7. Animals

The Etosha National Park is one of the largest and most renowned game parks in the world and the game animals which visit the pans include buffalo, eland, elephants, giraffes, hartebeest, kudu, leopards, lions, oryx, rhinoceroses, wildebeest and zebras. Among the smaller animals are found hunting dogs, foxes and jackals, wildcats, warthhogs and bushpigs, baboons, scaly anteaters, hares, and numerous rodents including porcupines, ground squirrels, spring hares, gerbils, mice and dormice. A variety of snakes and other reptiles occur in and around the pans, and there is a wealth of bird life. Etosha Pan is the only known mass breeding ground of the lesser flamingo (Phoeniconaias minor) and the greater flamingo (Phoenicopterus ruber) in southern Africa, and in some years the flamingo population of the pan may exceed one million birds. Other species observed there include Aquila rapax (tawny eagle), Ardea cinerea (grey heron), Corvus alba (pied crow), Larus cirrocephalus (grey headed gull), Leptoptilus crumeniferus (marabou stork), Pelecanus onocrotalus (white pelican), Platalea alba (spoonbill), Plegadis falcinellus (glossy ibis), Struthio camelus (ostrich), Terathopius ecaudatus (bataleur eagle), Threskiornis aethiopicus (sacred ibis) and Torgos tracheliotus (lappet faced vulture).

8. Human impact and activity

There are three camp sites in the Etosha National Park offering bungalows, cabins and tents for rental. During 1983 a total of 51 780 people visited the park; 13 959 from overseas, 18 583 from SW Africa and 19 292 from the Republic of South Africa. No other people live in the park apart from park staff, and the grazing of domestic animals is prohibited. The Etosha National Park is a protected area and is covered by a Nature Conservation Ordinance (1975). However, the use of anti-malarial agents in the catchment areas in recent years has led to the appearance of chlorinated hydrocarbons in the food chains of the pan. Most river water originates in Owambo and since 1965 indoor sprays have been applied to the roofs and upper walls of tribal huts. Today some 120 000 kg of 5% DDT solution is used annually for this purpose in the catchments, and eggs of the lesser flamingo were found to contain traces of the following compounds: DDT 0.013 ppm, TDE 0.097 ppm, DDE 0.19 ppm, dieldrin 0.03 ppm and BHC 0.03 ppm (Berry 1971).

8.4 THE OKAVANGO DELTA AND THE MAKGADIKGADI PANS

by J.S. MEPHAM

Readers of travellers' tales have long been enchanted by stories of a mighty river which flows into the heart of Africa and then apparently disappears. This is the Okavango River, which is no less fascinating for having been investigated to some extent in recent times. It is derived from two rivers which rise in the highlands of Angola, the Cubango and Cuito which flow in an approximately southerly direction across Angola, before uniting to form the Okavango River which enters northwestern

Botswana. This river then flows in a southeasterly direction for a short distance before forming a typical delta with anastomosing distributaries, in the north of the Kalahari Desert. The heaviest rains fall in Angola in January and February, but the floodwaters which develop do not reach the beginning of the delta, the so called 'Panhandle' before March. The delta has a very gentle slope (1:36 000) and the floodwaters spread slowly and thinly over it, not reaching the eastern limits until August. Evapo-transpiration from the delta is high, and in most years the floods do not proceed beyond the southeastern fringes of the delta. However in years of high flood levels, water overflows the delta and forms two continuation rivers, the Nghabe (or Lake) River which drains into Lake Ngami in the SE, and the Boteti (Botletle) River which drains first into Lake Xau (Dow) in central Botswana, but may finally spill into the Makgadikgadi Pans over 250 km distant from the Delta. Occasionally excess water even reaches the Zambesi River, via the Selinda Spillway to the north, or the Mababe Depression via the Khwai.

8.4.a THE OKAVANGO DELTA

The Okavango Delta (Figs.8.8 and 8.9) comprises a complex system of channels and ridges, swamps and pools. The highest and largest ridge known as Chief's Island lies in the approximate centre of the delta. Areas covered with perennial surface water are considered as 'permanent swamp', and the rest of the delta showing seasonal inundation as 'seasonal swamp'. The permanent swamp extends from approximately half way down the panhandle to cover large areas to the northwest of the delta. It penetrates further down the eastern drainage system of the Nghoka, Moanachira and Santantadibe than the others. It is characterised by deep permanent flowing channels and lagoons with extensive beds of papyrus (Cyperus papyrus) and reeds (Phragmites spp.). Islands occur throughout the delta with increasing frequency to the south. Many of the islands are separated by 'Melapo', which are wide (up to 500 m), shallow, grass- and sedge- covered floodplains. Those 'melapo' which are regularly inundated are referred to as 'primary' and are characterised by the presence of sedges (above 75 cm high). Secondary 'melapo' are inundated only when the flood is higher than average, and are characterised by the presence of grasses over 1 m tall. Large permanent pools are referred to as 'Madiba' (singular = 'Lediba').

Superficially the landscape of the Okavango Delta is always changing. A new growth of vegetation can quickly close a large channel, and new channels may be created by the feeding activities of a hippopotamus herd. In addition the swamp is subject to seismic shocks which are thought to have a marked effect on the topography. There is good evidence that a hundred years ago the Thaoghe System drained into Lake Ngami, but now it runs dry long before reaching there.

The proceedings of a symposium on the Okavango Delta held in Gabarone in 1976, and published by the Botswana Society in the same year, contains several useful chapters on this subject.

1. Geology

The delta is traversed by two fault lines running roughly parallel to each other, from NE to SW, and seismic events are common in the delta, the majority registering between 3.0 and 3.9 on the Richter scale. It is thought that the formation of a graben between these faults accounted for the original build up of the delta. Another, narrower graben running from NW to SE confines the upper panhandle of the delta. A wide belt of granitoid gneisses of the Archaean Basement Complex contains the oldest rocks in the area, forming the bedrock to the NE of the Gomare fault. The central area comprises Karoo sediments of sandstones, shales and coalseams underlying basalts. To the south, quartzites, shales and limestones of the relatively unmetamorphosed late Pre-Cambrian Ghanzi Formation occur, overlying the Kgwebe Formation. The bedrock is overlain with sands which may be up to 300 m deep. These are brown and white, deltaic and aeolian (wind-blown), medium to fine grained sands of Cenozoic age, which are collectively grouped with the Kalahari beds. Associated with these semi-consolidated layers of detritus are hard concretionary lenses of calcrete and silcrete.

