P. N. R., and H. C. P. Pieris. 1989. Studies on the biology of *Panicum repens* L. II. intraspecific competition and resource - allocation. Tropical Pest Management 35:316-320.

Chang-Hung, C. 1977. Phytotoxic substances in twelve subtropical grasses I. Additional evidences of phytotoxicity in the aqueous fractions of grass extracts. Botanical Bulletin of the Academia Sinica 18:131-141.

Chapman, P. 1989. Pick a pair of peacocks. Florida Sportsman. July 1989:48-51, 53, 54.

*Chapman, P., and N. Young. 1973. Completion report, Lake Effie fish kill investigation, Citrus World, Incorporated pollution incident, March, 1973. Unpublished report, State of Florida Game and Fresh Water Fish Commission. 18 pp.

Charudattan, R. 1984. Role of *Cercospora rodmanii* and other pathogens in the biological and integrated controls of waterhyacinth. Pages 834-859 in G. Thyagarajan, editor. Proceedings of the international conference on water hyacinth, United Nations Environmental Program, Nairobi, Kenya.

Charudattan, R. 1986. Integrated control of waterhyacinth (*Eichhornia crassipes*) with a pathogen, insects, and herbicides. Weed Science 34:26-30.

Charudattan, R. 1990. Special problems associated with aquatic weed control. Pages in 287-303. R. R. Baker and P. E. Dunn, editors. New directions in biological control: alternatives for suppressing agricultural pests and diseases. Alan R. Liss, Inc., New York.

*Charudattan, R., and H. Browning, editors. 1992. Regulations and guidelines: critical issues in biological control. Unpublished report, U.S. Department of Agriculture national workshop. Vienna, Va. 205pp.

Charudattan, R., B. D. Perkins, and R. C. Littell. 1978. Effects of fungi and bacteria on the decline of arthropod-damaged waterhyacinth (*Eichhornia crassipes*)in Florida. Weed Science 26:101-107.

Chesnut, T. L., and E. H. Barman, Jr. 1974. Aquatic vascular plants of Lake Apopka, Florida. Florida Science 37:60-64.

Chew, K. K. 1990. Global bivalve shellfish introductions. World Aquaculture 21(3):9-22.

Chew, R. L. 1973. The failure of largemouth bass, *Micropterus salmoides floridanus* (LeSuer), to spawn in eutrophic, overcrowded environments. Proceedings of the Annual Conference of the Southeastern Association Game and Fish Commissioners 26:306-319.

Clark, L. R., P. W. Geier, R. D. Hughes, R. F. Morris. 1967. The ecology of insect populations in theory and practice. Methuen and Co., Ltd., London.

Clarke, A.H. 1986. Competitive exclusion of *Canthyria* (Unionidae) by *Corbicula fluminea* (Muller). Malacology Data Net 1:3-10.

Clarke, A.H. 1988. Aspects of corbiculid-unionid sympatry in the United States. Malacology Data Net 2:57-99.

Clausen, C. P. 1978. Introduced parasites and predators of arthropod pests and weeds, a world review. U.S. Department of Agriculture Agricultural Handbook 480:i-vi, 1-545.

Clench, W. J. 1969. *Melanoides tuberculata* (Muller) in Florida. Nautilus 83:72.

Clench, W. J. 1970. *Corbicula manilensis* (Philippi) in lower Florida. Nautilus 84:36.

Clench, W. J., and S. L. H. Fuller. 1965. The genus *Viviparus* (Viviparidae) in North America. Occasional Papers Mollusca 2:385-412.

Clench, W. J., and R. D. Turner. 1956. Freshwater mollusks of Alabama, Georgia, and Florida from the Escambia to the Suwannee River. Bulletin of the Florida State Museum (Biological Science) 1(3):97-239.

Clugston, J. P. 1986. Strategies for reducing risks from introductions of aquatic organisms: the federal perspective. Fisheries 11(2):26-33.

Clugston, J. P., and J. V. Shireman. 1987. Triploid grass carp for aquatic plant control. U.S. Fish and Wildlife Service, Washington, D.C., Fish and Wildlife Leaflet 8. 3 pp.

*Cochran, M. J. 1992. Applying the general framework for benefit costs analysis on non-indigenous species to the case of Melaleuca. Unpublished report, U.S. Office of Technology Assessment, Washington, D.C.

*Cofrancesco, A. F., Jr. 1984. Biological control activities in Texas and California. Pages 57-61 in Proceedings of the 18th annual meeting of the Aquatic Plant Control Research Program. Unpublished report, US Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. Miscellaneous Paper A-84-4

Colle, D. E., and J. V. Shireman. 1980. Coefficients of condition for largemouth bass, bluegill, and redear sunfish in hydrilla infested lakes. Transactions of the American Fisheries Society 109:521-531.

Colle D. E. and J. V. Shireman. 1995. Use of grass carp in two Florida Lakes, 1975 to 1994. Pages 111-120. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Colle, D. E., J. V. Shireman, W. T. Haller, D. E. Canfield, and J. C. Joyce. 1985. Influence of hydrilla on angler utilization, harvest and monetary expenditure at Orange Lake, Florida. Unpublished report, University of Florida, Gainesville. 22 pp.

Colle, D. E., J. V. Shireman, W. T. Haller, J. C. Joyce, and D. E. Canfield, Jr. 1987. Influence of hydrilla on harvestable sport-fish populations, angler expenditures at Orange Lake, Florida. North American Journal of Fisheries Management 7:410-417.

Conant, R. 1975. A field guide to reptiles and amphibians: eastern and central North America. Houghton Mifflin Company, Boston. 429 pp.

Conant, R. D. Jr., T. K. Van, and K. K. Steward. 1984. Monoecious hydrilla produces viable seeds in the United States. Aquatics 6(3):10.

Connaly, H. 1968. The pike livebearer. Aquarium 2:45-50.

Connelly, J. 1981. The great American pet: costs and choices. Money 19(12):40-44.

Conner, J. V., R. P. Gallagher, and M. F. Chatry. 1980. Larval evidence for natural reproduction of the grass carp (*Ctenopharyngodon idella*) in the lower Mississippi River. Pages 1-19 in , L. A. Fuiman, editor. Proceedings of the fourth annual larval fish conference held 27-28 February 1980 in Oxford, Miss. U.S. Fish and Wildlife Service, Ann Arbor, Mich. FWS/OBS 80/43. 179 pp.

Conroy, D. A., J. Morales, C. Pedromo, R. A. Ruiz, J. A. Santicana. 1981. Preliminary observations on ornamental fish diseases in northern South America. Rivista Italiana di Piscicoltura e Ittiopatologia 16:86-100.

Conway, K. E. 1976a. *Cercospora rodmanii*, a new pathogen of waterhyacinth with biological control potential. Canadian Journal of Botany 54:1079-1083.

Conway, K. E. 1976b. Evaluation of *Cercospora rodmanii* as a biological control of waterhyacinths. Phytopathology 66:914-917.

Conway, K. E. and T. E. Freeman. 1977. Host specificity of *Cercospora rodmanii*, a potential biological control of waterhyacinth. Plant Disease Report. 61:262-266.

Conway, K. E., T. E. Freeman, and R. Charudattan. 1978. Development of *Cercospora rodmanii* as a biological control for *Eichhornia crassipes*. Pages 225-230 in Proceedings of the European Weed Research Society 5th symposium on aquatic weeds held in Wageningen, The Netherlands. Florida Agriculture Experiment Station Series No. 1122.

Cook, C. D. K. 1990. Origin, autecology, and spread of some of the world's most troublesome aquatic weeds. Pages 31-73 in A. H. Pieterse and K. J. Murphy, editors. Aquatic weeds. Oxford University Press. Cary, North Carolina.

Cook, C. D. K., and B. J. Gut. 1971. Salvinia in the state of Kerala, India. PANS 17(4):438-447.

Cook, C. D., B. J. Gut, E. M. Rix, J. Schneller and M. Seitz. 1974. Water plants of the world. Dr. W. Junk B.V. Publishers, The Hague. 561 pp.

Cook, C. D. K., and R. Luond. 1982. A revision of the genus *Hydrilla* (Hydrocharitaceae). Aquatic Botany 13:485-504.

Cook, D. K., and Urmi-Konig. 1984. A revision of the genus *Egeria* (Hydrocharitaceae). Aquatic Botany 19:73-96.

Cooper, C. M., and V. W. Johnson. 1980. Bivalve mollusca of the Yalobusha River, Mississippi. Nautilus 94:22-24.

Cooper, E. L. 1987. Carp in North America. American Fisheries Society, Bethesda, Md. 84 pp.

Cordo, H. A., J. C. DeLoach, and R. Ferrer. 1981. Biological studies on two weevils, *Ochatina bruchi* and *Onychylis cretatus*, collected from *Pistia* and other aquatic plants in Argentina. Annals of the Entomology Society of America 74:363-369.

*Cost, N.D. and G. C. Carver. 1981. Distribution of melaleuca in south Florida measured from the air. Pages 1-8. in R. K. Geiger, editor. Proceedings of the *Melaleuca* symposium. Unpublished report, Florida Department of Agriculture, Tallahassee.

Couch, R., and E. Nelson. 1986. *Myriophyllum spicatum* in North America. Pages 8-18. in L.W.J. Anderson (editor). Proceedings of the first international symposium of watermilfoil (*Myriophyllum spicatum*) and related Haloragaceae species. Aquatic Plant Management Society. Vicksburg, Mississippi.

*Coulson, J. R. 1977. Biological control of alligatorweed, 1959-1977: A review and evaluation. Unpublished report, U.S. Department of Agriculture. 98 pp.

Coulson, J. R., and R. S. Soper. 1989. Protocols for the introduction of biological control agents in the United States. Pages 1-35 in R. P. Kahn, editor. Plant protection and quarantine, Volume III, Special Topics. CRC Press, Boca Raton, Fla.

Countryman, W. D. 1970. The history, spread and present distribution of some immigrant aquatic weeds in New England. Hyacinth Control Journal 8(2):50-52.

Counts, C. L., III. 1981. *Corbicula fluminea* (Bivalvia: Sphaeriacea) in British Columbia. Nautilus 95:12-13.

Counts, C. L., III. 1986. The zoogeography and history of the invasion of the United States by *Corbicula fluminea* (Bivalve: Corbiculidae). Pages 7-39 in J. C. Britton and R. S. Prezant, editors.

Proceedings of the second international *Corbicula* symposium. American Malacology Bulletin Special Edition No. 2.

Counts, C. L. III. 1991. *Corbicula* (Bivalvia: Corbiculidae). Part I. Catalog of fossil and recent nominal species. Part 2. Compendium of zoogeographic records of North America and Hawaii, 1924-1984. Tryonia 21:1-134.

Courtenay, W. R., Jr. 1978. Additional range expansion in Florida of the introduced walking catfish. Environmental Conservation 5:273-275.

Courtenay, W. R., Jr. 1979a. The introduction of exotic organisms. Pages 237-252 in H. P. Brokaw, editor. Wildlife and America: contributions to an understanding of American wildlife and its conservation. Council on Environmental Quality, U.S. Government Printing Office, Washington, D.C.

Courtenay, W. R. 1979b. Continued range expansion in Florida of the walking catfish. Environmental Conservation 6:20.

*Courtenay, W. R., Jr. 1980. Introduced non-native fishes in Florida:1978-1979 Summary Report. Unpublished report, U.S. Fish and Wildlife Service, Gainesville, Fla. 399 pp.

*Courtenay, W. R., Jr. 1980. Survey of introduced non-native fishes. Phase II Report: Introduced non-native fishes in Florida: 1978-79 Summary Report. Unpublished report, U.S. Fish and Wildlife Service, Gainesville, Fla. 16 pp. + 2 maps.

*Courtenay, W. R., Jr. 1989. Exotic fishes in the National Park system. In L. K. Thomas, Jr., editor. Conference on science in the national parks. Proceedings, Management of exotic species in natural communities, Volume 5. Unpublished report, National Park Service, Washington, D.C.

*Courtenay, W. R., Jr. 1991. Pathways and consequences of the introduction of non-indigenous fishes in the United States. Unpublished report, U.S. Office of Technology Assessment, Washington, D.C. 26 pp.

Courtenay, W. R., Jr. 1993. Biological pollution through fish introductions. In B. N. McKnight, editor. Biological pollution: the control and impact of exotic species. Indiana Academy of Science, Indianapolis. 261 pp.

*Courtenay, W. R., Jr., and D. A. Hensley. 1979a. Introduced exotic fishes in North America: status 1979. Unpublished report, U.S. Fish and Wildlife Service, University of Florida, Gainesville. 395 pp.

Courtenay, W. R., Jr., and D. A. Hensley. 1979b. Range and expansion in southern Florida of the introduced spotted tilapia, with comments on its environmental impress. Environmental Conservation 6:149-151.

Courtenay, W. R. Jr., and D. A. Hensley. 1980. Special problems associated with monitoring exotic species. Pages 281-307 in C. H. Hocutt and J. R. Stauffer Jr., editors. Biological monitoring of fish. Lexington Books. Lexington, Mass.

Courtenay, W. R. Jr., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1984. Distribution of exotic fishes in the continental United States. Pages 41-71 in W. R. Courtenay, Jr., and J. R. Stauffer, Jr., editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Md.

Courtenay, W. R., D. A. Hensley, J. N. Taylor, and J. A. McCann. 1986. Distribution of exotic fishes in North America. Pages 675-698 in W. R. Courtenay, Jr. and J. R. Stauffer, Jr., editors. The zoogeography of North American freshwater fishes. John Wiley and Sons, New York.

Courtenay, W. R., D. P. Jennings, and J. D. Williams. 1991. Appendix 2, exotic fishes. Pages 97-107 in Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brokker, E. A. Lachner, R. N. Lea, and W. B. Scott, editors. Common and scientific names of fishes from the U.S. and Canada. Special Publication 20, American Fisheries Society, Bethesda, Md.

Courtenay, W. R., Jr., and G. F. Meffe. 1989. Small fishes in strange places: a review of introduced Poeciliidae. Pages 319-331 in G. K. Meffe and F. F. Snelson, Jr., editors. Ecology and evolution of livebearing fishes. Prentice-Hall, Englewood Cliffs, N.J.

Courtenay, W. R., Jr., and W. W. Miley, II. 1975. Range expansion and environmental impress of the introduced walking catfish in the United States. Environmental Conservation 2:145-148.

Courtenay, W. R., and V. E. Ogilvie. 1971. Species pollution. Animal Kingdom 74(2):22-28.

Courtenay, W. R., Jr., and C. R. Robins. 1973. Exotic aquatic organisms in Florida with emphasis on fishes: a review and recommendations. Transactions of the American Fisheries Society. 101:1-12.

Courtenay, W. R., Jr., and C. R. Robins. 1975. Exotic organisms: an unsolved complex problem. BioScience 25:306-313.

Courtenay, W. R., Jr., H. F. Sahlman, W. W. Miley, II, and D. J. Herrema. 1974. Exotic fishes in fresh and brackish waters of Florida. Biological Conservation 6:292-302.

Courtenay, W. R., Jr., and J. R. Stauffer, Jr. 1990. The introduced fish problem and the aquarium fish industry. Journal of the World Aquaculture Society 21:145-159.

Courtenay, W. R., Jr., and J. N. Taylor. 1984. The exotic ichthyofauna of the contiguous United States, with preliminary observations on intranational transplants. EIFAC Technical Papers 42:466-87.

Courtenay, W. R., and J. N. Taylor. 1986. Strategies for reducing risks from introductions of aquatic organisms: a philosophical perspective perspective. Fisheries 11(2):30-33.

Courtenay, W. R., and J. D. Williams. 1992. Dispersal of exotic species from aquaculture sources, with emphasis on freshwater fishes. Pages 49-81 in A. Rosenfield and R. Mann, editors. Dispersal of Living Organisms into Aquatic Ecosystems. Maryland Sea Grant, University of Maryland, College Park.

Craig, G. J., Jr. 1993. The diaspora of the Asian tiger mosquito. Pages 101-120 in B. N. McKnight, editor. 1993. Biological pollution: the control and impact of invasive exotic species. Indiana Academy of Science, Indianapolis. 261 pp.

Craven, R. B., D.A. Eliason, D.B. Francy, P. Reiter, E.G.Campos, W.L. Jakob, G.Cc Smith, C.J. Bozzi, and C.G. Moore. 1988. Importation of *Aedes albopictus* and other exotic mosquito species into the United States in used tires from Asia. Journal of the American Mosquito Control Association 4:138-142.

Cremer, M. C., and R. O. Smitherman. 1980. Food habits and growth of silver and bighead carp in cages and ponds. Aquaculture 20:57-64.

Cressey, R. F. 1978. The genus *Argulus* (Crustacea: Branchiura) of the United States. Water Pollution Control Federation, Cincinnati, Oh. 14 pp.

*Crider, E. D. 1968. Pato real duck trial releases. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 16 pp.

Crittenden, E. 1962. Status of *Tilapia nilotica* in Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 16:257-262.

Crittenden, E. 1965. Status of *Tilapia nilotica* Linneaus in Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 16:257-262.

Cruickshank, A. D. 1980. The birds of Brevard County, Florida. Florida Press, Orlando, Fla. 200pp.

Cunningham, R. L. 1962. The spread of the spotted-breasted Oriole in Florida (*Icterus pectoralis*). Audubon Field Notes 16:340-342.

Cunningham, R. L. 1965. Predation on birds by the cattle egret. Auk 82:502-503.

Cunningham, V.D. and R.D. Dunford. 1970. Recent coyote record from Florida. Quarterly Journal of the Florida Academy of Sciences 33:279-280.

Daget, J., and A. Iltis. 1965. Poissons de Côte d'Ivorie. Mémoires de l'Institute Francais d'Afrique

Noire 74:1-385.

Darnell, R. M. 1962. Fishes of the Rio Tamesi and related coastal lagoons in east-central Mexico. Institute of Marine Science, University of Texas, Austin. Publication of the Institute of Marine Science 8:229-365.

Davidson, J. R., J. A. Brock, L. G. L. Young. 1992. Introduction of exotic species for aquaculture purposes. Pages 83-101 in A. Rosenfield and R. Mann, editors. Dispersal of Living Organisms into Aquatic Ecosystems. Maryland Sea Grant, University of Maryland, College Park.