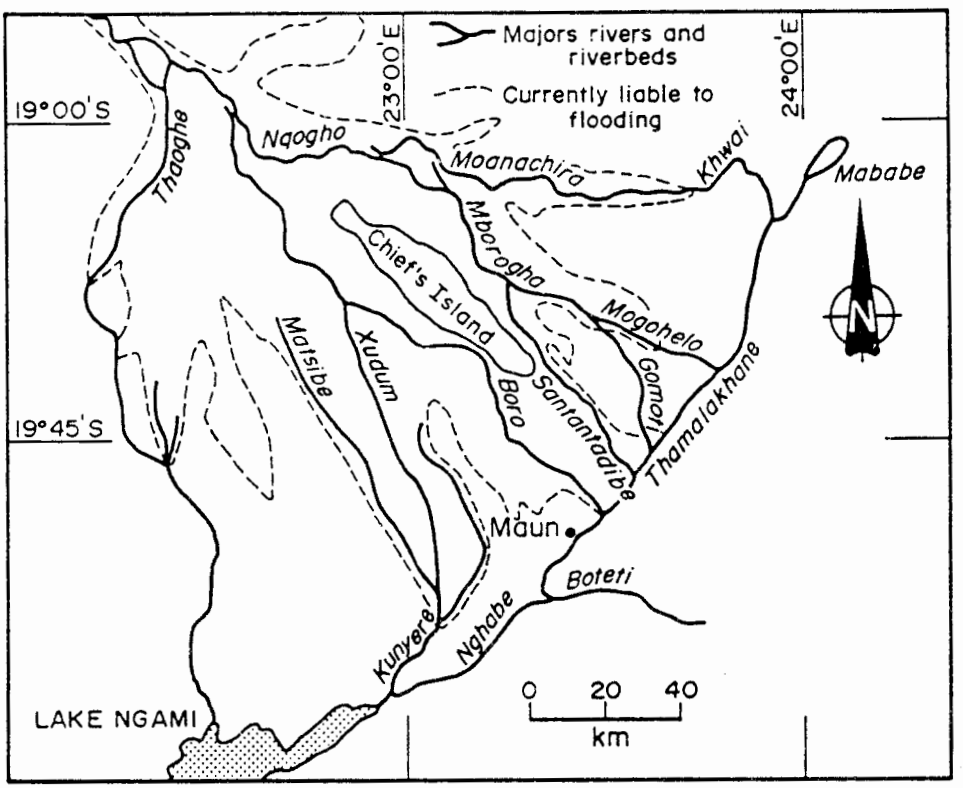


Fig. 8.8 Map of the Okavango Delta showing principal distributaries and the current extent of flooding.

The Boteti River has a conveyance capacity much in excess of its present needs, and it is likely that it once carried the waters of the Okavango River.

Sedimentation: In the swamp water there is very little suspended sediment, but there is a considerable bed load. The Okavango river bed consists of sand with a median grain diameter of 0.2-0.4 mm. Preliminary calculations by Wilson and Dincer (1976) show that sand discharge at Mohembo may exceed 2 x 10^6 t annually, while in the lower swamps it is considerably less than this, with a smaller median grain diameter, below 0.2 mm.

2. Geography

The Okavango Delta is situated in NW Botswana, in the mid-north region of the Kalahari Desert. Although the delta is in a dynamic state the distribution of the principal river remains fairly constant together with three large land masses, Moremiland to the NE, Chief's Island in the centre of the delta and the Sanveld Tongue in the SW. Figure 8.8 shows a map of the principal rivers in the delta, and the areas currently liable to flooding. Figure 8.9 shows a diagrammatic representation of the distributaries and their major blockages.

Location: 18°45'S; 22°45'E, in NW Botswana.

Length:		
	of panhandle	95 km
	of delta (apex to base)	170 km

Area: Estimates of the area of the Okavango Swamp vary from 10 000 to 18 000 km^2. Wilson and Dincer (1976) have made estimates from satellite imagery, and give the following statistics:

Panhandle	1 000 km^2
Central Swamp	1 500 km^2
Thaoghe System	700 km^2
Boro-Kiri-Kunyere System	3 500 km^2
Moanachira-Santantadibe System	3 000 km^2
Magwegqana (Spillway) System	300 km^2
Total	10 000 km^2

Altitude:		
	at Mohembo (beginning of the panhandle)	1000 m asl
	at apex of delta	980 m asl
	at base of delta (Maun)	930 m asl

Water Depth: varies from place to place, and from season to season, but the average depth is generally considered to be of the order of 1 m, ranging from 0.75-1.5 m. Maximum water depths recorded in the river itself have been about 10 m.

Morphology: The Okavango Swamps are considered to consist of those areas within the delta where suface water lies for extended periods, including adjoining riverine grass and woodland margins where evapotranspiration proceeds at, or near, the potential rate. Perennial swamps, where water cover is permanent, occupy approximately 45%, and seasonal swamps, which are flooded for only part of the year, approximately 55% of the total area. Large termite mounds, reaching elevations above maximum high water mark, have characteristic vegetation and are a conspicuous feature of the