Davidson, N. A., and N. D. Stone. 1989. Imported fire ants. Pages 196-214 in Dahlsten, D.L. and R. Garcia, editors. Eradication of exotic pests: analysis with case histories, Michigan. Yale University, New Haven, Conn.

Davis, J. H. 1943. The natural features of southern Florida, especially the vegetation and the Everglades. Florida Geological Survey Bulletin 25. 311 pp.

*Decell, J. L. 1975. Large-scale field test with the monosex white amur in Florida. Pages 112-126 in J. L. Decell, editor. Proceedings of the research planning conference of the aquatic plant control program. Unpublished report, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms.

DeKay, J. E. 1842. Natural History of New York. I Zoology, Reptiles and Fishes- Part IV: Fishes. W. and A. White and J. Visscher, Albany, N.Y. 415 pp.

de Kinkelin, P., T. Hastein, J. Krecek, S. N. Chen, and B. J. Hill. 1990. The role of the OIE (Office International des Epizooties) in improving awareness and control of international transfers of fish and shellfish diseases. Bulletin of European Association of Fish Pathologists 10:4-6.

de la Pena, R. 1983. In Taro. A review of *Colocasia esculenta* and its potentials. Pages 167-179 in Taro. University of Hawaii Press. Honolulu.

Del Fosse, E. S., B. D. Perkins, and K. K. Steward. 1976. A new United States record for *Parapoynx diminutalis* (Lepidoptera: Pyralidae), a possible biological control agent for *Hydrilla verticillata*. Florida Entomologist 59:19-20.

del Hoyo, J. 1992. Family Phoenicopteridae (Flamingos). Pages 508-524 in J. del Hoyo, A. Elliott, and J. Sargatal, editors. Handbook of the birds of the world. Vol. 1 International Council for Bird Perservation Lynx Edicions.

Denmark, H.A. 1964. Florida Department of Agriculture's position on parasites and predators introduced into Florida for biological control. Hyacinth Control Journal 3:16-19.

Denmark, H. A., and J. E. Porter. 1973. Regulation of importation of arthropods into and of their movement within Florida. Florida Entomologist 56:347-358.

Denzer, H. W. 1966. Studies on the physiology of young *Tilapia*. FAO Fisheries Report 44:356-366.

Dial, R. S., and S. C. Wainright. 1983. New distributional records for non-native fishes in Florida. Florida Scientist 46(1):8-15.

Diamond, C., D. Davis, and D. C. Schmitz. 1991. Economic impact statement: the addition of *Melaleuca quinquenervia* to the Florida Prohibited Aquatic Plant List. Pages 87-114 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06.

Dickel, T. S. 1991. New records of noctuid moths from Florida (Lepidoptera: Noctuidae). Tropical Lepidoptera 2:53-58.

Djerassi, C., C. Shih-Coleman and J. Diekman. 1974. Insect control of the future: Operational and policy aspects. Science 186: 596-607.

Dobson, A. P., and R. M. May. 1986. Patterns of invasions by pathogens and parasites. Pages 59-76 in H. A. Mooney and J. A. Drake, editors. Ecology of biological invasions of North America and Hawaii. Springer-Verlag, New York.

Doren, R. F. 1991. Management of *Melaleuca quinquenervia* within East Everglades Wetlands. Pages 237-253 in T. D. Center, R.F. Doren, R.L. Hofstetter, R.L. Myers, and L.D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/ NREVER/NRTR-91/06.

Doren, R. F., and L. D. Whiteaker. 1991. The exotic pest plant council: an example of interagency cooperation to solve resource related problems. In T. D. Center, R.F. Doren, R.L. Hofstetter, R.L. Myers, and L.D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06.

*Dozier, H. L. 1951. The present status and future of nutria in the southeastern states. 5th Annual Meeting Southeast Association of Game and Fish Commission. Unpublished report, 10 pp.

Drake, J., and H. Mooney, editors. 1989. Ecology of biological invasions: a global perspective. John Wiley and Sons, New York. 450 pp.

Dray, F. A., and T. D. Center. 1992. Waterlettuce biocontrol agents: releases of *Namangana pectinicornis* and dispersal by *Neohydronomus affinis*. Pages 237-243 in Proceedings of the 26th annual meeting of the Aquatic Plant Control Research Program. U.S. Corps of Engineers, Waterway Experiment Station, Vicksburg, Mississippi.

Dray, F. A., Jr., T. D. Center, D. H. Habeck, C. R. Thompson, A. F. Cofrancesco, and J. K. Balciunas. 1990. Release and establishment in the southeastern United States of *Neohydronomus affinis* (Coleoptera:Curculionidae), an herbivore of waterlettuce. Environmental Entomology 19:799-802.

*Dray, F. A., C. R. Thompson, D. H. Habeck, J. K. Balciunas, and T. D. Center. 1988. A survey of the fauna associated with *Pistia stratiotes* L. (waterlettuce) in Florida. Unpublished report, U.S. Army Corps Engineers, Waterways Experiment Station, Vicksburg, Ms. Technical Report A-88-6. 20pp.

*Dreier, H. 1977. Study of *Corbicula* in Lake Sanchris. Pages 7.1-7.52 in Annual report for fiscal year 1976. Unpublished report, Illinois Natural History Survey, Urbana.

Duellman, W. E., and R. I. Crombie. 1970. *Hyla septentrionalis*. Cat. American Amphibian Report 92.1-92.4.

Duellman, W. E., and A. Schwartz. 1958. Amphibians and reptiles of southern Florida. Bulletin of the Florida Museum 3:181-324.

Dundee, D. S. 1965. Veronicellids still on the move in the Gulf Coast. Nautilus 85:72.

Dundee, D. S. 1969. Introduced molluscs of the United States. Malacologia 9:264.

Dundee, D. S. 1970a. Introduced gulf coast molluscs. Tulane Studies in Zoology and Botany 16:101-115.

Dundee, D. S. 1970b. Discussion of Dr. Clench's paper. Pages 36-37 in American Malacological Union Symposium on Rare and Endangered Mollusks. Malacologia 10.

Dundee, D. S. 1971. Subulinids and Veronicelids in the United States. The Biologist 53:128-132.

Dundee, D. S. 1977. Observations on the Veronicellid slugs of the southern United States. Nautilus 91:108-114.

Dundee, D. S., and W. J. Harman. 1963. *Corbicula fluminea* (Müller) in Louisiana. Nautilus 77:30.

Dundee, D. S., P. H. Phillips, and J. D. Newsom. 1967. Snails on migratory birds. Nautilus 80:89-91.

Dundee, D. S. 1970. Introduced gulf coast molluscs. Tulane Studies in Zoology and Botany 16:101-115.

Dundee, D. S. 1974. Catalog of introduced molluscs of eastern North America (North of Mexico). Sterkiana 55:1-37.

Dunkle, S. W. 1989. Dragonflies of the Florida Peninsula, Bermuda and the Bahamas. Scientific Publications, Gainesville, Fla. 154 pp.

Dunkle, S. W. 1990. Damselflies of Florida, Bermuda and the Bahamas. Scientific Publications, Gainesville, Fla. 148 pp.

Dykova, E., and J. Lom. 1980. Tissue reaction of microsporidean infections in fish. Journal of Fish Diseases 3:265-283.

Edie, H. H., and B. W. C. Ho. 1969. *Ipomoea aquatica* as a vegetable crop in Hong Kong. Economic Botany 23:32-36.

Eggeman, D. 1995. Integrated hydrilla management plan utilizing herbicides and triploid grass carp in Lake Istokpoga. pages 164-165. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Eigenmann, C. H., and W. R. Allen. 1942. Fishes of western South America. University of Kentucky, Waverly Press, Baltimore, Md. 494 pp.

Ellis, T. M. 1980. *Caiman crocodylus*: An established exotic in south Florida. Aopeia 1980:152-154.

Elton, C. S. 1958. The ecology of invasions by animals and plants. Methuen & Company, London. 181 pp.

*Eng, L. L. 1979. Population dynamics of the Asiatic clam, *Corbicula fluminea* (Müller), in the concrete-lined Delta-Mendota Canal of central California. Pages 39-68 in J. C. Britton, editor. 1979. Proceedings of the first international *Corbicula* symposium. Unpublished report, Texas Christian University, Fort Worth.

Ernst, C. H., and R. W. Barbour. 1972. Turtles of the United States. University Press of Kentucky. Lexington, Ky. 347 pp.

Esch, M. 1993. Lovely birds might face ugly demise. Orlando Sentinel September 5:G-7.

Esser, R. P., G. R. Buckingham, C. A. Bennett, and K. J. Harkom. 1985. A survey of phytoparasitic and free living nematodes associated with aquatic macrophytes in Florida. Proceedings of the Soil Crop Science Society 44:150-155.

*Evans, James. 1960. Florida waterfowl survey. Unpublished report, Pittman-Robertson Quarterly Progress Report. Florida Game and Fresh Water Fish Commission, Tallahassee.

*Evans, L. P., Jr., C. E. Murphy, J. C. Britton, and L. W. Newland. 1979. Salinity relationships in

Corbicula fluminea (Müller 1774). Pages 193-214 in J. C. Britton, editor. Proceedings of the first international *Corbicula* symposium. Unpublished report, Texas Christian University, Fort Worth.

Everglades Recreational Planning Board. 1974. Recreational development of the Florida Everglades water conservation areas. Report submitted to Florida Game and Fresh Water Fish Commission, Tallahassee. 187 pp.

Ewel, J. 1978. Ecology of *Schinus*. Pages 9-21 in, editor. *Schinus* technical proceedings of techniques for control of *Schinus* in south Florida: a workshop for natural area managers. Unpublished report of the Sanibel-Captiva Conservation Foundation, Ft. Myers, Florida. 87pp.

Ewel, J. J. 1986. Invasibility: lessons from South Florida. Pages 214-230 in H. A. Mooney and J. A. Drake, editors. Ecology of biological invasions of North America and Hawaii. Springer-Verlag, New York.

*Ewel, J. J., D. S. Ojima, D. A. Karl, and W. F. DeBusk. 1982. *Schinus* in successional ecosystems of Everglades National Park. Unpublished report, South Florida Research Center National Park Service, Homestead, Fla. Report T-676. 141 pp.

*Exotic Pest Plant Council. 1991. Department of Biological Science, Florida Atlantic University, Boca Raton,Fla. Newsletter 1(3):3.

*Exotic Pest Plant Council. 1992. Department of Biological Science, Florida Atlantic University, Boca Raton, Fla. Newsletter 2(2):3.

*Exotic Pest Plant Council. 1993. Exotic Pest Plant Council's list of Florida's most invasive species. Unpublished report, Department of Biological Sciences, Florida Atlantic University, Boca Raton. 4 pp.

Fairchild, D. G. 1944. Garden islands of the great east: collecting seeds from the Phillipines and Netherlands-India in the Junk Cheng Ho. Scribner's and Son, New York. 239 pp.

Feinberg, H. S., editor. 1979. Simon and Schuster's guide to shells. A fireside book. Simon and Schuster, New York. 512 pp.

Fernald, M. L. 1950. Gray's manual of botany. 8th ed. D. Van Nostrand Company, New York. 1632 pp.

Fernald, E. L., and D. J. Patton, editors. 1984. Water resources atlas of Florida. Institute of Scientific Public Affairs, Florida State University, Tallahassee. 291pp.

Finucane, J. H., and G. R. Rinckey. 1964. A study of the African cichlid, *Tilapia heudeloti* Drumeril, in Tampa Bay, Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 18:259-269.

Fishman, M. C. 1982a. Down on the farm. Tropical Fish Hobbyist 30(12):14-21.

Fishman, M.C. 1982b. Down on the farm, part 2. Tropical Fish Hobbyist 31(3):47-55.

Fisk, E. J. 1966. A happy newcomer in a fruitful land. Florida Naturalist 39:10-11.

Fitch, H. S., P. Goodrum, and C. Newman. 1952. The armadillo in the southeastern United States. Journal of Mammalogy 33:21-36.

Flinchbaugh, P. 1984. Mystery solved! Strange crabs in Alafia River hail from Mexico. Tampa Tribune, July 15:1 and 3B.

*Florida Agricultural Statistics Service. 1988. Aquaculture: Florida Agriculture. Unpublished report, Orlando. 4 pp.

*Florida Agricultural Statistics Service. 1992. Aquaculture: Florida Agriculture. Unpublished report, Orlando. 4 pp.

*Flowers, J. D. 1991. Subtropical fire supression in *Melaleuca quinquenervia*. Pages 151-158 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado, NPS/NREVER/NRTR-91/06.

*Foote, K. J. 1977. Study I: preliminary status investigations of blue tilapia. Unpublished report, Florida Game and Fresh Water Fish Commission, Eustis. 72 pp.

Ford, D. M. 1981. The hobby of ornamental fish keeping. Pages 317-322 in D. M. Ford, editor. Waltham Symposium 3, The Diseases of Ornamental Fishes. Pedigree Pet Foods Animal Studies Centre, Waltham-on-the-Wolds, Leicestershire, England.

Forgarty, M. J., and W. M. Hetrick. 1973. Summer foods of cattle egrets in north central Florida. Auk 90:268-280.

Forrester, D. J., J. H. Porter, R. C. Belden, and W. B. Frankenberger. 1982. Lungworms of feral swine in Florida. Journal of American Veterinary Medicine Association 181:1278-1280.

Forshaw, J. M. 1973. Parrots of the world. Doubleday and Company, Garden City, N.Y. 584 pp.

*Fox, R. O. 1970. The *Corbicula* story: Chapter Two. Unpublished report, Third Annual Meeting of the Western Society of Malacologists, Stanford University, Stanford, California. 10 pp.

*Fox, R. O. 1971a. The *Corbicula* story: Chapter Three. Unpublished report, Fourth Annual Meeting of the Western Society of Malacologists, Asilomar Conference Grounds, Pacific Grove, California, June 17, 1971. California Academy of Sciences, Department of Invertebrate Zoology, San Francisco, CA. 10 pp.

Fox, R. O. 1971b. Have you met *Corbicula*--the fresh water invader? Tabulata 1:3-5.

Fowler, H. W. 1954. Os peixes de água doce do Brasil. Archivos de Zoologia do Estado Sao Paulo 9:203-404.

*Fowler, L. 1981. Exotic felids in Florida. Unpublished term report - Zoology 6486, Department of Zoology, University of Florida, Gainesville.

Foy, C. L., D. R. Forney and W.E. Colley. 1983. History of weed introductions. Pages 56-92 in C. L. Wilson and C. L. Graham, editors. Exotic plant and pests and North American agriculture. Academic Press, New York. 552pp.

Frank, J. H. 1981. Recycling of discarded tires for control of *Aedes aegypti*. Journal of Florida Anti-Mosquito Association 52:44-48.

Frank, J. H., and E. D. McCoy. 1990. Endemics and epidemics of shibboleths and other things causing chaos. Florida Entomologist 73(1):1-8.

Frank, J. H., and E. D. McCoy. 1992. The immigration of insects to Florida, with a tabulaton of records published since 1970. Florida Entomologist 75(1):1-28.

Frank, J. H., and E. D. McCoy. 1993. The introduction of insects into Florida. Florida Entomolgist 76(1):1-52.

Frankenberger, W. B., and R. C. Belden. 1976. Distribution, relative abundance and management needs of feral hogs in Florida. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners Annual Conference 13:641-644.

Fryer, G. 1960. Studies on some parasitic crustaceans on African freshwater fishes, with descriptions of a new copepod of the genus *Ergasilus* and a new branchiuran of the genus *Chonopeltis*. Proceedings of the Zoological Society of London 133:169-176.

Fujita, T. 1927. On new species of nematodes from fishes of Lake Biwa. Japan Journal of Zoology 1:169-176.

Fulks, W., and K. L. Main. 1992. Diseases of cultured Penaeid shrimp in Asia and the United States. The Oceanic Institute, Honolulu. 392 pp.

Fuller, S. L. H., and M. J. Imlay. 1976. Spatial competition between *Corbicula manilensis* (Philippi), the Chinese clam (Corbiculidae), and fresh-water mussels (Unionidae) in the Waccamaw River Basin of the Carolinas (Mollusca: Bivalvia). Association of Southeastern Biologists Bulletin 23:60.

Funasaki, G. Y., P.-Y. Lai, L. M. Nakahara, J. W. Beardsley, and A. K. Ota. 1988. A review of biological control introductions in Hawaii: 1890 to 1985. Proceedings of the Hawaiian Entomology Society 28:105-160.

*Futch, C. R., and S. A. Willis. 1992. Characteristics of the procedures for marine species introductions in Florida. Pages 59-60 in M. R. DeVoe, editor. Proceedings of the conferences and workshop: introductions and transfers of marine species: achieving a balance between economic development and resource protection. Unpublished report, South Carolina Sea Grant Consortium, Charleston.

Gallagher, J. E., and W. T. Haller. 1990. History and development of aquatic weed control in the United States. Review of Weed Science 5:115-192.

Ganzhorn, J., J. S. Rohovec, J. L. Fryer. 1992. Dissemination of microbial pathogens through introductions and transfers of finfish. Pages 175-192 in A. Rosenfield and R. Mann, editors. Dispersal of Living Organisms Into Aquatic Ecosystems. Maryland Sea Grant, College Park. 471 pp.

Gardner, J. A., Jr., W. R. Woodall, Jr., A. A. Straats, Jr., and J. F. Napoli. 1976. The invasion of the Asiatic clam (*Corbicula manilensis* Philippi) in the Altamaha River, Georgia. Nautilus 90:117-125.

Garret, C.M. and D.M. Boyer. 1993. *Bufo marinus* (cane toad) predation. Herpetologiaal Review 24:148.

Gasaway, R. D., and T. F. Deda. 1977. Effects of grass carp on waterfowl habitat. Transactions of the North American Wildlife Resources Conference 42:73-85.

*Gasaway, R. D., T. F. Deda, and F. J. Ware. 1977. Effects of grass carp introduction on waterfowl habitat. in The grass carp: a special research report to the governor and the cabinet. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee.

Gasaway, R. D., S. Hardin, and Judy Howard. 1977. Factors influencing wintering waterfowl abundances in Lake Wales, Florida. Proceedings of the Annual Conference of the Southeast Association Game and Fish Agencies.
31:77-82.

Gaudet, J. J. 1973. Growth of a floating aquatic weed, *Salvinia*, under standard conditions. Hydrobiologia 41:77-106.

Gerber, K., and G.C. Smart, Jr. 1987. Plant-parasitic nematodes associated with aquatic vascular plants. Pages 488-501 in J. A. Veech and D. W. Dickson, editors. Vistas on nematology, Society of Nematologists, Hyattsville, Md.

Germany, R. D. 1977. Population dynamics of the blue tilapia and its effects on the fish populations of Trinidad Lake, Texas. Ph.D. dissertation, Texas A&M University, College Station. 85 pp.

Germany, R. D., and R. L. Noble. 1978. Population dynamics of blue tilapia in Trinidad Lake, Texas. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 31:412-417.

Getsinger, K. D., and C. R. Dillion. 1984. Quiescense, growth, and senescense of *Egeria densa* in Lake Marion. Aquatic Botany 20:329-338.

*Gilbert, K. M. 1984. A review of the aquatic plants *Limnophila heterophylla* and *Limnophila sessiliflora*. Unpublished report, Florida Department of Natural Resources, Tallahassee. 12 pp.

Gillett, J. D., C. R. Dunlop, and I. L. Miller. 1968. Occurrence, origin, weed status and control of water lettuce (*Pistia stratiotes* L.) in the northern territory. Plant Protection Quarterly 3(4):144-148.

*Gleason, P. J., editor. 1984a. Environments of south Florida, present and past II. Memoir. Unpublished report, Miami Geological Society, Coral Gables, Fla. 452 pp.

*Gleason, P. J. 1984b. Saving the wild places: a necessity for growth. Pages viii-xxv in P. J. Gleason, editor. Environments of south Florida: present and past. Memoir 2. Unpublished report, Miami Geological Society, Miami, Fla.

Godfrey, R. K., and J. W. Wooten. 1979. Aquatic and wetland species of the southeastern United States: monocotyledons. University of Georgia Press, Athens. 712 pp.

Godfrey, R. K., and J. W. Wooten. 1981. Aquatic and wetland plants of southeastern United States: dicotyledons. University of Georgia Press, Athens. 933 pp.

Goldsby, T. L., D. Tarver, R. Theriot, and R. Lazor. 1976. The aquatic plant regulation program in Florida. Journal of Aquatic Plant Management 14:7-8.

Goodwin, D. 1967. Pigeons and doves of the world. British Museum of Natural History, London. 446 pp.

Gopal, B. 1987. Water hyacinth. Elsevier Science Publishers, Amsterdam. 471 pp.

Gore, R. H. 1982. Invertebrates: Benedict's wharf crab *Sesarma* (Holometopus) *benedicti*. Page 119 in F. R. Rathbun, editor. Rare and endangered biota of Florida. University Presses of Florida, Gainesville.

Gosline, W. A. 1945. Catálogo dos nematognatos de água-doce da América do Sul e Central.

Boletim do Museau Nacional (Brasil), Zoologia 33:1-138.

Gosse, J. P. 1975. Révision du genre *Geophagus* (Pisces, Cichlidae). Mémoire Académie Royal de Sciences d'Outre-Mer. Class de Sciences Naturelles et Médicales, N.S. 19-3:1-172.

Gottfried, P. K., and J. A. Osborne. 1982. Distribution, abundance and size of *Corbicula manilensis* (Philippi) in a spring-fed central Florida stream. Florida Scientist 45:178-188.

Gould, F. W. 1968. Grass systematics. McGraw-Hill Book Company, New York. 382 pp.

Gowanloch, J. N. 1945. Economic importance of the waterhyacinth, *Eichhornia crassipes*, in management of water areas. Transactions of the 10th North American Wildlife Conference 10:339-345.

Grace, J. B., and R. G. Wetzel. 1978. The production biology of Eurasian watermilfoil (*Myriophyllum spicatum* L.): a review. Journal of Aquatic Plant Management 16:1-11.

*Gratzek, J. B. 1980. An overview of the diseases of ornamental fishes. Pages 25-40 in , Lynn D. Howell editor. Proceedings of the 4th Kal Kan symposium. Unpublished report. KAL KAN Foods, Vernon,CA. 77pp.

Gratzek, J. B., E. B. Shotts, and J. L. Blue. 1976. A survey of parasites, bacteria, and viruses associated with tropical fish imported from Southeast Asia. Aquatic Mammals 4:1-5.

Gratzek, J. B., E. B. Shotts, and J. L. Blue. 1978. Ornamental fish: diseases and problems. Marine Fisheries Review 1299:58-60.

Greenfield, D. T. 1973. An evaluation of the advisability of the release of grass carp into the natural waters of the United States. Illinois State Academy of Science 66:47-53.

Greenwell, A. B. H. 1947. Taro - with special reference to its culture and uses in Hawaii. Economic Botany 1:276-289.

Greiner, E. C., C. Taylor, III, W. B. Frankenberger, and R. C. Belden. 1982. Coccidia of feral swine from Florida. American Veterinary Medicine Association 181:1275-1277.

Griffen, J. 1989. The Everglade kite. Aquatics 11(3):17-19.

Griffo, J.V., Jr. 1957. The status of the nutria in Florida. Quarterly Journal of Florida Academy Science 20:209-215.

*Grissell, E. E. 1978. Biological Control Laboratory. Unpublished report. Florida Department of Agriculture Consumer Services, Tallahassee. Bienniel Report 31:41-42.

*Grow, G. 1984. New threats to the Florida panther. ENFO Newsletter. Florida Game and Fresh Water Fish Commission, Tallahassee. October:2,4-8,10-12.

Guest, W. C., B. W. Lyons, and G. Garza. 1979. Effects of temperature on survival of peacock bass fingerlings. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 33:620-627.

*Guest, W.C., B.W. Lyons. 1980. Temperature tolerance of peacock bass (Cichla temensis). Unpublished report, Proceedings of the annual meeting, Texas ahapter of the American Fisheries Society 3:42-48.

Guillory, V., and R. D. Gasaway. 1978. Zoogeography of the grass carp in the United States. Transactions of the American Fisheries Society 107:105-112.

*Gunderson, L. H. 1983. Status of exotic woody species in Big Cypress National Preserve. Unpublished report, National Park Service, Homestead, Fla. 22 pp.

Haag, K. H. 1986. Effective control of waterhyacinth using Neochetina and limited herbicide application. Journal of Aquatic Plant Management 24:70-75.

Habeck, M. H., S. B. Lovejoy, and J. G. Lee. 1993. When does investing in classical biological control research make economic sense?. Florida Entomologist 76:96-101

Habel, M. L. 1975. Overwintering of the cichlid, *Tilapia aurea*, produces fourteen tons of harvestable size fish in a south Alabama bass-bluegill public fishing lake. Progressive Fish-Culturist 37:31-38.

Haertel, L., and C. Osterberg. 1967. Ecology of zooplankton, benthos and fishes in the Columbia River Estuary. Ecology 48:459-472.

Hale, M. C. 1964. The ecology and distribution of the introduced snail, *Marisa cornuarietis* (Ampullariidae) in South Florida. M.S. thesis, University of Miami, Coral Gables. 115 pp.

*Hall, D. W. 1985. Personal communication to K. Gilbert. Florida Department of Natural Resources, Tallahassee, Fla.

Hall, E. R., and K. R. Kelson. 1959. Nine-banded armadillo. Pages 243-244 in , E.R. Hall editor. The mammals of North America. The Ronald Press,New York, NY.

Haller, W. T. 1976. Hydrilla. A new and rapidly spreading aquatic weed problem. Florida Agricultural Experiment Station, University of Florida, Gainesville. Circular S-245. 13pp.

*Handley, L. L., and P. C. Ekern. 1981. Irrigation of California grass with domestic sewage effluent: water and nitrogen budgets and crop productivity. Unpublished report, University of

Hawaii at Manda.

Hanna, G. D. 1966. Introduced mollusks of western North America. California Academy of Sciences Occasional Papers 48:1-108.

Hansen, K. L., E. G. Ruby, and R. L. Thompson. 1971. Trophic relationships in the water hyacinth community. Quarterly Journal of the Florida Academy of Sciences 34:107-113.

Hanson, J. A. and H. L. Goodwin. 1977. Shrimp and prawn farming in the Western Hemisphere: state-of-the-art reviews and status assessments. Dowdon, Hutchinson and Ross, Stroudsburg, Pa. 439 pp.

Hardin, S., R. Land, M. Spelman and G. Morse. 1984. Food items of grass carp, American coots, and ring-necked ducks from a central Florida lake. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 38:313-318.

Harley, K. L. S., I. W. Forno, R. C. Kassulke, and D. P. A. Sands. 1984. Biological control of waterlettuce. Journal of Aquatic Plant Management 22:101-102.

Harris, C. 1978. Tilapia: Florida's alarming alien menace. Florida Sportsman 9(11):12, 15, 17-19.

Harris, P. 1979. Cost of biological control of weeds by insects in Canada. Weed Science 27:242-250.

Harvey, D. 1992. Aquaculture situation and outlook. U.S. Department of Agriculture, Washington, D.C. Aqua-9. 45 pp.

Herbert, P. D. N., B. W. Muncaster, and G. L. Mackie. 1989. Ecological and genetic studies of *Dreissena polymorpha* (Pallas): a new mollusc in the Great Lakes. Canadian Journal of Fisheries and Aquatic Science 46:1587-1591.

Heinsohn, G. E. 1958. Life history and ecology of the freshwater clam, *Corbicula fluminea*. M.A. thesis, University of California, Berkeley. 64 pp.

Herwig, N. 1976. Exotic parasite in Florida. Aquarium Industry October:14.

Hestand, R. S. III, B. Z. Thompson, and C.T. Mallison. 1995. Effects of triploid grass carp and Sonar treatments on aquatic plants in Yale Lake. 1995 Pages 129-135. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Hetrick, L. A. 1970. Biology of the "love bug," *Plecia nearctica*, (Diptere: Bibionidae). Florida Entomologist 53(1):23-29.

Hicks, D. W., and J. W. Tunnell, Jr. 1993. Invasion of the south Texas coast by the edible brown mussel *Perna perna* (Linnaeus, 1758). Veliger 36:92-94.

Hillis, D.M. and J.C. Patton. 1982. Morphological and electrophoretic evidence for two species of Corbicula (Bivalvia: Corbiculacea), in north Central America. American Midland Naturalist 108:74-80.

Hine, P. M. 1975. Fish disease control in New Zealand. FAO Aquaculture Bulletin 7(1-2):21.

Hocutt, C. H. 1984. Toward the development of an environmental ethic for exotic fishes. Pages 374-386 in W. R. Courtenay and J. R. Stauffer, editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Md.

*Hodges, E. M., and D. W. Jones. 1950. Torpedo grass. Unpublished report, University of Florida, Gainesville. 4 pp.

Hickling, C. F. 1966. On the feeding process in the white Amur, (*Ctenopharyngodon idella*). Journal of Zoology 148:408-419.

Hodgson, R. G. 1949. Fur farming for profit. Fur Trade of Canada, Toronto. 113 pp.

Hoebeke, E. R., and A. G. Wheeler. 1983. Exotic insects reported new to Northeastern United States and Eastern Canada since 1970. Journal of New York Entomology Society 91:222.

Hoffman, G. L. 1967. Parasites of North American freshwater fishes. University of California Press, Berkelely. 486 pp.

Hoffman, G. L. 1970. Intercontinental and transcontinental dissemination and transfaunation of fish parasites with emphasis on whirling disease (*Myxosoma cerebralis*). Pages 69-81 in S. F. Snieszko, editor. A Symposium on Diseases of Fish and Shellfish, American Fisheries Society, Bethesda, Md. 526 pp.

*Hoffman, G. L. 1976. The Asian Tapeworm, *Bothriocephalus gowkongensis*, in the United States, and research needs in fish parasitology. Pages 84-90. Proceedings of the 1976 fish farming conference and annual convention of the Catfish Farmers of Texas. Unpublished report, Texas A&M University, College Station.

Hoffman, G. L. 1978. Ciliates of freshwater fishes. Pages in J. P. Kreier, editor. Parasitic protozoa, vol. 2. Academic Press, New York.

*Hoffman, G. L. 1981a. Recently imported parasites of baitfishes and relatives. Pages 45-46. Third annual proceedings of the Catfish Farmers of America research workshop held in Littlerock, Arkansas. Unpublished report, *Hoffman, G. L. 1981b. Two fish pathogens, *Parvicapsula* sp. and *Mitraspora cyprini* (Myxosporea), new to North America. Pages 184-197 in , editor. Proceedings of the international seminar: fish, pathogens and environment in polyculture. Unpublished report, Fisheries Research Institute, Szarvas, Hungary.

Hoffman, G. L., and G. Schubert. 1984. Some parasites of exotic fishes. Pages 233-254 in W. R. Courtenay, Jr. and J. R. Stauffer Jr., editors. Distribution, biology, and management of exotic fishes. John Hopkins University Press, Baltimore, Md.

Hofstetter, R. H. 1991. The current status of *Melaleuca quinquenervia* in Southern Florida. Pages 158-176 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/ NREVER/NRTR-91/06.

Hogg, R. G. 1974. Environmental hazards posed by exotic fish species newly established in Florida. Environmental Conservation 1:176.

Hogg, R. G. 1976a. Ecology of fishes of the family Cichlidae introduced into the freshwaters of Dade County, Florida. Ph.D. dissertation, University of Miami, Coral Gables. 142 pp.

Hogg, R. G. 1976b. Established exotic fishes in Dade County, Florida. Florida Scientist 39:97-103.

Holdgate, M. W. 1960. The fauna of the mid-Atlantic islands. Proceedings of the Royal Society B152:550-567.

Holm, L. G., L. W. Weldon, and R. D. Blackburn. 1969. Aquatic weeds. Science 166:699-709.

Holm, L. G., D. L. Plucknett, J. V. Pancho, and J. P. Herberger. 1977. The world's worst weeds: distribution and biology. University of Hawaii Press, Honolulu. 609 pp.

Holm, L., and R. Yeo. 1980. The biology, control and utilization of aquatic weeds Part I. Weeds Today Fall:7-10.

Hopkins, J. S. 1991. Status and history of marine and freshwater shrimp farming in South Carolina and Florida. Pages 17-35 in P. A. Sandifer, editor. Shrimp culture in North America and the Caribbean. The World Aquaculture Society, Baton Rouge, La. 235 pp.

*Horel, G. 1969. Lake management, research and development. Study 3. Fish population studies. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 70 pp.

Howarth, F. G. 1991. Environmental impacts of classical biological control. Annual Review of Entomology 36:485-509.

Howarth, F. G. 1992. Environmental impacts of species purposefully introduced for biological control of pests. Pacific Science 46:388-389.

Howarth, W. 1992. Regulating the introduction of freshwater fish: the United Kingdom, the European Community, and beyond. ICES Marine Science Symposium 194:21-30.

Hughes, J. H., and J. E. Porter. 1956. Dispersal of mosquitoes through transportation, with particular reference to immature stages. Mosquito News 16:106-111.

*Hulon, M. W., and V. P. Williams. 1983. A preliminary evaluation of blue tilapia population expansion in Lake Tohopekaliga, Florida. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 16 pp.

Humphrey, S. R. 1974. Zoogeography of the nine-banded armadillo (*Dasypus novemcinctus*) in the United States. Bioscience 24:457-462.

Hunt, B. P. 1958. Introduction of *Marisa* into Florida. Nautilus 72:53-55.

Hutchison, A. M. 1992. A reproducing population of *Trachemys scripta elegans* in southern Pinellas County, Florida. Herpetological Review 23(3):74-75.

Hutt, A. 1967. New ducks for Florida. Florida Wildlife 21(2):14-17.

Idyll, C. P. 1969. New Florida resident, the walking catfish. National Geographic 135:846-851.

Immelmann, K. 1968. Australian parakeets. 2nd ed. Wittemberg A. Ziemsen. Association of Ornithologique de Belgigue. 195 pp.

Ingram, W. M. 1959. Asiatic clams as potential pests in California water supplies. Journal of American Water Works Association 51:363-370.

Isbrücker, I. J. H. 1980. Classification and catalog of the mailed Loricariidae. Verslagen en Technische Gegevens, Instituut voor Taxonomische Zoölogie (Zoölogisch Museum), Universiteit van Amsterdam 22:1-181.

Isom, B. G. 1974. Mussels of the Green River, Kentucky. Transactions of Kentucky Academy of Science 35:55-57.

Isom, B. G. 1986. Historical review of Asiatic clam (*Corbicula*) invasion and biofouling of waters and industries in the Americas. American malacological bulletin. Special edition no. 2. Pp. 1-5.

Jaggers, B. V. 1995. Economic considerations of integrated hydrilla management - a case history of John's Lake, Florida. Pages 151-163. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Janssen, W. A. 1970. Fish as potential vectors of human bacterial diseases. Pages 284-290 in S. F. Snieszko. A symposium on diseases of fish and shellfishes. American Fisheries Society, Bethesda, Md. 526 pp.

Janssen, W. A., and C. D. Meyers. 1968. Fish: serologic evidence of infection with human pathogens. Science 159:547-548.

Jennings, D. P. 1986. Characterization of a localized Jack Dempsey, *Cichlasoma octofasciatum*, population in Alachua county, Florida. Biological Sciences 49:255-260.

Jennings, D. P. 1988. Bighead carp (*Hypophthalmichthys nobilis*): biological synopsis. U.S. Fish and Wildlife Service, Washington DC. Biological report 88-29. 35 pp.

Jennings, D. P. 1991. Behavioral aspects of cold tolerance of blackchin tilapia, *Sarotherodon melanotheron* (Pisces, Cichlidae) at different salinities. Environmental Biology of Fishes 31:185-195.

*Jennings, D. P., and J. A. McCann. 1991. Research protocol for handling non-indigenous aquatic species. Unpublished report, U.S. Fish and Wildlife Service, Gainesville, Fla. 43 pp.

Jennings, D. P., and J. D. Williams. 1992. Factors influencing the distribution of black chin tilapia, *Sarotherodon melantheron*, in the Indian River System, Florida. Northeast Gulf Science 12:111-117.