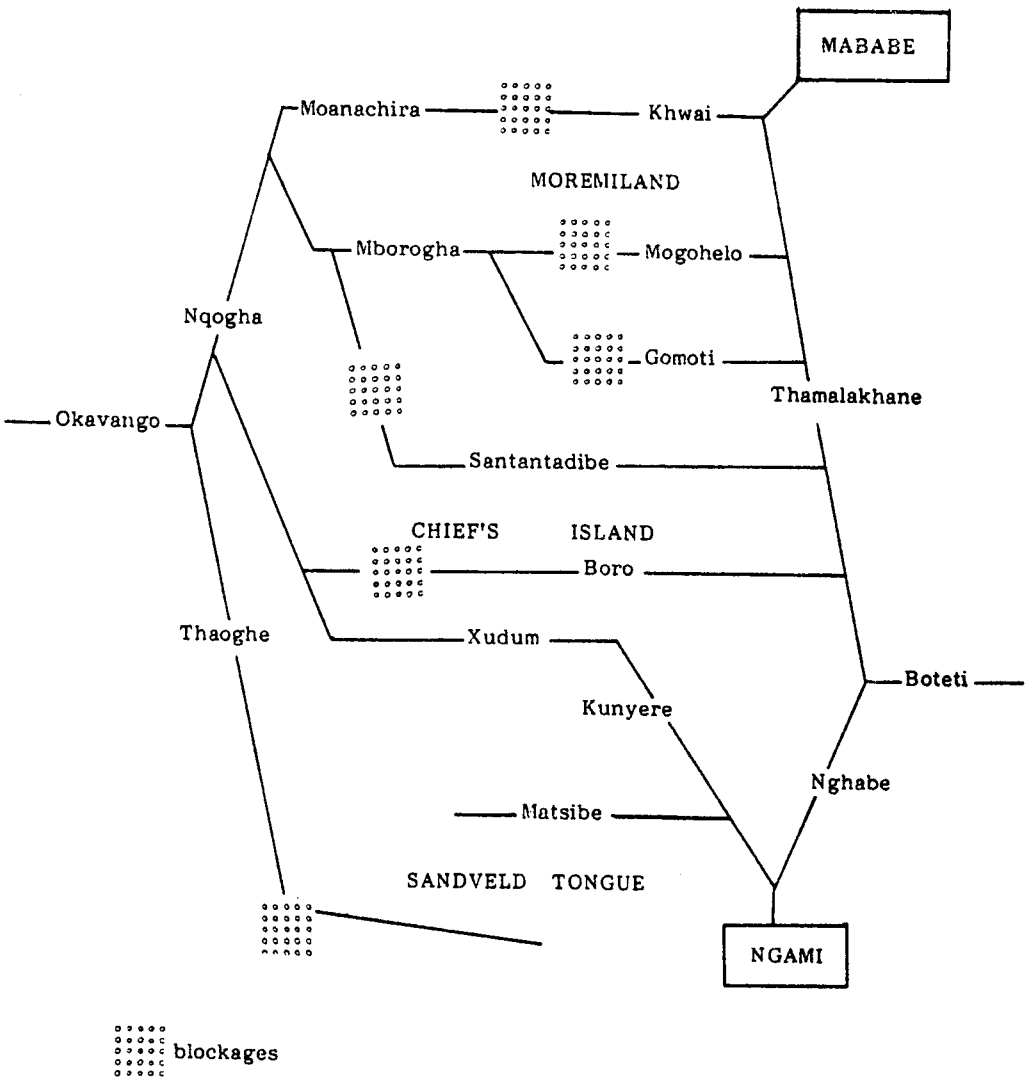


Fig. 8.9 Diagrammatic representation of the principal distributaries of the Okavango Delta

delta. These mounds often occur close together in groups and provide refuges for even quite large animals during the floods.

3. Climate

The summer season is from October to March, during which time it is hot and wet, much of the rain falling during violent thunderstorms. Cooler, dry winters extend from April to September.

Temperature: (°C)	annual, mean	22.2
	highest monthly mean, October	26.9
	lowest monthly mean, June	15.6
	annual, mean maximum	30.4
	October, mean maximum	35.1
	June, mean maximum	24.9
	annual, mean minimum	14.9
	Nov., Dec., mean minimum	19.6
	June, mean minimum	7.0
Insolation: (h day^{-1})	annual, mean	9.2
	month of highest, Sept., mean	10.6
	month of lowest, Dec., mean	8.3
Solar Radiation: (cal cm^{-2} day^{-1})	annual, mean	498.3
	month of highest, Oct., mean	575.1
	month of lowest, June, mean	386.6
Relative Humidity: (%)	annual, mean	51.3
	month of highest, Feb., mean	68.9
	month of lowest, Sept., mean	30.8
Wind Speed: (km hr^{-1})	annual, mean	4.4
	October, mean	6.1
	April, mean	3.5
Precipitation: (mm)	annual, mean	500
	month of highest, January	c.120
	month of lowest, July	c. 0
Potential Evaporation: (mm)		
(Class A Pan)	annual, mean	2825.7
	month of highest, Oct., mean	326.4
	month of lowest, April, mean	182.1
(Open water)	annual, mean	1860.0
	October, mean	214.5
	June, mean	87.0

4. Hydrography and hydrology

Wilson and Dincer (1976) have estimated the catchment area of the Cubango River to be 115 000 km^2 with a mean rainfall of 983 mm

(range 605-1 125 mm) and the catchment area of the Cuito at 6 500 km^2 with a mean rainfall of 876 mm (range 476-1100 mm).

Rainfall on the delta is completely out of phase with the annual flood, except at the upper end. Most rain falls between November and March, but although the flood maximum at Mohembo (to the NW of the delta) usually occurs in March, it does not reach its peak at Maun (SE delta) until about August. The flood wave through the delta, from Mohembo to Maun moves at an average speed of 3.2 cm per second, or 2.74 km per day.

Another consequence of the delta's slow hydraulic response is that intensities of rainfall in both space and time are of little importance for the delta considered as a whole, though the local effects may be quite significant. Rainfall immediately outside the margins of the swamp is insignificant, since it soaks into the Kalahari sands as fast as it falls and produces no run off. A water balance equation has been derived by Wilson and Dincer (1976):

Input	10^9 $m^3.y^{-1}$	Output	10^9 $m^3.y^{-1}$
inflow	11	evapo-transpiration	15.4
precipitation	5	outflow (Boteti)	0.3
		ground water outflow (not exceeding)	0.3
total	16	total	16

The mean active storage of the delta has been estimated at 4 x 10^9 m^3, with a minimum of 1, and a maximum of 7 x 10^9 m^3.

5. Physico-chemical characteristics of the water

What little information is available is contradictory and although there must be considerable variation from place to place, and from time to time, it is clear that there is need for systematic research in this area.

According to Wilson and Dincer (1976) Okavango River water contains 40-50 $mg.l^{-1}$ dissolved solids giving an estimated annual input to the delta of 0.5 x 10^6 t. They believe that surface outflow removes about 30 000 t per annum, and that ground water may remove a further 100 000 t, resulting in the deposition of approximately 0.37 x 10^6 t per annum, which is equivalent to 37 g per m^2. Conductivity of ground water may reach 3000 micro Siemens cm^{-1} locally.

The following figures were given for Kanjane, a cattle watering place in the south of the delta:

	$mg.l^{-1}$
HCO_3	1250
CO_3	40
Cl	1509
SO_4	1618
Na	42
Ca^2	35
Mg^2	0
NO_3	127

6. Macrophytes

The vegetation varies according to the degree of flooding which normally occurs in any one place. Plant communities range from submerged aquatic, through swamp grassland to riparian forest and savanna woodland. A comprehensive account of the vegetation of the area is given by Smith (1976). As is the case with many seasonal swamplands, fire plays an important role in the local ecology.

Perennial Swamps: In the perennial swamps of the upper and middle delta, Cyperus papyrus is dominant over large areas. It is a giant sedge which grows very quickly forming enormous mats of culms, rhizomes and debris, usually spreading out from steep channel banks over deep water. Although essentially floating, the mats are so dense and so deep that they often rest on the substratum and become firmly wedged in the channels in which they grow. They frequently form blockages, even in principal channels, and play a significant role in determining the morphology of the delta, diverting stream flow and producing islands. Papyrus develops best where there is little variation between minimum and maximum water levels, and is therefore a useful indicator of perennial swamplands which become progressively less common towards the lower end of the delta. Although it commonly grows in pure stands, papyrus swamps often contain other species. These include some low growing forms such as Polygonum pulchrum, various small Commelinaceae, and the swamp-fern Cyclosorus interruptus, and the tall species Miscanthidium junceum, Phragmites australis, and Typha latifolia. These latter species may also grow in pure stands and become dominant locally. Phragmites australis grows best in sluggish waters of medium depth and is prominent around 'madiba' edges and at channel sides away from the papyrus areas. Miscanthidium is widely distributed and usually occurs in pure stands in still less deeply inundated sites. It often occurs behind papyrus, where the channel banks slope comparatively gently. In other places populations of this plant form long 'ribbons' on strips of sediment which may be submerged levees. Typha latifolia flourishes around 'madiba', pools, channel corners and backwaters, in the shallowest permanent water, and is most abundant in the middle delta.