Johnson, C. D. 1983. Ecosystematics of *Acanthoscelides* (Coleoptera: Bruchidae) of southern Mexico and Central America. Miscellaneous Publications of the Entomological Society of America 56:1-370.

Johnson, F. A. 1987. Lake Okeechobee's waterfowl habitat: problems and possibilities. Aquatic 9(2):20-21.

Johnson, F. A., and F. Montalbano. III. 1984. Selection of plant communities by wintering waterfowl on Lake Okeechobee, Florida. Journal of Wildlife Management 48:174-178.

Johnson, F. A., and F. Montalbano. 1987. Considering waterfowl habitat in hydrilla control policies. Wildlife Society Bulletin 15:466-469.

*Jones, P. 1959. The European wild boar in North Carolina. Unpublished report, North Carolina Wildlife Resource Commission, Raleigh. 29 pp.

Joyce, J. C. 1990. Practical uses of aquatic weeds. Pages 274-291 in A. H. Pietrese and K. J. Murphy, editors. Aquatic weeds: the ecology and management of nuisance aquatic vegetation. Oxford University Press, Cary, North Carolina. 581 pp.

*Joyce, J. C. 1991. History of aquatic plant management in Florida. Pages 3-8 in K. A. Langeland, editor. Aquatic pest control applicator training manual. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville.

Joyce, J. C., W. T. Haller, and D. Colle. 1980. Investigation of the presence and survivability of hydrilla propagules in waterfowl. Aquatics 2(3):10-14.

Jubb, R. A. 1967. Freshwater fishes of Southern Africa. A. A. Balkema, Cape Town. 248 pp.

*Jubinsky, G. 1991. The rules and regulations of aquatic plant management. Pages 9-13 in K. A. Langeland, editor. Aquatic pest control applicator training manual. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville.

Julien, M. H. 1987. Biological control of weeds: a world catalogue of agents and their target weeds--second edition. CAB International Institute of Biological Control, Wallingford, U.K. 150 pp.

Kay, S. H., and W. T. Haller. 1982. Evidence for the existence of distinct alligatorweed biotopes. Journal of Aquatic Plant Management 20:37-41.

Kelly, H. D. 1955. Preliminary studies on *Tilapia mossambica* Peters relative to experimental pond culture. Proceeding of the Southeastern Association of Fish and Game Commissioners 10:139-149.

Kern, F. G., and A. Rosenfield. 1992. Shellfish health and protection. Pages 313-323 in A. Rosenfield and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems, Maryland Sea Grant, University of Maryland, College Park, Md.

Kerwin, J. A., and L. G. Webb. 1971. Foods for duck wintering in coastal South Carolina, 1965-1967. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 25:23-245.

Keup, L., W. B. Horning, and W. M. Ingram. 1963. Extension of range of Asiatic clam to Cincinnati reach of the Ohio River. Nautilus 94:189-197.

King, F. W. 1974. Trade in crocodilians. International Zoo Yearbook 14:52-56.

King, W. 1960. New populations of West Indian reptiles and amphibians in southeastern Florida. Quarterly Journal of Florida Academy Science 23:71-73.

King, W. 1968. As a consequence many will die. Florida Naturalist 41(3):99-103, 120.

King, W., and T. Krakauer. 1966. The exotic herpetofauna of southern Florida. Quarterly Journal of Florida Academy Science 29:144-154.

Kirtisinghe, P. 1964. A review of the parasitic copepods of fish recorded from Ceylon with descriptions of additional forms. Bulletin of the Fisheries Research Station, Ceylon 17(1):45-132.

Klee, A. J. 1966. A history of the aquarium hobby in America. Part III: father of the aquarium hobby. Aquarium Illustrated 1(3):23-28, 39.

Klee, A. J. 1967. A history of the aquarium hobby in America. Part VIII: the titans. Aquarium Illustrated. 2(2):12-17.

Klee, A. J. 1969a. A history of the aquarium hobby in America. Part 14. The aquarium, 2nd Series 2(3):32-33, 49-53.

Klee, A. J. 1969b. A history of the aquarium hobby in America. Part 19. The aquarium, 2nd Series 2(8):32-33, 49-53.

Klee, A. J. 1969c. A history of the aquarium hobby in America. Part 22. Conclusion. The aquarium, 2nd Series 2(11):32-33, 50-57.

Klingman, D. L., and J. R. Coulson. 1983. Guidelines for introducing foreign organisms into the United States for the biological control of weeds. Bulletin of the Entomological Society of America 19(3)55-61.

Klippel, W. E., and P. W. Parmalee. 1979. The naiad fauna of Lake Springfield, Illinois: an assessment after two decades. Nautilus 94:189-197.

Klose, N. 1950. America's Crop Heritage: The history of foreign plant introduction by the Federal government. Iowa State College Press, Ames. 146 pp.

Knaggs, E. H. 1977. Status of the genus *Tilapia* in California's estuarine and marine waters. California-Nevada Wildlife Transactions 1977:60-67.

Kohler, C. C. 1986. Strategies for reducing risks from introductions of aquatic organisms. Fisheries 11(2):2-3.

Kohler, C. C., and W. R. Courtenay, Jr. 1986a. Regulating introduced aquatic species: a review of past initiatives. Fisheries 11(2):34-38.

Kohler, C. C., and W. R. Courtenay, Jr. 1986b. American Fisheries Society position on introductions of aquatic species. Fisheries 11(2):39-42.

Kohler, C. C. 1992. An overview of management principles and objectives for a marine species introduction policy. Pages 27-29 in M. R. DeVoe, editor. Proceedings of the conference and workshops: introduction and transfer of marine species: achieving a balance between economic development and resource protection. Unpublished report, South Carolina Sea Grant Consortium, Charleston.

Kraemer. 1979. *Corbicula* vs. indigenous mussels. American Zoology 19:1085-1096.

Krakauer, T. 1968. The ecology of the neotropical toad, *Bufo marinus*, in south Florida. Herpetologica 24:214-221.

Krakauer, T. 1970. The invasion of the toads. Florida Naturalist January:12-14.

*Kretchman, D. W. 1962. Torpedo grass and citrus groves. Unpublished report, University of Florida Agriculture Experiment Station, University of Florida, Gainesville. Circular S-136.

*Kuitert, L.C. and D.E. Short. 1993. Lovebugs in Florida. Unpublished report, Department of Entomology and Nematology, University of Florida, Gainesville, Fla. 2pp.

Kulakovskaya, O. P., and B. A. Krotas. 1961a. On *Khawia sinensis* Hsu (Caryophyllaidae, Cestoda) -- a parasite transferred from Far East to the fish farms of the U.S.S.R. western districts. Doklady Adademi Nauk SSSR 127:1253-1255.

Kulakovskaya, O. P., and B. A. Krotas. 1961b. A parasite introduced into carp hatcheries of the western U.S.S.R. from the Far East. Doklady Akademi Nauk SSSR 137:1253-1255.

Kushlan, J. A. 1972. The exotic fish (*Aequidens portalegrensis*) in the Big Cypress Swamp. Florida Naturalist 45:29.

Kushlan, J. A. 1986. Exotic fishes in the Everglades, A reconsideration of proven impact. Environmental Conservation 13:67-69.

Kushlan, J. A. 1987. External threats and internal management: the hydrologic regulation of the Everglades, Florida, USA. Environmental Management 11:109-119.

Lachner, E. A., C. R. Robins, and W. R. Courtenay, Jr. 1970. Exotic fishes and other aquatic organisms introduced into North America. Smithsonian Contributions to Zoology 59:1-29.

Laing, J. E., and J. Hamai. 1976. Biological control of insect pests and weeds by imported parasites, predators, and pathogens. Pages 685-743 in C. B. Huffaker and P. S. Messenger, editors. Theory and practice of biological control. Academic Press, New York.

Langeland, K. A. 1990. Hydrilla: a continuing problem in Florida waters. University of Florida, Gainesville. 22 pp.

*Langeland, K. A. editor. 1990. Exotic woody plant control. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville. 16 pp.

*Langford, F. H. 1976. Haul seine project 1976 status report. Unpublished report, Annual Report Florida Game and Fresh Water Fish Commission, Tallahassee Fla. 7 pp.

Langford, F. H., F. J. Ware, and R. D. Gasaway. 1978. Status and harvest of introduced *Tilapia aurea* in Florida lakes. Pages 102-108 in R. O. Smitherman, W. L. Shelton, and J. H. Grover, editors. Symposium on Culture of Exotic Fishes. Fish Culture Section, American Fisheries Society, Department of Fisheries and Allied Aquaculture, Auburn University, Auburn, Ala. 257 pp.

Laycock, G. 1966. The alien animals. Natural History Press, Garden City, N.Y. 240 pp.

Layne, J. N. 1984. The land mammals of south Florida. Pages 269-296 in P. J. Gleason, editor. Environments of south Florida: present and past. Memoir 2, Miami Geological Society, Miami, Fla.

*Layne, J. N. 1988. Overview of mammals of south Florida. Wildlife in the Everglades and Latin American wetlands. Pages 6-7 in George h. Dalrymple, William F. Loftus and Frank S. Barnardino, Jr., editors. Abstracts of the Proceedings of the first Everglades National Park symposium held in Miami, Fla. Unpublished report.

Lazor, R. L. 1983. Corps field operation studies: large-scale operation management test on the use of the white amur to control the aquatic plants at Lake Conway, Florida. Pages 62-68 in Proceedings of the 17th annual meeting of the Aquatic Plant Control Research Program. U.S. Army Corps of Engineeers, Waterways Experiment Station, Vicksburg, Ms. Miscellaneous Paper A-83-3.

Lee, D. S. 1969. Treefrogs of Florida. Florida Naturalist 42:117-120.

Lee, D. S., C. R. Gilbert, C. H. Hocutt, R. E. Jenkins, D. E. McAllister, and J. R. Stauffer. 1980 et seq. Atlas of North American freshwater fishes. North Carolina State Museum of Natural History, Raleigh, N.C. 854 pp.

Lee, H. G. 1987. Immigrant mussel settles in Northside generator. The Shell-O-Gram (Jacksonville Shell Club, Jacksonville, FL) 28(1):7-9.

Lee, J. C. 1979. Reproduction and hybridization of three cichlid fish, *Tilapia aurea* (Steindachner), *Tilapia hornorum* (Trewavas), and *Tilapia nilotica* (Linnaceus) in aquaria and in plastic pools. Ph.D. dissertation, Auburn University, Auburn, Ala. 94 pp.

Leff, L.G., J.L. Burch and J.V. McArthur. 1990. Spatial distribution, seston removal, and potential competitive interactions of the bivalves Corbicula fluminea and Elliptio complanata, in a coastal stream. Freshwater Biology 24:409-416.

Legner, E. F., and F. W. Pelsue. 1977. Adaptions of *Tilapia* to *Culex* and chironomid midge ecosystems in south California. Proceedings of the California Mosquito Control Association 45:95-

Legner, E. F., R. A. Medved, and F. Pelsue. 1980. Changes in chironomid breeding patterns in a paved river channel following adaptation of cichlids of the *Tilapia mossambica-honorum* complex. Annals of the Entomology Society of America 73:293-299.

Leist, J. 1993. Bugs to the rescue: melaleuca trees targeted. The Wetlands Research Program Bulletin 3(3):1-3.

Les, D. H., and R. P. Wunderlin. 1981. *Hygrophila polysperma* (Acanthaceae) in Florida. Florida Scientist 44:189-192.

Leslie, A. J., Jr., J. M. VanDyke, R. S. Hestand, III, and Thompson. 1987. Management of aquatic plants in multi-use lakes with grass carp (*Ctenopharyngodon idella*). Lake and Reservoir Management 3:266-276.

Leslie, A. J., L. E. Nall, G. P. Jubinsky and J. D. Schardt. 1995. Effects of triploid grass carp on the aquatic vegetation in Lake Conway, Florida. 1995. Pages 121-128. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

*Levine, D. S., J. T. Krummrich, and P. L. Shafland. 1979. Renovation of a borrow pit in Levy County, Florida containing Jack Dempseys (*Cichlasoma octofasciatum*). Unpublished report, Florida Game and Fresh Water Fish Commission, Boca Raton. 6 pp.

Li, Y., J. R. Gold, and D. Tave. 1994. A cytogenetic analysis of karyotypes of the golden shiner, *Notemigonus crysoleucas*, the rudd, *Scardinius erythrophthalmus*, and their reciprocal F_1 hybrids. Journal of Applied Aquaculture. In press.

Licop, S. R. 1988. Hatchery operationa and management. Pages 59-88 in Anonymous. Biology and Culture of *Penaeus monodon*. Southeast Asian Fisheries Development Center. Tigbauan, Iloilo, Philippines.

Lightner, D. V. 1988. Diseases of cultured Penaeid shrimp and prawns. Pages 8-127 in C. J. Sindermann and D. V. Lightner, editors. Disease diagnosis and control in North American marine aquaculture. Elsevier, Amsterdam.

Lightner, D. V., R. M. Redman, and T. A. Bell. 1983. Infectious hypodermal and hemalopietic necrosis (IHHN), a newly recognized virus disease of Penaeid shrimp. Journal of Invertebrate Pathology 42:62-70.

Lightner, D. V., T. A. Bell, and R. M. Redman. 1989. A review of the known hosts, geographical range and current diagnostic procedures for the virus disease of cultured Penaeid shrimp. Pages 113-126 in Advances in tropical aquaculture. Aquacop, Actes de Colloque, Tahiti.

Lightner, D. V., B. T. Poulos, L. Bruce, R. M. Redman, J. Mari, and J. R. Bonami. 1992. New developments in penaeid virology: application of biotechnology in research and disease diagnosis for shrimp viruses of concern in the Americas. Part II. Pages 233-256 in W. Fulks and K. L. Main, editors. Diseases of cultured penaeid shrimp in Asia and the United States. The Oceanic Institute, Honolulu.

Lightner, D. V., and R. M. Redman. 1990. Host, geographic range and diagnostic procedures for the Penaeid virus diseases of concern to shrimp culturists in the Americas. Pages 173-196 in W. Doughtery, editor. Proceedings of a symposium on the frontiers of shrimp research. Elsevier, New York.

Lightner, D. V., R. M. Redman, T. A. Bell, and R. B. Thurman. 1992. Geographic dispersion of the viruses IHHN,MBV, and HPV as a consequence of transfers and introductions of penaeid shrimp to new regions of aquaculture purposes. Pages 155-173 in A. Rosenfield and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems. Maryland Sea Grant, University of Maryland, College Park, Md.

Lofgren, C. S. 1985. The economic importance and control of the imported fire ants in the United States. Pages 227-255 in S. B. Vinson, editor. The economic impact and control of social insects. Praeger Press, New York.

Lofgren, C. S. 1986. History of imported fire ants in the United States. Pages 36-47 in C. S. Lofgren and R. K. Vander Meer, editors. Fire ants and leaf-cutting ants: biology and management. Westview, Boulder, Colo.

Loftus, W. F. 1987. Possible establishment of the Mayan cichlid, *Cichlasoma urophthalmus* (Gunther) (Pisces: Cichlidae), in Everglades National Park, Florida. Florida Scientist 50(1):1-6.

*Loftus, W. F. 1989. Distribution and ecology of exotic fishes in Everglades National Park. Pages 24-34 in L. K. Thomas, Jr., editor. Management of exotic species in natural communities. Unpublished report, The George Wright Society and the National Park Service, Washington, D.C.

Loftus, W. F., and J. A. Kushlan. 1987. The freshwater fishes of southern Florida. Bulletin of the Florida State Museum 31(4):1-344.

Lom, J. 1970. Observations on trichodinid ciliates from freshwater fishes. Archiv fur Protistenkunde 112:153-177.

Lom, J., and D. P. Haldar. 1977. Ciliates of the genera *Trichodinella*, *Tripartiella* and *Paratrichodina* (Peritricha, Mobilina) invading fish gills. Folia Parasitologicka (Praha) 24:193-210.

Lom, J., and G. L. Hoffman. 1964. Geographic distribution of some species of Trichodinids (Ciliata: Peritricha) parasitic on fishes. Journal of Parasitology 50:30-35.

Long, J. L. 1989. Introduced Birds of the World: The worldwide history, distributions, and influence of bird introductions to new environments. Universe Books, New York.

Long, R. W. 1974. Origin of the vascular flora of South Florida. Pages 28-36 in P. J. Gleason, editor. Environments of south Florida: present and past. Memoir 2, Miami Geological Society, Miami, Fla.

Long, R. W., and O. Lakela. 1976. A flora of tropical Florida. 2nd Ed. Banyan Books, Miami. 962 pp.

Lonsdale, W. M., I. L. Miller, and I. W. Forno. 1989. The biology of Australian weeds 20. *Mimosa pigra* L. Plant Protection Quarterly 4:119-131.

Luck, R. F. 1981. Parasitic insects introduced as biological control agents. Pages 125-284 in D. Pimentel, editor. CRC handbook of pest management in agriculture. Vol. II. CRC Press, Boca Raton, Fla.

Ludlow, M. E., and S. J. Walsh. 1991. Occurrence of a South American armored catfish in the Hillsborough River, Florida. Florida Scientist 54(1):48-49.

*Maffei, M. D. 1991. Melaleuca control on Arthur R. Marshall Loxahatchee National Wildlife Refuge. Pages 197-207 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. Unpublished report, National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06.

Mahler, M. J. 1980. *Limnophila* a new exotic pest. Aquatics 2:4-7.

Malevitskaya, M. A. 1958a. On the transfer of a parasite of complex development, *Bothriocephalus gowkongensis* Yeh, during acclimation of Amur fishes. Doklady Akademi Nauk SSSR 123:572-575.

Malevitskaya, M. A. 1958b. The introduction of a parasite with a complex life cycle, *Bothriocephalus gowkongensis* Yeh, 1955, during aclimatization of fish from the Amur River. Doklady Akademi Nauk SSSR 123:961-964.

Mallison, C. T., R. S. Hestand III and B. Z. Thompson. 1995. Response of fish populations to aquatic plant management in Lake Yale. Pages 136-145. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Malmberg, G. 1962. Taxonomical and ecological problems in *Gyrodactylus* (Trematoda, Monogenea). Pages 203-230 in Symposium on Parasitic Worms and Aquatic Conditions. House of the Czechoslovak Academy of Science. Prague, Czechoslovakia.

Mann, R. 1978. Exotic species in aquaculture: An overview of when, why and how. Pages 331-353 in , R. Mann, editor. Proceedings of a symposium on exotic species in mariculture held in Woods Hole, Mass. MIT Press, Cambridge, Mass.

Manooch, C. S., III. 1972. Culturing, a method used to identify algae ingested by tilapia. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 25:626-635.

Manter, H. W. 1963. The zoogeographical affinities of trematodes of South American freshwater fishes. Systematic Zoology 12:45-70.

Marchand, L. J. 1946. The saber crab, *Platychirograpsus typicus* Rathbun, in Florida: a case of accidental dispersal. Quarterly Journal Florida Academy Sciences 9:93-100.

Mattice, J. S., and L. L. Dye. 1976. Thermal tolerance of adult Asiatic clam. Pages 130-134 in G. W. Esch and R. U. McFarlane, editors. 2nd Proceedings of Thermal Ecology Symposium. I, ERDA Symposium Series.

*Maxwell, F. G., W. A. Banks, J. L. Bagent, W. G. Buren, O. Franke, S. J. Risch, A. Sorenson, W. L. Sterling, and J. L. Stimac. 1982. Pages 67-74 in S. L. Battenfield, editor. Proceedings of the symposium on the imported fire ant. Unpublished report of the nter- Society Consortium for Plant Protection, Atlanta, Ga.

May, M. L. 1980. Temporal activity patterns of *Micathyrea* in Central America (Anisoptera: Libellulidae). Odonatologica 9:57-74.

Mazzotti, F. I., W. Ostrenko, and A. T. Smith. 1981. Effects of the exotic plants *Melaleuca quinquenervia* and *Casuarina equisetifolia* on small mammal populations on the eastern Florida Everglades. Florida Science 44(2):65-71.

McBay, L. G. 1962. The biology of *Tilapia nilotica* Linnaeus. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 15:208-218.

McCann, J. A. 1984a. Preface. Pages ix-x in W. R. Courtenay and J. R. Stauffer, editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Md.

McCann, J. A. 1984b. Involvement of the American Fisheries Society with exotic species. Pages 1-7. in W. R. Courtenay and J. R. Stauffer, editors. Distribution, biology and management of exotic fishes. Johns Hopkins University Press, Baltimore, Md.

*McCann, J. A. 1993. Protocol for evaluating research proposals concerning nonindigneous aquatic species. Appendix E1-3. In G. B. Edward and D. Cottingham, editors. Proposed report to congress: findings, conclusions, and recommendations of the intentional introductions policy review. Unpublished report, U.S. Fish and Wildlife Service, Washington D.C.

McCarthy, S. A., R. M. McPhearson, A. M. Guarino, and J. L. Gaines. 1992. Toxigenic *Vibrio cholerae* 01 and cargo ships entering Gulf of Mexico. Lancet 339:624.

McCoy, R. H., and R. J. Seidler. 1973. Potential pathogens in the environment: Isolation, enumeration, and identification of seven genera of intestinal bacteria associated with small green pet turtles. Applied Microbiology 24:534-538.

McLane, W. M. 1969. The aquatic plant business in relation to infestations of exotic aquatic plants in Florida waters. Hyacinth Control Journal 8(1):48-49.

McMahon, R. F. 1983. Ecology of an invasive pest bivalve, Corbicula. Pages 505-561 in W. D. Russell-Hunter, editor. The mollusca. Ecology. Academic Press, New York.

McMahon, R.F. 1991. Mollusca: Bivalvia. Pages: 315-399 in J.H. Thorp and A. P. Covich, editors. Ecology and classification of North American freshwater invertebrates. Academic Press, New York.

McVicar, J. W., C. A. Mebus, H. N. Becker, R. C. Belden, and E. J. Gibbs. 1981. Induced African swine fever in feral pigs. Journal of American Veterinary Medicine Association 179:441-446.

Mead, A. R. 1961. The giant African snail: a problem in economic malacology. University of Chicago Press, Chicago. xvii + 257 pp.

Merilainen, J. 1968. *Najas minor* (all). North American Rhodora 70:161-175.

Meryman, C. D. 1978. Farm production of introduced ornamental fishes in Florida. Pages 230-239 in R. O. Smitherman, W. L. Shelton, and J. H. Grover, editors. Symposium on Culture of Exotic Fishes. Fish Culture Section, American Fisheries Society, Department of Fisheries and Allied Aquaculture, Auburn University, Auburn, Ala. 257 pp.

Meskimen, G. F. 1962. A silvical study of the *Melaleuca* tree in south Florida. M.S. thesis, University of Florida, Gainesville. 177 pp.

Metcalf, A. L. 1966. *Corbicula manilensis* in the Mesilla Valley of Texas and New Mexico. Nautilus 80:16-20.

*Metcalf, R. L., D. L. Severn, E. L. Alley, M. Blum, M. K. Hinkel, H.N. Nigg, W. H. Schmid, and J. Wood. 1982. Environmental toxicology. Pages 75-81 in S. L. Battenfield, editor. Proceedings of the symposium on the imported fire ant. Unpublished report of the Inter- Society for Plant Protection, Atlanta, Ga.

Metzger, R. J., and R. L. Shafland. 1984. Possible establishment of *Geophagus surinamensis*

(Cichlidae) in Florida. Florida Science 47(3):201-203.

Michelson, E. H. 1956. Studies on the biology of the genus *Ceratodes* (Mollusca: Pilidae). Ph.D. dissertation, Harvard University, Cambridge, Mass. 171 pp.

Michelson, E. H., and D. L. Augustine. 1957. Studies on the biological control of schistosome-bearing snails. V. The control of *Biomphalaria pferifferi* populations by the snail, *Marisa cornuarietis*, under laboratory conditions. Journal of Parasitology 43:135.

Michewichewicz, J. E., D. L. Sutton, and R. D. Blackburn. 1972. Water quality of small enclosures stocked with white amur. Journal of Hyacinth Control 10:22-25.

Middlebrook, G. 1965. The mycobacteria. Pages 521-522 in R. J. Dubos, editors. Bacterial and mycotic infections of man. 4th ed. J.B. Lippencott, Philadelphia. 1025 pp.

*Migaki, G., J. R. Hill, and G. L. Hoffman. 1981. Another exotic (*Dermocystidium koi*). Fish Health Section, American Fisheries Society Newsletter 9(1):2.

Miley, W. W., II. 1978. Ecological inpact of the pike killifish, *Belonesox belizanus* Kner (Poeciliidae) in southern Florida. M.S. thesis, Florida Atlantic University, Boca Raton. 55 pp.

Miller, I. L., and W. M. Lonsdale. 1987. Early records of *Mimosa pigra* in the northern territory. Plant Protection Quarterly 2:140-142.

Miller, R. C., and F. A. McClure. 1931. The fresh-water clam industry of the Pearl River. Lingnan Science Journal 10:307-332.

Miller, R. R. 1966. Geographical distribution of Central American freshwater fishes. Copeia 1966:773-802.

Mills, E. L., J. H. Leach, J. T. Carlton, and C. L. Secor. 1993. Exotic species in the Great Lakes: a history of biotic crises and anthropogenic introductions. Journal of Great Lakes Research 19:1-54.

*Milon, J. W. and R. Welsh. 1989. An economic analysis of sport fishing and the effects of hydrilla management in Lake County, Florida. Economics Report No.118. Food and Resource Economics Department, University of Florida, Gainesville. 47pp.

*Milon, J. W., J. Yingling, and J. E. Reynolds. 1986. An economic analysis of the benefits of aquatic weed control in north-central Florida. Economics Report No.113. Food and Resource Economics Department. University of Florida, Gainesville. 52pp.

Misik, V. 1958. Biometrika dunajskeho kapra (*Cyprinus carpio carpio* L.) z dunajskeho systemu na Slovensku (Biometry of the Danube wild carp (*Cyprinus carpio carpio* L.) of the Danube basin in Slovakia). Biologicke prace Slovenskej Akademie Vied. 4(6):55-125.

Mitchell, D. S. 1976. The growth and management of *Eichhornia crassipes* and *Salvinia* spp. in their native environment and in alien situations. Pages 167-175 in C. K. Varshney and J. Rzoska, editors. Aquatic weeds in southeast Asia. Dr. W. Junk Publisher. The Haque, Netherlands. 396 pp.

Mizelle, J. D., and D. C. Kritsky. 1969a. Studies on monogenetic trematodes, XXXIX. Exotic species of Monopisthocotylea with the proposal of *Archidiplectanum* gen. n. and *Longihaptor* gen. North American Midland Naturalist 81:370-386.

Mizelle, J. D., and D. C. Kritsky. 1969b. Studies on monogenetic trematodes, XL. New species from marine and freshwater fishes. American Midland Naturalist 82:417-428.

Mizelle, J. D., and C. E. Price. 1965. Studies on monogenetic trematodes. XVIII. Gill parasites of the piranha with proposal of *Anacanthorus* gen. n. Journal of Parasitoloty 51:30-36.

Moe, M. A., Jr. 1964. Survival potential of piranhas in Florida. Quarterly Journal of the Florida Academy of Science 27:197-210.

Molnar, G., R. H. Hofstetter, R. F. Doren, L. D. Whiteaker, and M. T. Brennan. 1991. Management of *Melaleuca quinquenervia* within East Everglades wetlands. Pages 237-253 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06.

Molnar, K. 1979. Gill spaerosporosis in the common carp and grass carp. Acta Veterinaria Academiae Scientiarum Hungaricae 27:99-113.

*Molnar, K. 1982. Parasite range extension by introduction of fish to Hungary. Symposium on stock enhancement in the management of freshwater fisheries. Unpublished report, European Inland Fisheries Advisory Commission, Budapest. 14 pp.

*Montegut, R. S., R. D. Gasaway, D. F. DuRant, and J. L. Atterson. 1976. An ecological evaluation of the effects of grass carp, *Ctenopharyngodon idella* introduction in Lake Wales, Florida. Unpublished report, Florida Game and Freshwater Fish Commission, Tallahassee. 106 pp.

Mookerjee, H. K., and S. R. Mazumdar. 1950. Some aspects of the life history of *Clarius batrachus* (Linn.). Proceedings of the Zoological Society of Calcutta 3:71-79.

Moore, C. B. 1954. The grinning crocodilian and his folklore. Science Monthly 14:52-56.

Morton, B. 1973. Analysis of a sample of *Corbicula manilensis* Philippi from the Pearl River, China. Malacology Review 6:35-37.

Morton, B. 1977. The population dynamics of *Corbicula fluminea* (Bivalvia: Corbiculacea) in Plover Cove Reservoir, Hong Kong. Journal of Zoology 181:21-42.

Morton, J. F. 1966. The Cajeput tree - a boon and an affliction. Economic Botany 20:31-39.

Morton, J. F. 1976. Pestiferous spread of many ornamental and fruit species in South Florida. Proceedings of the Florida State Horticulture Society 89:348-353.

Morton, J. F. 1978. Brazilian pepper - its impact on people, animals and the environment. Economic Botany 32:354-360.

Morton, J. F. 1980. The Australian pine or beefwood (*Casuarina equisetifolia*) an invasive "weed" tree in Florida. Proceedings of the Florida State Horticultural Society 93:87-95.

Moyle, P. B. 1976. Inland fishes of California. University of California Press, Berkeley. 405 pp.

Muhlberg, H. 1982. The complete guide to water plants. Translated from German by I. Linsay. E. P. Publishing Limited, German Democratic Republic. 392 pp.

Murray, H. D. 1971. New records of *Corbicula manilensis* (Phillipi) in Texas. Nautilus 58:35-36.

Myers, G. S. 1947. Foreign introductions of North American fishes: inadvisability of recommending North American fishes without careful appraisal of foreign fishes and ecology. Progressive Fish Culture 9:177-180.

Myers, G. S., editor. 1972. Piranha book. Tropical Fish Hobbyist Publications, Neptune, N.J. 128 pp.

Myers, R. L. 1983. Site susceptibility to invasion by the exotic tree *Melaleuca quinquenervia* in southern Florida. Journal of Applied Ecology 20:645-658.

Myers, R. L. 1984. Ecological compression of *Taxodium distichum* var. *nutans* by *Melaleuca quinquenervia* in southern Florida. Pages 358-364 in K. C. Ewel and H. T. Odum, editors. Cypress swamps. University of Florida Press, Gainesville.

Myers, R. L, and J. J. Ewel, editors. 1990. Ecosystems of Florida. University of Central Florida Press, Orlando. 765 pp.

Myers, S. 1977. Geographic distribution: *Osteopilus septentrionalis*. Herpetology Review 8(2):38.

*Nall, L., K. M. Gilbert, and R. L. Kipker. 1986. Survey and control of *Mimosa pigra* with a review of it's biology. Unpublished report, Florida Department Natural Resources, Tallahassee. 33 pp.

Nehrling, H. 1944. My garden in Florida and miscellaneous horticultural notes. From the

Manuscripts of Dr. Henry Nehrling. Vol. I. American Eagle of Estero, Fla. 422 pp.

Neill, W. T. 1952. The spread of the armadillo of Florida. Ecology 33:282-284.

Neill, W. T. 1957. Historical biogeography of present-day Florida. Bulletin Florida State Museum 2:175-220.

Nelson, B. 1984. *Salvinia molesta* Mitchell: does it threaten Florida? Aquatics 6(3):6-8.

Nelson, B. V., and J. M. Dupes. 1988. Publicly funded aquatic plant management operations in Florida. Aquatics 10(3):8-12.

*Nelson, E. N., and R. W. Couch. 1985. History of the introduction and distribution of *Myriophyllum aquaticum* in North America. Pages 19-26 in L. W. J. Anderson, editor. Proceedings of the 1st international symposium on watermilfoil (*Myriophyllum aquaticum*) and related Haloragaceae species. 23-24 July 1985, Vancouver, B.C., Canada.

Nesbitt, S.A., W.M. Hetrick, L.E. Williams, and D.H. Austin. 1977. Foods of the nine-banded armadillo in Florida. Proceedings of the Annual Conference Southeastern Association of Fish and Wildlife Agencies 31:57-61.

*Neville, B. 1990. A preliminary list of exotic bird species from south Florida. Unpublished report. 5 pp.

Newman, C. 1949. Florida's armored invasion. Florida Wildlife 3(5):3-5.

Noble, R. L., P. W. Bertolli., and R. J. Bestill. 1986. Considerations for the use of grass carp in large, open systems. Pages 46-48 in Redfield, G.,J.F. Taggart, and L. M. Moore. editors. Lake and reservoir management: Vol II. Proceedings of the 5th annual conference and international symposium. North American Lake Management Society, Washington, DC.

Noble, R. L., R. D. Germany, and C. R. Hall. 1975. Interactions of blue tilapia and largemouth bass in a power plant cooling reservoir. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 29:247-251.

Nyman, L. P., and J. Arditt. 1985. Germination of taro seeds. Ariodeana 8(3):83-88.

Ochse, J. J. 1951. Two vegetables for South Florida. Florida State Horticultural Society. Deland, Fl. 104pp.

Odum, Eugene P. 1954. Fundamentals of ecology. W. B. Saunders, Philadelphia. 384 pp.

*Ogilvie, V. E. 1966a. Report on the peacock bass project including Venezuelan trip report and a description of five Cichla species. Unpublished report, Florida Game and Freshwater Fish

Commission, Boca Raton. 62 pp.

*Ogilvie, V. E. 1966b. Preliminary report on peacock bass--revised. Unpublished report. Florida Game and Fresh Water Fish Commission, Boca Raton. 17 pp.

O'Hara, J. 1967. Invertebrates found in water hyacinth mats. Quarerly Journal of the Florida Academy of Sciences 30:73-80.

O'Kane, K. D. 1976. A population study of the exotic bivalve *Corbicula Manilensis* (Philippi, 1841) in selected Texas reservoirs. M.S. thesis, Texas Christian University, Fort Worth, Texas.

Oliver, A. D., T. E. Reagan, and C. E. Burns. 1979. The fire ant: an important predator of some agricultural pests. Louisiana Agriculture 22:6-9.

Oliver-Gonzales, J., P. M. Bauman, and A. S. Benenson. 1956. Effect of the snail, *Marisa cornuarietis* on *Australorbis glabratus* in natural bodies of water in Puerto Rico. Journal of Agriculture, University of Puerto Rico 46:241-242.

O'Meara, G. F., V. L. Larson, D. H. Mook, and M. D. Latham. 1989. *Aedes bahamensis*: its invasion of south Florida and association with *Aedes aegypti*. Journal American Mosquito Control Association 5(1):1-5.

*O'Meara, G. F. and A. D. Gettman. 1991. The Asian tiger mosquito in Florida. Unpublished report, Florida Medical Entomology Laboratory, Institue of Food and Agriculture Sciences, University of Florida, Vero Beach. 4 pp.

O'Meara, G. F., A. D. Gettman, L. F. Evans, Jr., and F. D. Scheel. 1992. Invasion of cemeteries in Florida by *Aedes albopictus*. Journal American Mosquito Control Association 8(l):1-10.

Oppenheimer, C. H. 1962. Pages 541-566 in G. Borgstrom, Editor. Fish as food. Volume II. Academic Press, New York. 777pp.

Owre, O. T. 1973. A consideration of the exotic avifauna of southeastern Florida. Wilson Bulletin 85:491-500.

Pace, G. L. 1973. The freshwater snails of Taiwan (Formosa). Malacologist Review, Supplement 1, 118 pp.

Pafume, B. A., E. G. Campos, D.B. Francy, E.L. Peyton, A.N. Davis, and M. Nelms. 1988. Discovery of *Aedes* (Howardina) *bahamensis* in the United States. Journal of the American Mosquito Control Association 4:380.

Page, L. A. 1975. Wildlife diseases: proceedings of the third international wildlife diseases conference. Plenum Press, New York. 686 pp.

Page, L. M. and B. M. Burr. 1991. A field guide to freshwater fishes. Houghton Mifflin, Boston. 432 pp.

Page, T. L., D. A. Neitzel, and M. S. Simmons. 1986. Biofouling of power plant water systems by *Corbicula.* American Malacological Bulletin, Special Edition 2:41-45.

Paperna, I. 1964. The metazoan parasite fauna of Israel's inland water fishes. Bamidgeh 16:1-66.