Open Water Communities: In the perennial swamps, mats of short sedges such as Pycreus nitidus, Cyperus nudicaulis and Scirpus cubensis, and the grass Leersia friesii, often float free on the surface of permanent ponds. Small mats are usually monospecific, but

large mats often comprise several species. Both these mats and occasional low emergent mounds of peat, are frequently colonised by the insectivorous plants Drosera madagascarensis and Utricularia spp., and by a species of the grass-like genus Xyris. The so called 'swimming-grass' Vossia cuspidata is common among papyrus bases, and along all stream sides. Brasenia schreberi and Nymphaea caerulea are the commonest floating-leaved aquatics, covering large areas, but almost always with small proportions of Caldesia reniformis, Nymphaea lotus, Nymphoides brevipedicellata, Nymphoides indica, Potamogeton schweinfurthii and Trapa natans, while Ceratophyllum demersum, Lagarosiphon ilicifolius and Najas pectinata are the commonest submerged plants. Where areas of shallower water occur in these permanent ponds there may be a sparse cover of emergents, including Phragmites australis, Typha latifolia, Eleocharis spp., Sacciolepis spp., and Eriochrysis pallida.

Seasonal Swamps: In parts of the panhandle, seasonal grass swamps, dominated by species of Acrocerus, Andropogon, Echinochloa, Eulalia, Leersia, Oryza, and Paspalum, abut the rivers directly. Elsewhere in the seasonal swamps, two sedges are overwhelmingly dominant; Cyperus articulatus and Scirpus inclinatus. These two species occupy vast areas and form a dense community, reaching some 2 m in height, which occurs throughout the delta and is known as 'sica'. Common, but seldom dominant associate species, include Cyperus longus, Cyperus denudatus and Panicum repens. The fringe areas, between the seasonal swamps and dry land, which are flooded only shallowly and briefly each year, are covered by grasses. Here Chloris gayana and Setaria anceps are widespread, but in places the vegetation is terraced, with tall species like Cymbopogon excavatus, Imperata cylindrica and Hyparrhenia rufa occurring in bands at different levels. Sandy soils on the floodplains tend to be dominated by Eragrostis inamoena, Eragrostis lappula, Setaria angustifolia and Trachypogon spicatus, and saline areas by Sporobolus spicatus, Sporobolus tenellus and a sedge, Cyperus laevigatus. The driest and least frequently flooded areas of all, are covered by lawns of Cynodon dactylon.

Open Waters: The surfaces of the smaller temporary ponds tend to be totally occluded by the waterlily, Nymphaea caerulea, with a small admixture of Caldesia reniformis, Nymphoides indica and Potamogeton thunbergii. In other areas the water fern Azolla pinnata is locally common, together with the duckweeds Lemna perpusilla and Spirodela polyrhiza. However, in the larger depressions, where wave motion inhibits the growth of floating-leaved forms, clear open water occurs in the centre and waterlilies are confined to the periphery. Submerged aquatics, many free floating, occupy the deeper parts of these central areas. In these situations free floating species include Aldrovanda vesiculosa, and several species of Utricularia (e.g.benjaminiana, foliosa, inflexa, reflexa, and stellaris), while rooted submerged species comprise Ceratopteris thalictroides (a fern), Limnophila ceratophylloides, Limnophila indica, Najas pectinata, Nesaea crassicaulis, Ottelia kunenensis, Ottelia muricata, Ottelia ulvifolia, Rotala myriophylloides, Vallisneria aethiopica and Wiesneria schweinfurthii. The mats of floating vegetation, so characteristic of permanent ponds, are generally replaced by emergent species. Among these, the grasses Panicum repens, Oryza longistaminata, and Leersia hexandra are prominent, together with a

number of sedges belonging to the genera Eleocharis, Fimbristylis, Fuirena and Rhynchospora. However a range of other species also occurs in these situations, but seldom forms the dominant vegetation. These other herbaceous emergents include Adenostemma caffrum, Alternanthera nodiflora, Alternanthera sessilis, Ammannia baccifera, Ammannia prieuriana, Caperonia serrata, Centella asiatica, Commelina diffusa, Commelina fluviatilis, Commelina macrospatha, Commelina zambesica, Crassocephalum picridifolium, Cyclosorus interruptus (a fern), Ethulia conyzoides, Eulophia latilabris, Floscopa glomerata, Hygrophila prunelloides, Kosteletzkya buettnen, Limnophyton angolense, Ludwigia abyssinica, Ludwigia erecta, Ludwigia palustris, Ludwigia stolonifera, Melanthera scandens, Microlepia speluncа, Oldenlandia lancifolia, Pentodon pentander, Polygonum limbatum, Polygonum salicifolium, Pycnostachys coerulea, Senecio strictifolius, Torenia thouarsii, Thelypteris confluens (a fern), Xyris capensis, Xyris rehmannii and Xyris straminea. Creepers in this vegetation include the parasitic forms Cassytha filiformis, Cuscuta capensis and Cuscuta australis, together with Cissampelos mucronata, Ipomoea rubens, Mikania cordata and Vigna luteola.

Riparian Forests: Strips of mixed forest occur along watercourses and around islands throughout most of the delta. Some of these occur in perennial swamps, to which, Ekebergia capensis, Rhus quartiniana, Syzgyium guineense, and the palm Phoenix reclinata are virtually confined. In the middle delta, a shrubby tree, Ficus verruculosa (water fig), forms dense thickets around the edges of many low islands, often spending several months of the year with its trunk bases submerged. Other arborescent species which occur in both perennial and seasonal swamps include Acacia galpinii, Acacia karroo, Acacia nigrescens, Albizia harveyi, Albizia versicolor, Berchemia discolor, Carrisa edulis, Cassine transvaalensis, Combretum hereroense, Croton megalobotrys, Diospyros mespiliformis, Ficus natalensis), Garcinia livingstonei, Hyphaene benguellensis (a palm), Kigelia africana, Lonchocarpus capassa and Sclerocarya caffra.