Parija, P. 1934. Physiological investigations on water hyacinth (*Eichhornia crassipes*) in Orissa with notes on some other aquatic weeds. Indian Journal of Agricultural Science 4:399-429.

Paulson, D. R. 1978. An Asiatic dragonfly, *Crocothemis servilia* (Drury) established in Florida (Anisoptera:Libellulidae). Notulae Odonatologica 1:9-10.

Pauley, D. 1976. The biology, fishery and potential for aquaculture of *Tilapia melanotheron* in a small West African lagoon. Aquaculture 7:33-49.

Peacock, B. E., J. P. Smith, P. G. Gregory, T. M. Loyless, J. A. Mulrennan, P. R. Simmonds, L. Padgett, Jr., E. K. Cook, and T. R. Eddins. 1988. *Aedes albopictus* in Florida. Journal of the American Mosquito Control Association 4:362-365.

Pearsall, W. H. 1959. The ecology of invasion: ecological stability and instability. New Biology 29:95-101.

Peckham, D. G. 1977. The "love bugs." Pages 113-125 in D. J. Jackson and D. Stoll, editors. Some endangered and exotic species in Florida, part 2: some exotic species. Florida International University, Miami. 234 pp.

Penfound, W. T., and T. T. Earle. 1948. The biology of the water hyacinth. Ecology Monographs 18:448-472.

Peng, S. Y., and L. T. Twu. 1979. Studies on the regenerative capacity of rhizomes of torpedograss (*Panicum repens* L.). Journal of the Agriculture Association of China, New Series 107:61-74.

Peoples, R. A., Jr., J. A. McCann, and L. B. Starnes. 1992. Introduced organisms: policies and activities of the U.S. Fish and Wildlife Service. Pages 325-352 in A. Rosenfield and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems. Maryland Sea Grant, University of Maryland, College Park.

Perdales, J. R., and A. G. Dingal. 1988. An allelopathic factor in taro residues. Tropical Agriculture (Trinidad) 65(1):21-24.

*Perkins, B. D. 1973. Release in the United States of *Neochetina eichhorniae* Warner, an enemy of waterhyacinth. Page 368 in Proceedings of the 26th annual meeting of the Southern Weed

Science Society held in Raleigh,NC. Unpublished report,

Perkins, B. D., and D. M. Maddox. 1976. Host specificity of *Neochetina bruchi* Hustache (Coleoptera: Curculionidae), a biological control agent for waterhyacinth. Journal of Aquatic Plant Management 14:59-64.

Pieterse, A. H. 1990a. Introduction. Pages 3-16 in A. H. Pierterse and K. J. Murphy, editors. Aquatic weeds. Oxford University Press, Cary, North Carolina.

Pieterse, A. H. 1990b. Introduction to biological control of exotic weeds. Pages 174-176 in A. H. Pierterse and K. J. Murphy, editors. Aquatic weeds. Oxford University Press, Cary, North Carolina.

Pigg, J. 1978. The tilapia *Sarotherodon aurea* (Steindachner) in the North Canadian River in central Oklahoma. Proceedings of the Oklahoma Academy of Sciences 58:111-112.

*Plant Importation and Technical Support Staff, Technical Information Unit. 1982. List of intercepted plant pests: fiscal years 1980 and 1981. Unpublished report. U.S. Department of Agriculture, Washington, D.C. 82-8:vi + 476 pp.

Pough, R. H. 1951. Audubon water bird guide. Doubleday, Garden City, N.Y. 352 pp.

Price, C. E., and J. D. Mizelle. 1964. Studies on monogenetic trematodes. XXVI. *Dactylogyrinae* from California with the proposal of a new genus *Pellucidhaptor*. Journal of Parasitology 50:572-578.

*Prochaska, F. J., and C. M. Adams. 1985. Florida aquaculture: current status and economic issues. Unpublished report, Food and Resource Economics Department Staff Paper Series No. 282, University of Florida, Gainesville. 19pp.

*Provine, W. C. 1975. The grass carp. Unpublished report, Texas Parks and Wildlife Department, Austin, Texas. 51 pp.

Purdom, C. E. 1983. Genetic engineering by the manipulation of chromosomes. Aquaculture 33:287-300.

Puyo, J. 1949. Poissons de la Guyane francaise. Faune de l'empire francais. XII. Paris: Office de la Recherche Scientifique outre-mar. pp. 1-280.

Quincy, P. A. 1977. The scarlet ibis *Eudocimus ruber*. Pages 190-203 in D. F. Jackson and D. Stoll, editors. Some endangered and exotic species in Florida: part two. Florida International University, Miami.

Rai, K. S. 1991. *Aedes albopictus* in the Americas. Annual Review of Entomology 36:459-84.

Ramsey, J. S. 1985. Sampling aquarium fishes imported by the United States. Journal of Alabama Academy of Science 56:220-245.

Rataj, K., and T. L. Horeman. 1977. Aquarium plants: their identification, cultivation, and ecology. Tropical Fish Hobbyist Publications, Neptune, N.J. 448 pp.

Rathbun, M. J. 1918. The grapsoid crabs of America. U.S. National Museum Bulletin 97:1-445 + illustrations.

*Ray, H. C. 1962. Chokage of filtered-water pipe systems by freshwater molluscs. Pages 20-23 in Proceedings of the all-India congress on zoology, 1959. Unpublished report,

Reams, W. M., Jr. 1953. The occurrence and ontogeny of hydathodes in *Hygrophila polysperma*. Thomas Anderson New Phytologist 52:8-13.

Reddy, K. R., and J. C. Tucker. 1983. Productivity and nutrient uptake of water hyacinth, *Eichhornia crassipes* L., effect of nitrogen source. Economic Botany 37:237-247.

Rees, W. J. 1965. The aerial dispersal of Mollusca. Proceedings of the Malacology Society London 36:269-282.

Regan, C. T. 1905. A revision of the fishes of the American cichlid genus *Cichlasoma* and of the allied genera. Annals and Magazine of Natural History 16:60-77, 225-243, 316-340, 433-445.

Regan, C. T. 1913. A revision of the Cyprinodon Fishes of the sub-family Poeciliinae. Proceedings of the Zoology Society London 2:977-1018.

Reichenbach-Klinke, H. (1960) 1961. Die transkontinentale Verschleppung von Parasiten insbesondere der Wassertiere. Sonderdruck Verhandlungen Deutsches Zoologischen Gesellschaft in Bonnam Rhein 24:410-415.

Reichenbach-Klinke, H., and E. Elkan. 1965. Pages 190-194. in The principal diseases of lower vertebrates. Academic Press, New York. 376pp.

Reilly, E. M., Jr. 1968. Audubon illustrated handbook of American birds. McGraw Hill, New York. 520pp.

Reimer, W. J. 1958. Giant toads of Florida. Journal of Florida Academy of Science 21:207-211.

Richard, D. I., J. W. Small, Jr., and J. A. Osbourne. 1985. Response of zooplankton to the reduction an elimination of submerged vegetation by grass carp and herbicide in four Florida lakes. Hydrobiologia 123:97-108.

Riley, D. M. 1978. Parasites of grass carp and native fishes in Florida. Transactions of the

American Fisheries Society 107:207-212.

Ringuelet, R. A., R. H. Aramburu, and A. Alonso de Aramburu. 1967. Los peces Argentinos de agua dulce, Comisión de Investigación Cientifica, La Plata. 602 pp.

Ripley, S. D. 1975. Report on endangered and threatened plant species of the United States: house document 94-51. Smithsonian Institute, Washington, D.C. 204 pp.

Rivas, L. R. 1965. Florida freshwater fishes and conservation. Quarterly Journal of the Florida Academy of Science 28:255-258.

Roback, S. S. 1974. Insects (Arthropoda: Insecta). Pages 313-376 in C. W. Hart, Jr. and S. L. H. Fuller, editors. Pollution ecology of freshwater invertebrates. Academic Press, New York.

Robertson, W. B., Jr. 1962. Florida region. Audubon Field Notes 16:468-473.

Robertson, W. B., Jr., and G. E. Woolfenden. 1992. Florida bird species: an annotated list. Florida Ornithological Society, Gainesville, Florida. 260 pp.

Robins, C. H. 1971. Ecology of the introduced snail, *Marisa cornuarietis* (Ampullariidae) in Dade County, Florida. Biologist 53:136-152.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1980. A list of common and scientific names of fishes from the United States and Canada. American Fisheries Society, Bethesda, Md. 174 pp.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991a. Common and scientific names of fishes from the United States and Canada. American Fisheries Society, Bethesda, Md. 183 pp.

Robins, C. R., R. M. Bailey, C. E. Bond, J. R. Brooker, E. A. Lachner, R. N. Lea, and W. B. Scott. 1991b. World fishes important to North Americans exclusive of species from the continental waters of the United States and Canada. American Fisheries Society, Bethesda, Md. 243 pp.

Roessler, M. A., G. L. Beardsley, and D. C. Tabb. 1977. New records of the introduced snail, *Melanoides tuberculata* (Mollusca: Thiaridae) in South Florida. Florida Scientist 40:87-94.

Rogers, H. H., and D. E. Davis. 1972. Nutrient removal by water hyacinth. Weed Science 20:423-428.

Rogers, W. A. 1967. Studies on *Dactylogyrniae* (Monogenea) with description of 24 new species of *Dactylogyrniae*, 5 new species of *Peleucidhapter*, and the proposal of *Aplodiscus* gen. n.. Journal of Parasitology 53:501-524.

Rogers, W. A. 1968. *Pseudacolpenteron pavlovskyi* Bychowski and Gussev, 1955 from North America, with notes on its taxonomic status. Journal of Parasitology 54:389.

Rollins, R. C. 1978. Watercresses in Florida. Rhodora 80:147-153.

Rosen, D. E. 1960. Middle-American poeciliid fishes of the genus *Xiphophorus*. Bulletin of the Florida State Museum, Biological Sciences 5(4):57-242.

Rosen, D. E., and K. D. Kallman. 1969. A new fish of the genus *Xiphophorus* from Guatemala, with remarks on the taxonomy of endemic forms. American Museum Novitates 2379:1-29.

Rosenberry, R. 1983. The IHHN shrimp virus. Aquaculture Digest 8(12):7-13.

Rosenfield, A., and R. Mann. 1992. Dispersal of living organisms into aquatic ecosystems. Maryland Sea Grant, College Park. 471 pp.

Rosenthal, H. 1985. Constraints and perspectives in aquaculture development. GeoJournal 10:305-324.

Rottman, R. W. 1977. Management of weedy lakes and ponds with grass carp. Fisheries 2(5):8,9,11-3.

Rue, L. L, III. 1967. Nutria. Pages 117-119 in Pictorial guide to the mammals of North America. Thomas Y. Crowell.New York, NY. 299pp.

Russo, T. N. 1974. Discovery of the gastropod snail *Melanoides* (Thiara) *tuberculata* (Müller) in Florida. Florida Scientist 36:212-213.

Sailer, R. I. 1978. Our immigrant insect fauna. Bulletin of the Entomology Society of America 24:1-11.

Sailer, R. I. 1983. History of insect introductions. Pages 15-38 in C. Graham and C. Wilson, editors. Exotic plant pests and North American agriculture. Chapter 2. Academic Press, New York.

Sandifer, P.A., J.S. Hopkins, and A.D. Stokes. 1988. Intensification of shrimp culture in earthen ponds in South Carolina: progress and prospects. Journal of World Aquaculture Society 19(4):218-226.

Sandifer, P. A., A. D. Stokes, and J. K. Hopkins.1991. Further intensification of pond shrimp culture in South Carolina. in Sandifer, P. A., editor. Advances in world aquaculture: shrimp culture in North America and the Caribbean. World Aquaculture Society, Baton Rouge, La.

Sainty, G. R., and S. W. L. Jacobs. 1981. Water plants of New South Wales. Stanley Owens and

Sons, Alexandria, New South Wales. 550 pp.

Saunders, G. B. 1980. The origin of white-winged doves breeding in south Florida. Florida Field Naturalist 8:50-51.

*Schardt, J. D. 1986. 1986 Florida aquatic plant survey report. Unpublished report. Florida Department of Natural Resources, Tallahassee. 124 pp.

*Schardt, J. D. 1988. 1987 Florida aquatic plant survey report. Unpublished report, Florida Department of Natural Resources, Tallahassee. 49 pp.

*Schardt, J. D., and L. E. Nall. 1989. 1988 Florida aquatic plant survey report. Unpublished report, Florida Department of Natural Resources, Tallahassee. 118 pp.

*Schardt, J. D., and D. C. Schmitz. 1990. 1990 Florida aquatic plant survey report. Unpublished report, Florida Department of Natural Resources, Tallahassee. 89 pp.

*Schardt, J. D. 1991. 1991 Florida aquatic plant survey report. Unpublished report, Florida Department of Natural Resources, Tallahassee. 68 pp.

*Schardt, J. D. 1992. 1992 Florida aquatic plant survey report. Unpublished report, Florida Department of Environmental Protection, Tallahassee. 83 pp.

Schliessmann, D. J. 1967. *Aedes aegypti* eradication program of the United States: progress report 1967. American Journal of Public Health 57:460-65.

Schliessmann, D. J., and L. B. Calheiros. 1974. A review of the status of yellow fever and *Aedes aegypti* eradication programs in the Americas. Mosquito News 34:1-9.

Schmidt, G. D., and A. G. Canaris. 1967. Acanthocephala from Kenya with descriptions of two new species. Journal of Parasitology 53:634-637.

Schmitz, D. C. 1990. The invasion of exotic aquatic and wetland plants into Florida: history and efforts to prevent new introductions. Aquatics 12(2):6-24.

Schmitz, D. C., and L. E. Nall. 1984. Status of *Hygrophila polysperma* in Florida. Aquatics 6:11-14.

Schmitz, D. C., B. V. Nelson, L. E. Nall, and J. D. Schardt. 1991. Exotic aquatic plants in Florida: a historical perspective and review of the present aquatic plant regulation program. Pages in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Resource Publication Office, National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06. 387 pp.

Schmitz, D. C., and J. A. Osborne. 1984. Zooplankton densities in a hydrilla infested lake. Hydrobiologia 111:127-132.

Schmitz, D., J. D. Schardt, and J. J. Craft. 1990. Seeds of destruction. Florida Environments 4(12):9.

Schmitz, D. C., J. D. Schardt, A. J. Leslie, F. A. Dray Jr., J. A. Osborne, and B. V. Nelson. 1993. The ecological impact and management history of three invasive alien aquatic plant species in Florida. Pages 173-194 in B. N. McKnight, editor. Biological pollution: the control and impact of invasive exotic species. Indiana Academy of Science, Indianapolis. 261 pp.

*Schortemeyer, J. L., R. E. Johnson, and J. D. West. 1981. A preliminary report on wildlife occurrence in *Melaleuca* heads in the Everglades Wildlife Management Area. Pages 81-89 in R. K. Geiger, editor. Proceedings of the *Melaleuca* Symposium. Unpublished report, Florida Department of Agriculture and Consumer Service, Division of Forestry, Tallahassee .

Schramm, H. L., K. J. Jerka, and M. V. Hoyer. 1987. Epiphytic macroinvertebrates on dominant macrophytes in two central Florida lakes. Journal of Freshwater Ecology 4:151-161.

Schramm, H. L., Jr., and A. V. Zale. 1985. Effects of cover and prey size on preferences of juvenile largemouth bass for blue tilapias and bluegills in tanks. Transactions of the American Fisheries Society 114:725-731.

Schroeder, D. and R. D. Goeden. 1986. The search for arthropod natural enemies of introduced weeds for biological control in theory and practice. Biocontrol News and Information 7:147-155.

Schultz, E. E. 1960. Establishment and early disperqal of a loach, *Misgurnus anguillicaudatus* (Cantor), in Michigan. Transactions of the American Fisheries Society 89:376-377.

Schultz, G. W. 1989. Cemetery vase breeding of dengue vectors in Manila, Republic of the Philippines. Journal of the American Mosqito Aontrol Association 5:508-513.

Schwartz, A. 1952. *Hyla septentrionalis* Dumeril and Bibron on the Florida mainland. Copeia 1952:117-118.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Fisheries Research Board of Canada, Ottawa. 966 pp.

Shafland, P. L. 1976. The continuing problem of non-native fishes in Florida. Fisheries 1(4):25.

Shafland, P. L. 1979. Non-native fish introduction with special reference to Florida. Fisheries 4(3):18-23.

*Shafland, P. L. 1984. A proposal for introducing peacock bass (*Cichla* spp.) in southeast Florida canals. Unpublished report, Florida Game and Freshwater Commission, Boca Raton, Fla. 20 pp.

Shafland, P. L. 1986. A review of Florida's efforts to regulate, assess and manage exotic fishes. Fisheries 11(2):20-25.

Shafland, P. L. 1989. Florida's peacock bass program. Introduced Fish Section Newsletter, American Fisheries Society 9(3):24-27.

*Shafland, P. L. 1990. 1989-1990: non-native fish research, first annual performance report. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee, FL. 12 pp.

*Shafland, P. L. 1991. Management of introduced freshwater fishes in Florida. Pages 214-237 in , editor. Proceedings of the 1990 invitational symposium/workshop: new directions in research, management and conservation of Hawaiian stream ecosystems. Unpublished report, Hawaii Department of Natural Resources, Honolulu.

Shafland, P. L. 1993. An overview of Florida's introduced butterfly peacock bass (Cichla ocellaris) sportfishery. Natura. 96:26-29.

Shafland, P. L., and K. J. Foote. 1979. A reproducing population of *Serrasalmus humeralis* Valenciennes in southern Florida. Florida Scientist 42:206-214.

*Shafland, P. L., D. S. Levine, and R. J. Wattendorf. 1980. An evaluation of inter-specific interactions between blue tilapia and certain native fishes in Florida: fish population analysis. Unpublished report, Florida Game and Fresh Water Fish Commission, Boca Raton. 31 pp.

Shafland, P. L., and W. M. Lewis. 1984. Terminology associated with introduced organisms. Fisheries 9(4):17-18.

Shafland, P. L., and J. M. Pestrak. 1981. Predation by blue tilapia on largemouth bass, in experimental ponds. Proceedings of the Annual Conference of the Southeast Association of Fish and Wildlife 35:442-448.