The understorey of these riparian forests is also floristically rich, often quite dense, and comprises bushes, scandent shrubs and lianes. In the wettest areas, there are a number of bushy species which can tolerate periods of prolonged, if not deep inundation. The most common of these being Ficus capreifolia, Ficus pygmaea, Hibiscus diversifolius (ssp. rivularius), Myrica serrata, Rubus exsuccus and Tacazzea apiculata. In slightly higher drier situations, fringing islands, and the mainland banks of rivers at the edges of the delta, Bauhinia macrantha, Boscia mossambicensis, Capparis tomentosa, Combretum albopunctatum, Commiphora africana, Cordia ovalis, Dichrostachys cinerea, Diospyros lyciodes, Ehretia amoena, Ehretia amoena, Flacourtia indica, Grewia bicolor, Grewia flava, Grewia flavescens, Grewia schinzii, Lantana angolensis, Markhamia acuminata, Maytenus heterophylla, Maytenus senegalensis, Pavetta lasiopeplus, Phyllanthus reticulatus, Plumbago zeylanica, Rhus pyroides, Rhus tenuinervis, Securinega virosa, Tricalysia allenii, Vangueria infausta, Vernonia amygdalina, Ximenia caffra and Ximenia americana also grow as bushes or small trees.

Bole climbers and lianes may be common on the foregoing trees and bushes and contribute to the density of the forest. The most abundant of these are Canthium huillense, Clematis brachiata,

Clematopsis scabiosifolia, Cocculus hirsutus, Combretum mossambicensis, Cynanchum schistoglossum, Gongrothamnus divaricatus, Gymnema sylvestre, Hippocratea africana, Jasminum fluminense, Pergularia daemii, Rhoicissus tridentata and Sarcostemma viminale.

Productivity: Thompson (1976) considers that the nutrient level is low throughout most of the delta and that it probably limits the productivity of emergent plants to 40% of their field potential. He estimates that productivity of submerged macrophytes does not exceed 0.5 $t.ha^{-1}.yr^{-1}$, although it should be greater in pools and channels during the dry season, when the concentration of nutrients will be greater, and also in 'madiba' close to human settlements, where there will be an additional input of nutrients. He also considers that dry grassland here does not produce more than about 2-3 $t.ha^{-1}.yr^{-1}$, but that the floodplain grasslands produce 10-20 $t.ha^{-1}.yr^{-1}$.

7. Invertebrates

No information is available concerning aquatic invertebrates, but some is available regarding terrestrial insects.

In both grasslands and woodlands of the delta, termites play an important role in the breakdown of litter, nutrient cycling and in soil formation. It is widely believed that the mounds of Macrotermes spp. play an important role in the formation of islands in the delta.

In the dry grasslands, ants make up by far the largest proportion of the ground layer community, and in particular a single species, Pheidole sp. accounts for 70-90% of the total active fauna. They are omnivorous, feeding on other insects, carrion and seeds. Other types of insect found there include beetles from the families Tenebrionidae and Carabidae. During the wet season various members of Homoptera, Heteroptera, Acrididae and Tettigonidae become more important.

Ground layer communities in surrounding 'Mopane' woodland is sparser than that of grassland during most of the year. Those feeding on litter include Tenebrionid beetles, and members of Grillidae and Blattidae.

Attempts are now being made to eradicate Glossina morsitans (tsetse fly), the vector of sleeping sickness, from the area, but it seems unlikely that this will ever be completely achieved. Dwellings are sprayed annually with DDT to try to keep down the numbers of Anopheles gambiae and Anopheles funestes, both mosquito vectors of malaria.

8. Fish

The density of fish in the swamp is probably lower than in other tropical, seasonally flooded areas of the world. This may be because of generally low productivity in the swamps, exacerbated no doubt by the presence of insecticides used in eradication campaigns. Estimated productivity for unenriched 'madiba' is 100-200 $kg.ha^{-1}$,

but in small enriched 'madiba', such as those found near to human settlements, it may be as high as 700 kg.ha^{-1}.

Eighty-two species of fish have been recorded, of which 19 may be of some commercial value, although until 1976 there were no commercial fisheries in the area. Herbivorous fish include Tilapia andersoni and Tilapia melanopleura, which contribute up to 50% of the total fish biomass. Species of Mormyrus, Synodontis and Serranochromis feed mainly on invertebrates, while Clarias spp. have a broad feeding range which includes fish, invertebrates and detritus. Predators include Hepsetus sp. (Kafue pike), Hydrocyon vittatus (tiger fish) and various members of the Claridae (catfish). The shallow 'melapo' at times of high flood provide prime breeding areas for cichlids (Tilapia) and clariids.

9. Other vertebrates

Reptiles: In the past crocodiles (Crocodilus niloticus) have been extensively hunted for commercial gain. For example in 1957 over 2000 were shot, most of which were over 3 m long. However, in 1973, when a concession was given to a game industry company to shoot 500 crocodiles, they were unable to fill their quota. Since that time crocodiles have been protected, and it is generally considered that numbers are increasing. Other reptiles found in the swamps include the monitors, Varanus niloticus and Varanus albigularis. Few other lizards are found although some geckos and skinks are present. A wide variety of snakes occur in the swamps and include non-venomous species, e.g. the African python (Python sebae); back-fanged species, e.g. the boomslang (Dispholidus typhus); cobras, e.g. the Egyptian cobra (Naja haje); and vipers e.g. the puff adder (Bitis arietans).

Birds: More than 400 species have been recorded, although this is poorer than some had expected. There are very few sites suitable for waders. Important species found in the area include warblers which are found in the reed and papyrus beds; Leptoptilos crumeniferus (marabou); Ibis ibis (wood ibis); Pelecanus rufescens (pink backed pelican); Plectropterus gambensis (spur winged goose); Dendrocygna viduata (white faced duck); and Haliaeetus vocifer (fish eagle).

Mammals: The permanent swamp does not harbour many kinds of larger mammals, except Hippopotamus amphibius (hippopotamus) and Tragelaphus spekii (sitatunga). However occasional visitors include Loxodonta africana (elephant), Panthera pardus (leopard) and Syncerus caffer (buffalo).

The greatest variety of animals is found in the channels, 'melapo', and on the islands. Among the most notable herbivore species found here are: Connochaetes taurinus (wildebeest), Equus burchelli (zebra), Rhaphicerus campestris (steenbok), Kobus lechwe (lechwe), Loxodonta africana (elephant), and Syncerus caffer (buffalo). The predominant mammals found in the delta are buffalo which may number 20 000 at any one time. There are an estimated 14 000 wildebeests, 12 000 zebras, and 4000 elephants.

As the flood waters recede a number of grazers e.g. Aephyceros

melampus (impala), Damaliscus lunatus (tsessebe), Phacochoerus aethiopicus (warthog) and Redunca arundicum (reedbuck); and browsers e.g. Giraffa camelopardalis (giraffe), Papio ursinus (baboon), Tragelaphus scriptus (bushbuck) and Tragelaphus strepsiceros (kudu) move in. Of these, impala and baboons contribute greatly to the biomass, with baboons estimated to total over 219 000 animals.

Large predators include Acinonyx jubatus (cheetah), Crocuta crocuta (spotted hyaena), Hyaena brunnea (brown hyaena), Lycaeon pictus (wild dog), Panthera leo (lion) and Panthera pardus (leopard). Domestic animals are limited to the edges of the swamp, but it is hoped that the tsetse fly eradication campaign will make available new areas for them within the swamp.

10. Human activity

Ngamiland has a population of 40 000, of which some 13 000 live in the town of Maun, and the rest are distributed mainly along the southern and western fringes of the delta. Some of the islands have a very sparse population, consisting primarily of women and children, the menfolk being employed in larger centres, further away. The population is not large having a density of 0.45 persons per km^2. Infant mortality is high and life expectancy short.

The Okavango Delta is situated in a region known as Ngamiland, and today the people who inhabit it are known as 'baTawana', and have many diverse origins. The first baTawana were named after a baNgwata prince, Tawana, who after a dispute of inheritance, took a group of people and cattle to seek a new land. After many years of wandering and fighting the baTawana finally settled in Ngamiland and created the capital of Toteng. Since then the baTawana have followed expansionist policies dominating all other groups living in the area, and eventually creating a more homogenous society. They have contributed to the cultural life, especially in the fields of political institutions, law, language and pastoralism. Peoples who inhabited the area before the arrival of the baTawana included the 'baSawara', who were related linguistically to the Hottentots and bushmen, and the 'baYei' and 'haMbushushu', who were forced south from the middle Zambezi area by the warring 'Lozis'. More recently, at the turn of the twentieth century, many 'baHerero' fled from the German wars of extermination, and were accepted by the Bechuanaland Protectorate and settled on the west bank of the delta. Other ethnic groups contributing to the present population include 'baKgalagadi', 'baGcereku', 'baRotse', 'baKalaka', 'maTabele', 'baSotho' and 'baSubiya', all of which have contributed to the knowledge of cattle rearing and subsistence agriculture, which today is still the principal form of livelihood.

Economy: The majority of people in this area live by subsistence farming and cattle rearing. The principal arable crops are sorghum, maize and millet. In 1976 it was estimated that there were over 250 000 head of cattle in Ngamiland. However over 50% of these belonged to just 10% of the population.

Income is also derived by the curio industry, manufacturing processed

skins and other wild life products; and from both hunting and photographic safaris.

In 1976 a symposium was held in Gabarone, Botswana, to discuss the present status and future utilisation of the delta. As in most natural swamps productivity is relatively high, and it is tempting for governments to try to harness this productivity for the economic development of their country. Many now realise that alteration of one aspect of an ecosystem may have a disastrous effect on another part. Suggestions which have been made for the future utilisation of the delta include: development of water, fisheries, livestock, wildlife, and tourism. Thompson (1976) cautioned against moving too rapidly to develop any of the assets of the delta.

8.4.b LAKE NGAMI

Lake Ngami is an ephemeral lake of inland drainage, without outlet, and is found to the south of the Okavango Delta. Much of the time it is covered by grass, and provides pasture for many cattle. In dry years (e.g. 1965/66) it may dry out completely, yet in rainy years it may fill to provide an open water area of 200 km^2.

1. Geography

Location: 20°37'S; 22°40'E.

Altitude: 932 m asl

Area and Volume: When David Livingstone first sighted Lake Ngami in 1849 he estimated its diameter to be 170 miles (275 km). Since then the lake has become progressively smaller, and on many occasions has completely dried out. At the present time it varies in area from zero to 200 km^2, when its maximum depth is 3.5 m and its capacity 350 x 10^6 m^3.

Depth: At maximum water levels the mean depth is of the order of 1 m.

2. Hydrology

Lake Ngami is fed by waters of the Nghabe (Lake) River, whose maximium flow in recent years has been about 11 m^3 sec^{-1} at its upper end. It does not always flow and when it does, it does not always reach the lake.

3. Vegetation

The lake floor is covered with grasses, and thorn bush is currently spreading over the river basin.

4. Fish

The principal species which are able to survive the intermittent long periods of drought are Clarias sp., Barbus sp. and Alestes sp.

5. Birds

When it contains water, Lake Ngami is one of the most important habitats for water birds in southern Africa. Eleven species of water fowl, 19 waders and 43 other species have been recorded in the area. Most notable are concentrations of pelicans and flamingoes which are found there periodically. In 1971 counts of 100 000 greater flamingoes (Phoenicopterus ruber), and 10 000 white pelicans (Pelecanus onocrotalus) were made.

6. Economic importance

Lake Ngami is an area where tsetse fly has been largely eradicated, allowing cattle to be kept there. It is generally considered that the fishing potential of the lake is not fully exploited. This is partly because the people of the area tend to consider it unacceptable to eat fish, and partly because large scale fishing concerns lose heavily when the lake becomes dry. Small scale operations have had some success in producing dried fish for sale in Francistown.

8.4.c THE BOTETI RIVER

The Boteti River is the outlet which carries away any excess water from the Okavango Delta at times of extra high floods. It comprises a wide, but confined, vegetated channel, leading intermittently to Lake Xau and the Makgadikgadi Pans. Now water is pumped from it to the Mopipi resevoir for use by the Orapa mine, and consequently the natural flows have changed.

Location: 20°08'S; 23°23'E.

Hydrology: The average annual discharge at Rakops, near its lower end, is about 200×10^6 m^3, with a maximum of about 600×10^6 m^3 and a minimum of zero.

Vegetation: Only riverine type vegetation is present and swamps are absent. The dominant riverbank community is Phragmites australis, and large reed beds are common in the upper reaches. They become more sparse in the lower reaches but increase again to surround Lake Xau. Sica and bulrush communities are also present, but Miscanthidium junceum is absent. A small relict fringe of papyrus lines the river below Samadupe bridge.

8.4.d THE MAKGADIKGADI PANS

The Makgadikgadi Pans (formerly Makarikari) is the name given to a region of shallow, alkaline, sandy depressions located in NE Botswana, which provide the ultimate end point of the Okavango River, where it finally evaporates away. The pans are flooded for varying lengths of time each year, when they are visited by vast numbers of wading birds. The area is renowned for weird optical effects which frequently occur there. During the cool nights mists form, which later develop into haze as the sun

rises. This causes objects to appear magnified, so that a small outcrop of limestone may appear as a range of hills, and an ostrich may be mistaken for an elephant or even a land rover! When the pans are flooded bubbles of oxygen rise from submerged algae and become trapped in the surface scum, giving it a grotesque warty appearance.

1. Geography

The basin contains two important depressions; Ntwetwe (Mokoamoto) Pan in the west, and Shua (Sua, Nata) Pan in the east.

Location: 25°00'-26°15'E; 20°15'-21°10'S.

Dimensions: Ntwetwe Pan, 160 x 96 km; Shua Pan, 112 x 72 km.

Altitude: The floor of the basin is 900 m asl, and rises to 960 m in the west and 1200 m in the east.

Depth: During flooding the pans may fill to 15-25 cm.