Shafland, P. L., and J. M. Pestrak. 1982. Lower lethal temperatures for fourteen non-native fishes in Florida. Environmental Biology of Fish 7:149-156.

Shafland, P. L., and J. M. Pestrak. 1983. Suppression of largemouth bass production by blue tilapia. 1983 Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 37:441-446.

Sharma, B. M. 1984. Ecophysiological studies on water lettuce in a polluted lake. Journal of Aquatic Plant Management 22:19-21.

Shelton, W. L. 1986. Strategies for reducing risks from introductions of aquatic organisms:an aquaculture perspective. Fisheries 11(2):16-19.

Shelton, W. L., and R. O. Smitherman. 1984. Exotic fishes in warmwater aquaculture. Pages 262-301 in W. R. Courtenay and J. R. Stauffer, editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Md.

Sherman, H. B. 1943. The armadillo in Florida. Florida Entomologist 26:54-59.

Shih, S. F., and G. H. Snyder. 1984. Evapotransporation and water use efficiency of taro. Transactions of the American Society of Agricultural Engineers 27(6):1745-1748.

*Shireman, J.V. 1976. Ecological study of Lake Wales, Florida after introduction of grass carp. Unpublished report, Florida Department of Natural Resources, Tallahassee. 63 pp.

*Shireman, J. V., and W. T. Haller. 1982. The impact of aquatic plants and their management techniques on the aquatic resources of the United States: an overview. Final report. Environmental Research Laboratory, Florida Environmental Protection Agency, Gulf Breeze, Fla. EPA 600/4-81-007. 157pp.

Shireman, J. V., D. E. Colle, and M. J. Maceina. 1980. Grass carp growth rates in Lake Wales, Florida. Aquaculture 19:379-82.

*Shireman, J. V., W. T. Haller, D. E. Colle, C. E. Watkins, II, D. E. DuRant, and D. E. Canfield, Jr. 1983. The ecological impact of integrated chemical and biological aquatic weed control. Final Report. U.S. Environmental Protection Agency, Environmental Research Laboratory, Gulf Breeze, Fla. 333 pp.

*Shireman, J. V., and W. J. Lindberg. 1985. A first look at Florida aquaculture. Unpublished report, Florida Cooperative Extension Service, University of Florida, Gainesville. 19 pp.

*Shireman, J. V., and M. J. Maceina. 1983. Recording fathometer techniques for hydrilla distribution and biomass studies. U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms. Miscellaneous Paper A-83-1. 43 pp.

Shireman, J. V., and M. J. Maceina. 1991. The utilization of grass carp (*Ctenopharyngodon idella*) for hydrilla control in Lake Baldwin, Florida. Journal of Fish Biology 19:629-636.

Shireman, J. V., and C. R. Smith. 1983. Synopsis of biological data on the grass carp. United Nations Food and Agriculture Organization, Rome. 86 pp.

Shotts, E. B., Jr., and J. B. Gratzek. 1984. Bacteria, parasites, and viruses of aquarium fish and their shipping waters. Pages 215-232 in W.R. Courtenay and J.R. Stauffer, editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Md.

Shotts, E. B., A. L. Kleckner, J. B. Gratzek, and J. L. Blue. 1976. Bacterial flora of aquarium fishes and their shipping waters imported from Southeast Asia. Journal of the Fisheries Research Board of Canada 33:732-735.

Sickel, J. B. 1973. A new record of *Corbicula manilensis* (Philippi) in the southern Atlantic slope region of Georgia. Nautilus 87:11-12.

*Sickel, J. B. 1979. Population dynamics of *Corbicula* in the Altamaha River, Georgia. Pages 69-80 in J. C. Britton, editor. Proceedings of the international *Corbicula* symposium. Unpublished report. Texas Christian University Research Foundation, Fort Worth, Texas.

Sinclair, R. M. 1964. Clam pests in Tennessee water supplies. Journal of American Water Works Association 56:592-599.

Sinclair, R. M. 1971a. *Corbicula* variation and *Dreissena* parallels. Biologist 53(3):153-159.

Sinclair, R. M. 1971b. Annotated bibliography on the exotic bivalve *Corbicula* in North America, 1900-1971. Sterkiana 43:11-18.

*Sinclair, R. M. 1974. Effects of an introduced clam (*Corbicula*) on water quality in the Tennessee River Valley. Pages 43-50 in Proceedings of the second industrial waste conference. Unpublished report, Tennessee Department of Public Health, Nashville.

*Sinclair, R. M., and B. G. Isom. 1961. A preliminary report on the introduced Asiatic clam *Corbicula* in Tennessee. Unpublished report, Tennessee Department of Public Health, Nashville. 31 pp.

*Sinclair, R. M., and B. G. Isom. 1963. Further studies on the introduced Asiatic clam *Corbicula* in Tennessee. Unpublished report, Tennessee Department of Public Health, Nashville. 76 pp.

Sindermann, C. J. 1986. Strategies for reducing risks from introductions of aquatic organisms: a marine perspective. Fisheries 11(2):10-15.

Sindermann, C. J. 1990a. Principal diseases of marine fish and shellfish. Vol. 1. Diseases of marine fish. Academic Press, San Diego. 521 pp.

Sindermann, C. J. 1990b. Principal diseases of marine fish and shellfish. Vol. 2. Diseases of shellfish. Academic Press, San Diego. 516 pp.

Sindermann, C. J. 1991. Case histories of effects of transfers and introductions on marine resources. Journal of the International Council for the Exploration of the Sea 47:377-378.

Sindermann, C. J. 1992a. Role of the International Council for the Exploration of the Sea (ICES) concerning introductions of marine organisms. Pages 367-376 in A. Rosenfield and R. Mann, editors. Dispersal of living organisms into aquatic ecosystems. Maryland Sea Grant, College Park. 471 pp.

Sindermann, C. J. 1992b. Precautions for importing and culturing non-native shrimp. Part II. Pages 325-332 in W. Fulks and K. L. Main, editors. Diseases of cultured penaeid shrimp in Asia and the United States. The Oceanic Institute, Honolulu.

*Sindermann, C. J. 1992c. Risks associated with introduction of nonindigenous marine species, with emphasis on disease. Unpublished report, Presented at the symposium on nonindigenous species regulations. American Fisheries Society, Bethesda, Md. 20 pp.

Sindermann, C. J. 1993a. The introduction of marine species: what the future holds. Pages 143-148 in M. R. DeVoe, editor. Proceedings of the conferences and workshop: introductions and transfers of marine species: achieving a balance between economic development and resource protection. South Carolina Sea Grant Consortium, Charleston.

Sindermann, C. J. 1993b. Disease risks associated with importation of nonindigenous marine animals. Marine Fisheries Review 54(3):1-10.

Sindermann, C. J., and A. E. Farrin. 1962. Ecological studies of *Cryptocotylea lingua* (Tremadoda: Heterophidae) whose larvae cause "pigment spots" of marine fish. Ecology 34:69-75.

Sindermann, C. J., and A. Rosenfield. 1967. Principal diseases of commercially important marine bivalve and crustacea. Fishery Bulletin 66:355-385.

Skiles, D. D. 1989. Yellow fever mosquito. Pages 257-273 in , Dahlsten, D. L. and R. Garcia, editors. Eradication of exotic pests: analysis with case histories: Michigan. Yale University, New Haven, Conn. 296pp.

Small, J. K. 1933. Manual of the southeastern flora. University of North Carolina Press, Chapel Hill. ii + 1554 pp. + illustrations.

Small, J. K. 1931. Ferns of Florida. Florida Press, New York. 237 pp.

Small, J. K. 1938. Ferns of the southeastern states. Science Press, Lancaster, Pa. 517 pp.

Smith, C. S., and J. W. Barko. 1990. Ecology of Eurasian watermilfoil. Journal of Aquatic Plant Management 28:55-64.

Smith, A. L., R. A. Muia, J. P. Farkas, and D. O. Bassett. 1979. Clams--a growing threat to inplant water systems. Plant Engineering 33:165-167.

*Smith, C. R., and J. V. Shireman. 1981. Grass carp bibliography. Unpublished report, U.S. Army Corps of Engineers, Waterways Experiment Station, Vicksburg, Ms. 179 pp.

Smith, G. 1969. The fur that failed. Florida Wildlife 22(10):4-5.

Smith, H. M. 1945. The fresh-water fishes of Siam, or Thailand. Bulletin of the U.S. National Museum 188:1-622.

Smith, H. M., and A. J. Kohler. 1978. A survey of herpetological introductions in the United States and Canada. Transactions of the Kansas Academy of Science 80(1):1-24.

Smith , J. P., T. M. Loyless, and J. A. Mulrennan, Jr. 1990. An update on *Aedes albopictus* in Florida. Journal of the American Mosquito Control Association 6:318-320.

*Smith, M. H., J. Britton, P. Burke, R. K. Chesser, M. W. Smith, and J. Hagen. 1979. Genetic variability in *Corbicula*, an invading species. Pages 243-248 in J. C. Britton. 1979. Proceedings of the first international *Corbicula* symposium. Unpublished report, Texas Christian University Research Foundation, Forth Worth.

Smith, P. W. 1987. The Eurasian collared-dove arrives in the Americas. American Birds 41:1370-1379.

Smith-Vaniz, W. F. 1968. Freshwater fishes of Alabama. Auburn University, Auburn, Ala. 211 pp.

Snelson, F., Jr., and W. K. Bradley, Jr. 1978. Mortality of fishes due to cold on the east coast of Florida, January 1977. Florida Scientist 41:1-12.

Snieszko, S. F. 1970. A symposium on diseases of fish and shellfishes. American Fisheries Society, Bethesda, Md. 526 pp.

Snodgrass, J. W. 1991. Winter kills of *Tilapia melanotheron* in coastal southeast Florida, 1989. Florida Scientist 54:85-86.

Somma, L.A. and D.M. Crawford. 1993. *Osteopilus septentrionalis*. Herpetological Review 24:153.

*South Florida Exotic Pest Plant Council. 1985. Draft model exotic species ordinance for municipalities and counties in south Florida. Unpublished report. South Florida Exotic Pest Plant Council, Everglades National Park, Homestead, Fla.

Southeastern Cooperative Wildlife Disease Study. 1985. Model for state regulations pertaining to captive wild and exotic animals. Unpublished Report. Southeastern Cooperative Wildlife Disease Study, College of Veterinary Medicine, University of Georgia, Athens. 48pp.

Spencer, W., and G. Bowes. 1985. Limnophila and hygrophilia: a review and physiological assessment of their weed potential in Florida. Journal of Aquatic Plant Management 23:7-16.

Springer, V. G., and J. H. Finucane. 1963. The African cichlid *Tilapia heudeloti* Dumeril, in commercial fish catch of Florida. Transactions of the Fisheries Society 92:317-318.

Sprunt, A., Jr. 1954. Florida bird life. Coward-McCann, New York. 504pp.

Sridahar, M. K. C. 1986. Trace element composition of *Pistia stratiotes* L. in a polluted lake in Nigeria. Hydrobiologia 131:273-276.

St. Amant, J. A., and F. G. Hoover. 1969. Addition of *Misgurnus anguillicaudatus* (Cantor) to the California fauna. California Fish and Game 55:330-331.

Stange, L. A. 1990. Snails and slugs of Florida. Florida Garden Guide January/February:1-2.

Stanley, J. G. 1972. Unisex studies on the white amur. Pages 89-95. in: Proceedings, Research Planning Conference on Integrated Systems of Aquatic Plant Control, held Oct. 29-30,1973. Waterways Experiment Station, U.S. Corps of Engineers, Vicksburg, Mississippi.

Stanley, J. G. 1976. Reproduction of the grass carp (*Ctenopharyngodon idella*) outside its native range. Fisheries 1(3):7-10.

Stanley, J. G., W. W. Miley, II, and D. L. Sutton. 1978. Reproductive requirements and likelihood for naturalization of escaped grass carp in the United States. Transactions of American Fisheries Society 107:119-128.

Stanley, J. G., R. A. Peoples, Jr., and J. A. McCann. 1991. U.S. federal policies, legislation, and responsibilities related to importation of exotic fishes and aquatic organisms. Canadian Journal of Fisheries and Aquatic Science 48(Supplement 1):162-166.

Stauffer, J. R., Jr., D. K. Vann, and C. H. Hocutt. 1984. Affects of salinity on preferred and lethal temperatures of the blackchin tilapia, *Sarotherodon melanotheron*. Water Resource Publication 20:771-775.

Sterba, G. 1966. Freshwater fishes of the world. Pet Library, New York. 877 pp.

Sterling, W. L. 1978. Imported fire ant...may wear a gray hat. Texas Agriculture Progress 24:19-20.

Stevenson, H. M. 1961. Florida region. Audubon Field Notes 15:402-405.

Steward, K. K. 1990. Aquatic weed problems and management in the eastern United States. Pages 391-405 in A. H. Pierterse and K. J. Murphy, editors. Aquatic weeds. Oxford University Press, Cary, North Carolina.

Stickney, R. R. 1976. Cellulase activity in the stomachs of freshwater fish from Texas. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners

29:282-287.

Stickney, R. R. 1979. Principles of warmwater aquaculture. Wiley Interscience, New York.

Stoddard, A. A. 1989. The phytogeography and paleofloistics of *Pistia stratiotes* L. Aquatics 11:21-24.

Stoetzel, M. B. 1989. Common names of insects and related organisms. Entomological Society of America, Lanham, Md.

Stoll, D. 1977. The red-whiskered bulbul *Pycnonotus jocosus*. Pages 204-224 in D. F. Jackson and D. Stoll, editors. Some endangered and exotic species in Florida: part two. Florida International University, Miami.

Stroud, R. H. 1969. Conference on exotic fishes and related problems. Sport Fishing Institute Bulletin 203:1-4.

Stuckey, R. L., and D. H. Les. 1984. *Pistia stratiotes*: (waterlettuce) recorded from Florida in Bartram's Travels, 1765-1774. Aquaphyte 4:6.

Stumpp, M. 1975. Untersuchëngen zur Morphologie and Biologie von *Camallanus cotti* (Fujita, 1927). Zeitschrift Parasitenkunde 46:277-290.

Suffern, J. S. 1980. The potential of tilapia in United States aquaculture. Aquaculture Magazine 6(6):14-18.

Summerlin, J. W., and L. R. Green. 1977. Red imported fire ant: A review on invasion, distribution, and control in Texas. Southwestern Entomologist 2:94-101.

Sutton, D. L. 1983. Aquatic plant competition. Aquatics 5(3):10,12-14.

*Sutton, D. L. 1985. Biology and ecology of *Myriophyllum aquaticum*. Pages 59-72 in , L. W. J. Anderson, editor. Proceedings of the 1st international symposium on watermilfoil (*Myriophyllum spicatum*) and related Haloragaceae species. Unpublished repor. Aquatic Plant Management Society, Vicksburg, Mississippi.

Sutton, D. L., and K. M. Portier. 1985. Density of tubers and turions of hydrilla in South Florida. Journal of Aquatic Plant Management 23:64-67.

*Sutton, D. L., and V. V. Vandiver, Jr. 1986. Grass carp, a fish for biological management of hydrilla and other aquatic weeds in Florida. Unpublished report, University of Florida, Gainesville. 10 pp.

Sweetman, H. L. 1958. The principles of biological control. Wm. C. Brown Company, Dubuque, Ia. 560 pp.

Swingle, H.S. 1956. Determination of balance in farm fish ponds. Transaction of North American Wildlife Conference 21:298-322.

Swingle, H. S. 1957. Control of pond weeds by use of herbivorous fishes. Proceedings of Southern Weed Conference 10:11-17.

Swingle, H. S. 1958. Further experiments with *Tilapia mossambica* as a pondfish. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 11:152-154.

Swingle, H. S. 1966. Temperature tolerance of the peacock bass and a pond test of its value as a piscivorous species. Proceedings of the Annual Conference of the Southeastern Association of Game and Fish Commissioners 20:297-299.

Sykes, P. W. 1987. The feeding habits of the snail kite in Florida, USA. Colonial Waterbirds 10:84-92.

Taber, F. W. 1945. Contribution on the life history and ecology of the nine-banded armadillo. Journal Mammalogy 26:211-226.

Tabita, A., and J. W. Woods. 1962. History of waterhyacinth control in Florida. Hyacinth Control Journal 1:19-23.

Tarver, D. P. 1979. Torpedograss (*Panicum repens* L.). Aquatics 1:5-6.

Tarver, D. P., J. A. Rodgers, M. J. Mahler, and R. L. Lazor. 1986. Aquatic and wetland plants of Florida. Florida Department of Natural Resources, Tallahassee. 127 pp.

*Tate, J., editor. 1984. Techniques for controlling wild hogs in Great Smokey Mountains National Park: proceedings of a workshop. Unpublished report, National Park Service, Gatlinburg, Tenn. 87 pp.

Taylor, J. N., D. B. Snyder, and W. R. Countenay, Jr. 1986. Hybridization between two introduced substrate-spawning tilapia (Pisces: Cichlidae) in Florida. Copeia 1986:903-909.

Taylor, J. N., W. R. Courtenay, Jr., and J. A. McCann. 1984. Known impacts of exotic fishes in the Continental United States, Pages 322-373 in W. R. Courtenay, Jr. and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. Johns Hopkins University Press, Baltimore, Md.

Taylor, R. W. 1980a. Mussels of Floyd's Fork, a small north central Kentucky stream (Unionidae). Nautilus 94:13-15.

Taylor, R. W. 1980b. Freshwater bivalves of Tygart Creek, northeastern Kentucky. Nautilus 94:89-91.

Taylor, R. W., and R. C. Hughart. 1981. The freshwater naiads of Elk River, West Virginia with a comparison of earlier collections. Nautilus 95:21-25.

Tebeau, C. W. 1980. A history of Florida. University of Miami Press, Coral Gables. 527pp.

Terres, J. K. 1980. The Audubon Society encyclopedia of North American birds. Alfred A. Knopf. New York, NY. 1109 pp.

*Thayer, D., M. Bodle, and K. Rutchey. 1990. Melaleuca management plan for south Florida: recommendations from the Melaleuca Task Force. Unpublished report, South Florida Water Management District, West Palm Beach. 25pp.

Thayer, D. D., K. K. Langeland, W. T. Haller, and J. C. Joyce. 1990. Weed control in aquaculture and farm ponds. Florida Cooperative Extension Service, University of Florida, Gainesville. 24 pp.