Morphology: During the rainy season water is derived from the Nata River, which rises in Zimbabwe to the northeast. Initially Shua Pan fills from this source, and may eventually overflow into Ntwetwe. Much later in the year any water from the Okavango River enters Ntwetwe via the Boteti River. For most of the year the area is completely dry, and is covered by a vast deposit of greyish sand and salt. A portion of the silt brought in by flood waters is removed by the predominantly easterly winds and attendant 'dust devils'. Barchan (crescent-shaped) dunes lying to the west of Ntwetwe form some of the only bare sand dunes in the Kalahari Desert.

2. Geology

Almost the entire area is covered by Kalahari sands, which are of white, grey, black and reddish hues. They are of both aeolian (wind blown) and fluviatile (riverine) origin, and include silicified sands, calcareous limestones and grits, surface limestones, lake limestones, diatomaceous sandy limestones, marls, conglomerates, pan tuffs, gravels, gritty sands and a full lithological range of silcretes and calcretes.

Fresh water pans and springs are found among the occasional limestone outcrops.

3. Climate

The region is arid, and any rains that fall, do so during the summer months between October and March. The mean annual rainfall is 380 mm, but the mean minimum is 80 mm. The average number of rainy days is 40 per year. The winters are cool and dry, and there may be frosts at night.

4. Vegetation

The almost barren pans are situated in typical savanna surroundings. Close to the edges of the pans are extensive areas of salt marsh, which is gradually replaced by grasslands, shrub savanna, and finally tree savanna.

Aquatic plants include Alternanthera nodiflora, Diplachne sp., Lagarosiphon muscoides, Najas sp., Potamogeton sp. and Scirpus maritimus. In moist crevices at the margins of the pans Amaranthus thunbergii, Cyperus aristatus, Cyperus compressus, Glinus bainesii, Pentzia sp., and Polygonum limbatum may be found.

Grasses include Aristida meridionalis, Heteropogon contortus, Odyssea pancineruis and Rhynchelytrum sp.

Shrub Savanna predominantly comprises Colophospermum mopane ('Mopane'), together with Acacia kirkii, Acacia hebeclada, Acacia nigrescens, Grewia flava, Grewia olukondae, Grewia villosa and Ziziphus sp. which form low thickets scattered over the grassy plain.

5. Animals

Fish: Barbel, which have overwintered buried in mud, are reactivated when the water returns at the start of the summer season. A variety of other fish enter with the flood waters, and eventually die when the water evaporates at the end of the season.

Birds: The sludgy water supplies a veritable nutrient soup which attracts thousands of migrant waders. Flamingoes have been observed in flocks so huge that they cover tens of square kilometers. Other bird visitors include ducks, geese, pelicans and ostriches.

Mammals: The pans supply watering places for a wide range of visiting mammals such as springbok, wildebeest, hartebeest, gemsbok (oryx), eland, giraffes, zebras, elephants, lions, leopards, cheetahs, lynxes, hyaenas, Cape hunting dogs, foxes, jackals, baboons, scaly anteaters, gerbils and mice.

6. Human activity

Many Tswana and related Africans, and a few Europeans farm in this area, but it is also favoured by the oldest inhabitants, the bushmen. These people are traditionally nomads of the Kalhari Desert. During the wet season they roam in groups of 5-16 families, seeking the food plants that supply the greater part of their diet. They use over 30 species of edible plants growing in the desert, and occasionally supplement this with the meat of antelopes and other herbivores, tortoises and other reptiles, and the flesh and eggs of all but the raptorial and scavenging birds. Plant gathering is mainly carried out by the women, and hunting by the men. The chief weapon used is a light bow which fires a flimsy, unfletched, poisoned arrow, with a range of only 20 m. Obviously it takes much skill to stalk and quarry prey from this short distance. At the end of the wet season the band breaks up into individual households, which go their own way

until the next summer. Today many bushmen work as labourers on the farms and ranches owned by both Africans and Europeans.

8.5 WETLANDS OF THE ZAMBESI BASIN AND THE LOWLANDS OF MOZAMBIQUE

by R.H & J.S. MEPHAM

Extensive wetlands occur along the upper Zambesi River and its tributaries as they cross the Central African Plateau. The most important of these are the seasonal floodplains of the Barotse and Chobe regions, Fig. 8.10. After leaving the high plateau, and traversing the Victoria Falls, where the upper course of the river is deemed to end, it flows comparatively swiftly and is generally confined to its incised channel throughout its middle course. However, extensive wetlands occur in the Kafue Basin, which drains into this part of the Zambesi via its largest tributary, the Kafue River. There are also two major impoundments on the middle course of the Zambesi, one at Kariba and another at Cabora Bassa. At this latter place the lower course of the river begins, and again, in Mozambique, the river overtops its banks seasonally. In addition, areas of seasonal and permanent swampland occur on some of its lower tributaries, notably the Shire River, which drains Lake Malawi. Elsewhere in Mozambique, seasonal wetlands occur along the lower courses of most rivers as they traverse the coastal plain, and also around numerous coastal lakes and lagoons. The wetlands of the Kafue are probably better known than the others on the Zambesi system, and are therefore described in more detail.

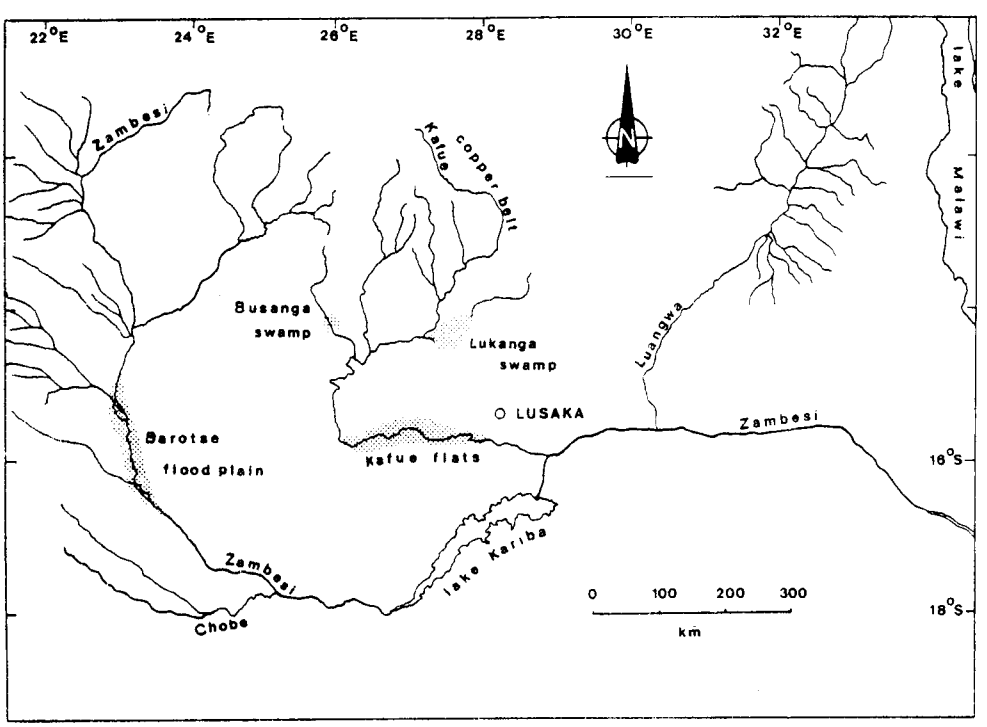
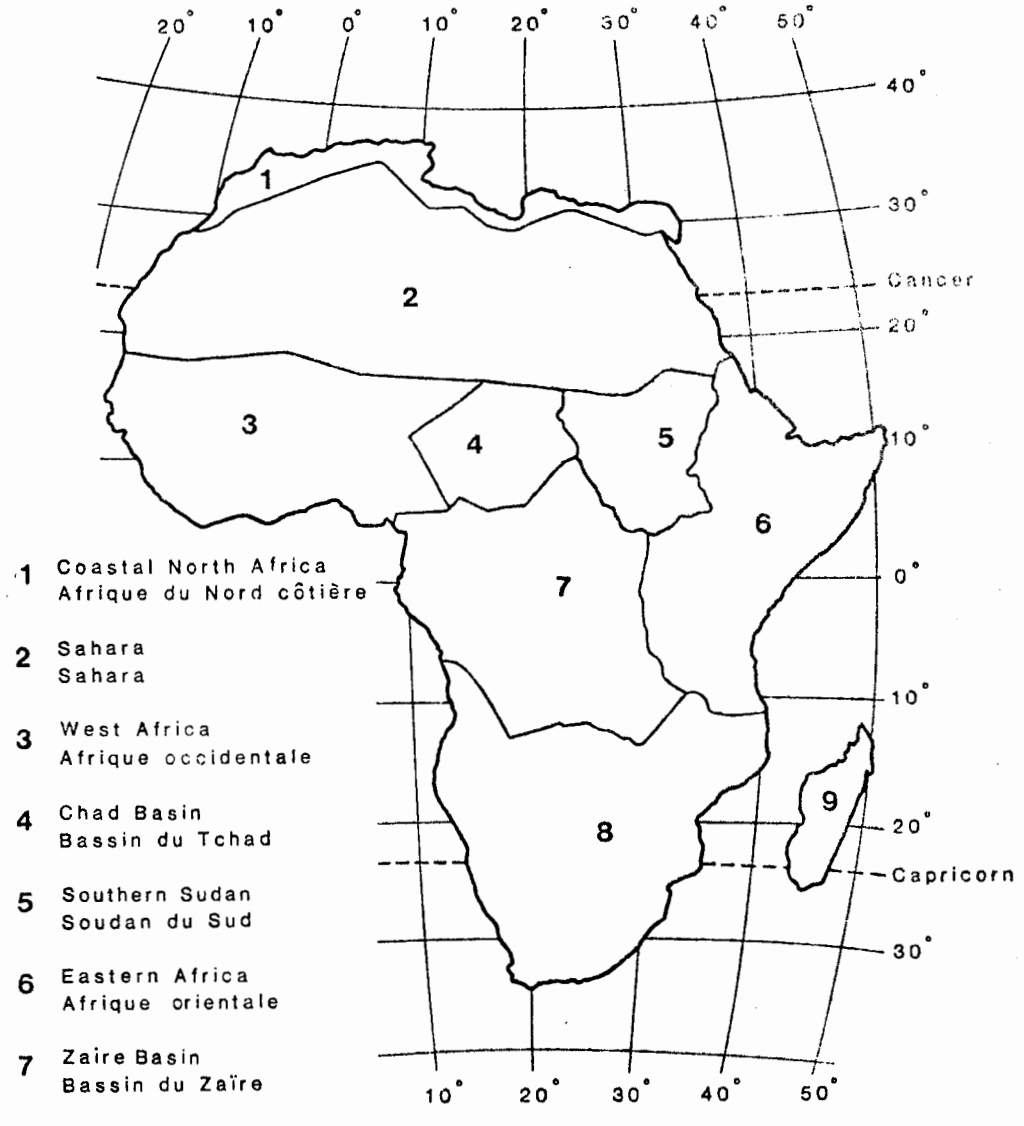


Fig. 8.10 Wetlands of the Upper Zambesi Basin



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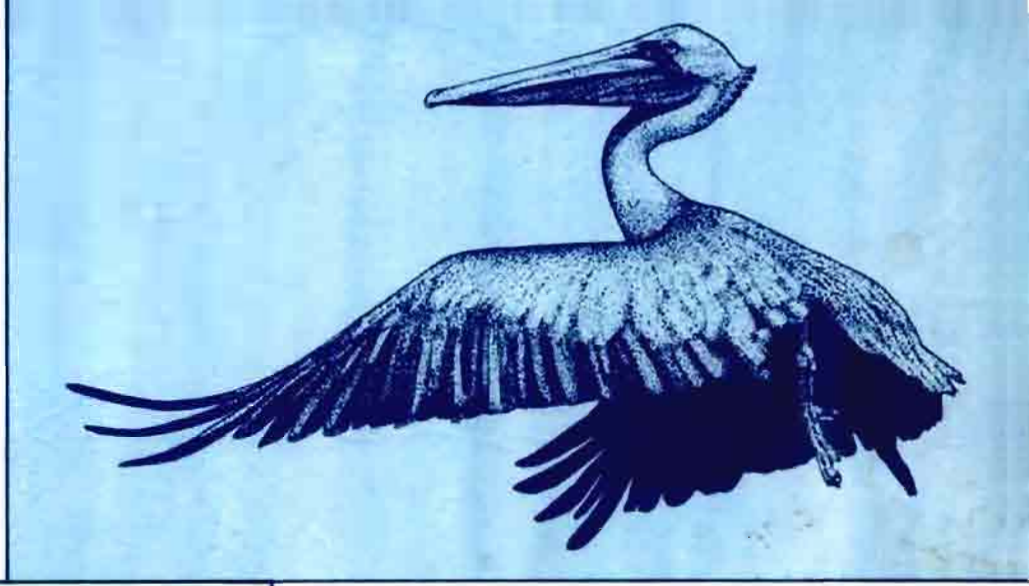

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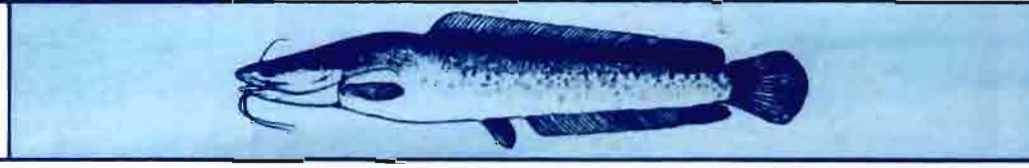

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