Theriot, R. F., and J. L. Decell. 1978. Large-scale operations management test of the use of the White Amur to control aquatic plants. Pages 220-229 in R. O. Smitherman, W. L. Shelton, and J. H. Grover, editors. Symposium on Culture of Exotic Fishes. Fish Culture Section, American Fisheries Society, Department of Fisheries and Allied Aquacultures, Auburn University, Auburn, Ala. 257pp.

Thomas, P. O., and P. M. Room. 1986. Taxonomy and control of *Salvinia molesta*. Nature 320:581-584.

Thompson, C. M., and R. E. Sparks. 1977. Improbability of dispersal of adult Asiatic clam, *Corbicula manilensis*, via the intestinal tract of migratory water fowl. American Midland Naturalist 98:219-223.

Thompson, C. R., and D. H. Habeck. 1989. Host specificity and biology of the weevil *Neohydronomus affinis* (Coleoptera: Curculionidae) a biological control agent of *Pistia stratiotes*. Entomophaga 34:299-306.

Thompson, F. G. 1984. The freshwater snails of Florida: a manual for identification. University of Florida Press, Gainesville. 94 pp.

*Thompson, R. L. 1977. Feral hogs on national wildlife refuges. Pages 11-16 in G. W. Wood, editor. Research and management of wild hog populations: proceedings of a symposium. Unpublished report, Georgetown, S.C.

Thorp, J. H., and A. P. Covich, editors. 1991. Ecology and classification of North American freshwater invertebrates. Academic Press, New York. 911 pp.

Thys von den Audenaerde, D. F. E. 1968. An annotated bibliography of tilapia (Pisces: Cichlidae). Musee Royale de l'Afrique Centrale, Documentation Zoologique 14:1-406.

Thys von den Awdenaerde, D. F. E. 1971. Some new data concerning the tilapia species of the subgenus Sarotherodon (Pisces: Cichildae). Revue de Zoologie de Botanique Africaine 84: 203-216.

*Tiebout, Harry M., III. 1983. The distribution and ecology of the exotic mammals of Florida. Unpublished term paper-Zoology 6486, Department of Zoology, University of Florida, Gainesville. 28 pp.

Tiller, A. 1982. The watermilfoils of Florida. Aquatics 4(2):4.

Timmer, C. E., and L. W. Weldon. 1967. Evapotranspiration and pollution of water by water hyacinth. Hyacinth Control Journal 6:34-37.

Tisdell, C. A. 1982. Health and disease risks from wild pigs. Pages 316-387 in wild pigs: environmental pests or economic resource? Pergamon Press, Sydney.

Todd, F. S. 1979. Waterfowl: ducks, geese and swans of the world. Sea World Inc. Harcourt, Brace, and Joronovitz. San Diego, CA. 399 pp.

Toops, C., and W. E. Dilley. 1986. Birds of south Florida: an interpretive guide. River Road Press, Conway, Ark. 150pp.

Tonn, R. J., R. Figueredo, and L. J. Uribe. 1982. *Aedes aegypti*, yellow fever and dengue in the Americas. Mosquito News 42:497-501.

Trapido, H. 1947. Range extension of *Hyla septentrionalis* in Florida. Herpetologica 3(6):190.

Trewavas, E. 1966. *Tilapia aurea* (Steindachner) and the status of Tilapia *niloltica exul*, *T. monodi* and *T. lemassoni* (Pisces, Cichlidae). Israel Journal of Zoology, 14:258-276.

Trewavas, E. 1974. The freshwater fishes of rivers Mungo and Meme and lakes Kotto, Mboandong and Soden, West Cameroon. Bulletin of the British Museum (Natural History), Zoology 26:331-419.

Trewavas, E. 1983. Tilapiine fishes of the genera *Sarotherodon*, *Orechromis* and *Danakilia*. Cornell University Press, Ithaca, N.Y. 583 pp.

Trimmer, C. E., and S. S. Teague. 1991. Melaleuca eradication program: Assessment of methodology and efficacy. Pages 339-352 in T. D. Center, R. F. Doren, R. L. Hofstetter, R. L. Myers, and L. D. Whiteaker, editors. Proceedings of the symposium on exotic pest plants. National Park Service, Denver, Colorado. NPS/NREVER/NRTR-91/06. 387 pp.

Trust, T. J., and K. H. Bartlett. 1974. Occurence of potential pathogents in water containing ornamental fishes. Applied Microbiology 28:35-40.

Trust, T. J., and V. G. Money. 1972. Bacterial population of diets for aquarium fishes. Journal of the Fisheries Research Board of Canada 29:429-433.

*Tschinkel, W. R. 1982. History and biology of fire ants. Pages 16-35 in S. L. Battenfield, editor. Proceedings of the symposium on the imported fire ant. Unpublished report of the Inter-Society Consortium for Plant Protection. Atlanta, Ga.

Tschinkel, W. R. 1993. The fire ant (*Solenopsis invicta*): still unvanquished. Pages 121-136 in B. N. McKnight, editor. Biological pollution: the control and impact of invasive exotic species. Indiana Academy of Science, Indianapolis. 261 pp.

Tucker, C. S., and T. A. DeBusk. 1981. Productivity and nutritive value of *Pistia stratiotes* and *Eichhornia crassipes*. Journal of Aquatic Plant Management 19:61-63.

Tucker, T. 1988. Peacock bass strut their stuff. Florida Sportsman Jan:77-80,82

Turgeon, D. D., A. E. Bogan, E. V. Coan, W. K. Emerson, W. G. Lyons, W. L. Pratt, C. F. E. Roper, A. Scheltema, F. G. Thompson, and J. D. Williams. 1988. Common and scientific names of aquatic invertebrates from the United States and Canada: mollusks. American Fisheries Society, Bethesda, Md. 277 pp.

*Turner, C. E. 1984. Conflicting interests and biological control of weeds. Pages 203-225 in Proceedings of the IV international symposium on biological control of weeds. Unpublished report. U.S. Department of Agriculture Research Service, Washington, D.C. 44 pp.

Turner, J. S. 1981. Population structure and reproduction in the introduced Florida population of the pike killifish, *Belonesox belizanus* (Pisces: Poeciliidae). M.S. thesis, University of Central Florida. Orlando. 56 pp.

Turner, J. T., and F. F. Snelson, Jr. 1984. Population structure, reproduction and laboratory behavior of the introduced *Belonesox belizanus* (Poeciliidae) in Florida. Environmental Biology of Fishes 10:89-100.

*U.S. Congress. 1957. Water hyacinth obstructions in the waters of the gulf and south Atlantic states: letter from the Secretary of the Army. Unpublished report, House document 37(85-1).

*U.S. Congress. 1965. Expanded project for aquatic plant control: letter from the Secretary of the Army. Unpublished report, House document 251(89-1).

U.S. Office of Technology Assessment. 1993a. Harmful non-indigenous species in the United States: executive summary. U.S. Government Printing Office, Washington, D.C. 57 pp.

U.S. Office of Technology Assessment. 1993b. Harmful non-indigenous species in the United States. U.S. Government Printing Office, Washington, D.C. 391 pp.

*U.S. Department of Agriculture. 1973-1991. Forms AD 941 and precursors completed and filed in the quarantine facility of the Florida Biological Control Laboratory to record shipments of insects received at that facility, for the years 1973 to 1991.

U.S. Bureau of the Census. 1990. Statistical abstract of the United States: 1990. U.S. Government Printing Office, Washington, D.C. 991pp.

*U.S. Department of the Interior. 1969. Environmental impact of the Big Cypress Swamp jetport. Unpublished report, U.S. Department of the Interior, Washington, D.C. 155 pp.

*U.S. Interagency Aquatic Nuisance Species Task Force. 1992. Proposed aquatic nuisance species program. Unpublished report, U.S. Fish and Wildlife Service, Washington, D.C. 55 pp. + appendix.

Van der Bosch, R. 1978. The pesticide conspiracy. Doubleday, New York, NY. 226pp.

Van Dijk, G. M., D. D. Thayer, and W. T. Haller. 1986. Growth of hygrophilia in flowing water. Journal of Aquatic Plant Management 24:85-87.

Van Dyke, J. M., A. J. Leslie, Jr., and L. E. Noll. 1984. The effects of grass carp on the aquatic macrophytes of four Florida lakes. Journal of Aquatic Plant Management 2:87-89.

Van Dyke, J. M. 1995. Long-term use of grass carp for aquatic plant control in Deer Point Lake, Bay County, Florida. Pages 146-150. in Proceedings of the grass carp symposium held in Gainesville, Florida, March, 1994. U. S. Corps of Engineers Waterways Experimentation Station, Vicksburg, Mississippi. 242 pp.

Villadolid, D. V., and F. G. Del Rosario. 1930. Some studies on the biology of Tulla (*Corbicula manilensis* Phillipi) a common food clam of Laguna de Bay and its tributaries. Philippine Agriculture 19:335-382.

Villano, D. 1988. I think that I shall never see a thing as deadly as a tree. New Times 2(40):6-8, 10.

*Vincente-Chandler, J., F. Abruna, R. Caro-Costas, J. Figarella, S. Silva, and R. W. Pearson. 1974. Intensive grassland management in humid tropics of Puerto Rico. Unpublished report, Agricultural Experiment Station, Rio Pedras, Puerto Rico. 164 pp.

Vinson, S. B., editor. 1985. Economic impacts and control of social insects. Praeger Press, New York. 421pp.

Vinson, S. B. and A. A. Sorensen. 1986. Imported Fire Ants: Life History and Impact. Unpublished Report. Department of Entomology, Texas A & M, University College Station, Texas. 28 pp.

Vismania, K. O., and V. N. Nikulina. 1968. On the systematics of *Philometra sanguinea* (Rud., 1819) (Nematoda: Dracunculidae) pathogen of Crucian carp philometrosis. Parasitologia 2:514-518.

Volovik, S. V., L. M. Mirzoeva, and A. V. Poddubnaya. 1974. On the parasite fauna of a buffalo (Catostomidae, *Ictiobus*) -- new objects of pisciculture, acclimatized in the U.S.S.R. All Union Conference on Diseases and Parasites of Fishes, Moscow 6:59-81. English translation by R.M. Howland, U.S. Fish and Wildlife Service.

*Waldner, R. E. 1974. Food preference of the walking catfish, *Clarias batrachus*. Unpublished report, Florida Atlantic University, Boca Raton. 23 pp.

Waldo, E. 1958. The Louisiana nutria story. Louisiana Wildlife and Fisheries Commission, Baton Rouge. 15 pp.

Ward, D. B. 1990. How many plant species are native to Florida? Palmetto Winter 89/90:3-5.

*Ware, F. J. 1966. Lake Morton tilapia eradication project. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 2 pp.

*Ware, F. J. 1973. Status and impact of *Tilapia aurea* after 12 years in Florida. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 8 pp.

*Ware, F., and W. Fish. 1971. Lake management and research, haul seine study. Unpublished report, Florida Game and Fresh Water Fish Commission, Tallahassee. 22 pp.

*Wattendorf, R. J. 1981. Lake Lena blue tilapia investigations: fishery analyses. Unpublished report, Florida Game and Fresh Water Fish Commission, Boca Raton. 16 pp.

*Wattendorf, R. J. 1982. Lake Lena blue tilapia investigations: fishery analyses. Unpublished report, Florida Game and Fresh Water Fish Commission, Boca Raton. 18 pp.

Wattendorf, R. J. 1986. Rapid identification of triploid grass carp with a coulter counter and channelizer. Progressive Fish Culturist 48:125-132.

*Wattendorf, R. J., D. S. Levine, and P. L. Shafland. 1980. An evaluation of inter-specific interactions between blue tilapia and certain native fishes in Florida: foods, feeding and selectivity analysis. Unpublished report, Florida Game and Fresh Water Fish Commission, Boca Raton. 18 pp.

Wattendorf, R. J., and P. L. Shafland. 1983. Hydrilla consumption by triploid hybrid grass carp in aquaria. Proceedings of the Annual Conference of the Southeastern Association of Fish and Wildlife Agencies 37:449-458.

Weatherby, C. A. 1937. A further note on Salvinia. American Fern Journal 27:98-102.

Weistreich, G. A., and M. D. Lechtman. 1973. Microbiology and human diseases. Glencoe Press, New York. 814pp.

Welcomme, R. L. 1984. International transfers of inland fish species. Pages 22-40 in W. R. Courtenay, Jr. and J. R. Stauffer, Jr., editors. Distribution, biology, and management of exotic fishes. The Johns Hopkins University Press, Baltimore, Md. 430 pp.

Welcomme, R. L. 1986. International measures for the control of introductions of aquatic organisms. Fisheries 11(2):4-9.

Welcomme, R. L. 1988. International introductions of inland aquatic species. United Nations Food and Agricultural Organization, Rome. 318 pp.

*Weldon, L. W. 1960. A summary review of investigations on alligatorweed and its control. Unpublished report, U.S. Department of Agriculture, Agricultural Research Service, Division of Crops. Research Series CR 33-60. Washington DC. 41 pp.

Wellborn, T. L., Jr. 1967. Trichodina (Ciliata: Urceolariidae) of freshwater fishes of the Southeastern United States. Journal of Protozoology 14:399-412.

Wells, J. G., G. McClark, and G. K. Morris. 1973. Evaluation of methods for isolating *Salmonella* and *Arizona* organisms from pet turtles. Applied Microbiology 27:8-10.

Wenner, A. S., and D. H. Hirth. 1984. Status of the feral budgerigar in Florida. Journal of Field Ornithology 55(2): 214-219.

Wenner, E. C., and D. M. Knott. 1992. Occurrance of Pacific white shrimp, *Penaeus vannamei*, in coastal waters of South Carolina. Pages 173-181 in M. R. DeVoe, editor. Proceedings of the conferences and workshop: introductions and transfers of marine species: achieving a balance between economic development and resource protection. Unpublished report, South Carolina Sea Grant Consortium, Charleston.

Westbrooks, R. G. 1990. Interstate sale of aquatic Federal Noxious Weeds as ornamentals in the United States. Aquatics 6:16-24.

Westbrooks, R. G. 1993. Exclusion and eradication of foreign weeds from the United States by USDA APHIS. Pages 225-250 in B. N. McKnight. Biological pollution: the control and impact of invasive exotic species. Indiana Academy of Science, Indianapolis. 261 pp.

Westman, W. E. 1990. Park management of exotic plant species: problems and issues. Conservation Biology 4:251-58.

Whitcomb, W. H., H. A. Denmark, W. F. Buren, and J. F. Carroll. 1972. Habits and present distribution in Florida of the exotic ant *Pseudomyrmex mexicanus* (Hymenoptera: Formicidae). Florida Entomologist 55:31-33.

White, D. 1984. *Mimosa pigra* - Armed and dangerous. Aquatics 6(4):16.

*Wieland, W., W. L. Shelton, and J. S. Ramsey. 1982. Biological synopsis of the Mozambique tilapia (*Tilapia mossambica*). Unpublished report, U.S. Fish and Wildlife Service, Gainesville, Fla. 168 pp.

Wilcut, J. W., R. R. Dute, B. Truelove, and D. E. Davis. 1988. Factors limiting the spread of cogon grass, *Imperata cylindrica*, and torpedograss, *Panicum repens*. Weed Science 36:577-582.

Williams, J. D., and D. P. Jennings. 1991. Computerized data base for exotic fishes: the Western United States. California Fish and Game 77(2):86-93.

Williams, M. C. 1980. Purposefully introduced plants that have become noxious or poisonous weeds. Weed Science 28:300-305.

Williams, R. J., F. B. Griffiths, E. J. Van der Wal, and J. Kelly. 1988. Cargo vessel ballast water as a vector for the transport of non-indigenous marine species. Estuarine, Coastal and Shelf Science 26:409-420.

*Wilson, L. D., and L. Porras. 1983. The ecological impact of man on the south Florida herpetofauna. Museum of Natural History, University of Kansas, Lawrence. Special Publication No. 9. 171pp.

Winsberg, M. D. 1990. Florida weather. University of Central Florida Press, Orlando. 171pp.

Wirth, W. W. 1979. *Siolimyia amazonica* Fittkau, an aquatic midge new to Florida with nuisance potential. Florida Entomologist 62:134-135.

Wolverton, B. C., and R. C. McDonald. 1978. Waterhyacinth (*Eichhornia crassipes*) productivity and harvesting studies. Economic Botany 33:1-10.

*Woodruff, R. E. 1974. A South American leaf beetle pest of crucifers in Florida (Coleoptera:Chrysomelidae). Unpublished report, Florida Department of Agriculture and Conservation Services, Tallahassee. 2 pp.

Yamaguti, S. 1963. Parasitic copepods and branchiura of fishes. Wiley Interscience Publishers, New York. 1104 pp.

Yashouv, A. 1960. Effect of low temperature on *Tilapia nilotica* and *Tilapia galilaea*. Bamidgeh 12:62-66.

Yerger, R.W., and H.A. Beecher.1975. First records of two percid fishes in Florida freshwaters. Biological Sciences 3:141-143.

Yerger, R.W., and R.D. Suttkus. 1962. Records of freshwater fishes in Florida. Tulane Studies in Zoology 9:323-330.

Zajicek, P. 1993. Live tilapia beats imports. Splash: Florida Aquaculture Marketing News 4(1):3.

Zajicek, P., and C. Watson. 1993. The aquatic nuisance species program. Florida Aquaculture Association Newsletter (July 1993):15-16.

Zale, A. V. 1984. Applied aspects of the thermal biology, ecology, and life history of the blue tilapia, *Tilapia aurea* (Pisces: Cichlidae). Ph.D. dissertation, University of Florida, Gainesville. 238pp.

Zale, A. V. 1987. Periodicity of habituation of a stenothermal spring run in north-central Florida by blue tilapia. North American Journal of Fisheries Management 7:575-579.

Zeiger, C. F. 1967. Biological control of alligatorweed with *Agasicles* n. sp. in Florida. Hyacinth Control Journal 6:31-34.

Zimpfer, S. P., C. F. Bryan, and C. H. Pennington. 1987. Factors associated with the dynamics of grass carp larvae in the lower Mississippi River Valley. Pages 102-108 in American Fisheries Society Symposium, Bethesda, Md.