# Foodplain vegetation in the Nxaraga Lagoon area, Okavango Delta, Botswana

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The phytosociology and patterns of vegetation distribution of the seasonal floodplains were studied. Cover-abundance data were collected from a total of 200 sample plots and captured in TURBO(VEG), a software package for input and processing and presentation of phytosociological data. Application of the Braun-Blanquet methods of vegetation survey followed by a polythetic divisive classification technique (TWINSPAN) resulted in the delineation of eight vegetation communities of which five were further divided into sub-communities. The eight communities are *Cyperus articulatus—Schoenoplectus corymbosus* community, *Alternanthera sessilis—Ludwigia stolonifera* community, *Vetiveria nigritana—Setaria sphacelata* community, *Miscanthus junceus—Digitaria scalarum* community, *Imperata cylindrica—Setaria sphacelata* community, *Paspalidium obtusifolorum—Panicum repens* community, *Setaria sphacelata—Eragrostis inamoena* community and *Sporobolus spicatus* community. All plant communities are related to specific flooding regime namely time and duration of inundation.

**Keywords:** Braun-Branquet, classification, plant community types, releve, TWINSPAN.

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## Introduction

Vegetation description is the starting point of both small and large scale vegetation research. Vegetation description aims to enable people, other than the observer, to build a mental picture of the area and its vegetation and to allow comparison and classification of different vegetation units (Kershaw 1973). The description of vegetation, with or without concurrent recording of factors of the environment, has played a major part in the development of plant ecology and continues to be important (Greig-Smith 1983). Vegetation description is, therefore, an essential and integral part of vegetation science as it provides a scientific inventory for conservation and monitoring purposes as well as for further research (Coetzee 1993).

Although a considerable proportion of ecological work has been directed towards the description of vegetation of various ecosystems in the world (Kershaw 1973), not much has been done on the phytosociology of the Okavango Delta seasonal floodplain vegetation. Papers by Smith (1976), Biggs (1979), and Ellery (1987), Ellery *et al.* (1990; 1991; 1993) are some of a few publications on the vegetation of the Okavango Delta, but none of these paid special attention to a quantitative classification of seasonal floodplain vegetation. Biggs (1979) described the vegetation types of the Okavango Delta using a visual physiognomic classification based on dominant species. Ellery *et al.* (1991) employed some quantitative objective methods of classification but concentrated on the vegetation of the back-swamps. In this study, the vegetation of the Okavango Delta floodplains was described at a community level, thus a floristic approached was employed.

## Study area

The main study site is by the Nxaraga lagoon (19°35' S 23°10' W) on the Southwest side of Chief's Island in Moremi Wildlife Reserve (Figure 1). The area is seasonally flooded by the Boro River currently the main outflowing river from the delta. The main flooding months are May to October. Rainfall in the area varies between 500 and 550 mm with the main rainfall months being November to February (S.M.E.C. 1986). The mean monthly maximum and minimum temperatures during summer range from 30.5°C. to 33.7°C and 14.8°C to 19.2°C with mean relative humidity at 0800 hours between 60% and 78% (Ellery *et al.* 1991) The cooler, drier winter months (June–August) have a mean monthly maximum of 25.3°C. to 28.7°C and a minimum of 7.0°C to 10.0°C. The relative humidity ranges between 43% and 63% (Ellery *et al.* 1991). Soils consist predominately of sands with an increase in the amount of peat and other organic matter in the lower floodplain. Vegetation types were divided into aquatic communities (e.g. *Cyperus papyrus* zone), primary floodplain communities. (e.g. *Miscanthus* sedgelands) secondary grassland (tall, wet and short, wet and dry grasslands) and island grassland and riverine woodland communities (S.M.E.C. 1986). Primary floodplains are the low lying areas adjacent to the channel which get flooded first, while secondary floodplains are those areas lying above the floodline and receive flood water after the primary floodplains.

## Materials and Methods

The Braun-Blanquet approach to the study of vegetation is the most widely used throughout the world, and it has proven to be a reliable and efficient method for vegetation survey and classification in most countries (Werger 1974). This approach takes a practical, intermediate position that recognises the heterogeneity of species distributions but emphasises, nonetheless, the interaction between plants in the community, which have a certain individuality because of relative discontinuities between communities in the field (Whittaker 1980). In this method an analysis of the vegetation, as a rule, is preceded by a preliminary survey of the area. This reconnaissance survey includes the study of general vegetation patterns and the establishment of the apparent relations of various vegetation types with geology topography and soil conditions (Whittaker 1980).

In a reconnaissance survey of the study area eight different zones were identified. The sampling design was stratified in relation to zones but randomised within the zones. Overall 200 sample plots were placed randomly within the eight zones. A 5 m × 5 m plot size was selected after determining the minimum species are as described in Kershaw (1973), Mueller-Dombois and Ellenberg (1974), Werger (1974), Whittaker (1980), and Kent and Coker (1992). Floristic data were collected when most of the species were in their flowering stage to allow for easy identification. The total species composition and relative abundance of each species were recorded in each sample plot using the Braun-Branquet cover abundance scale, with the

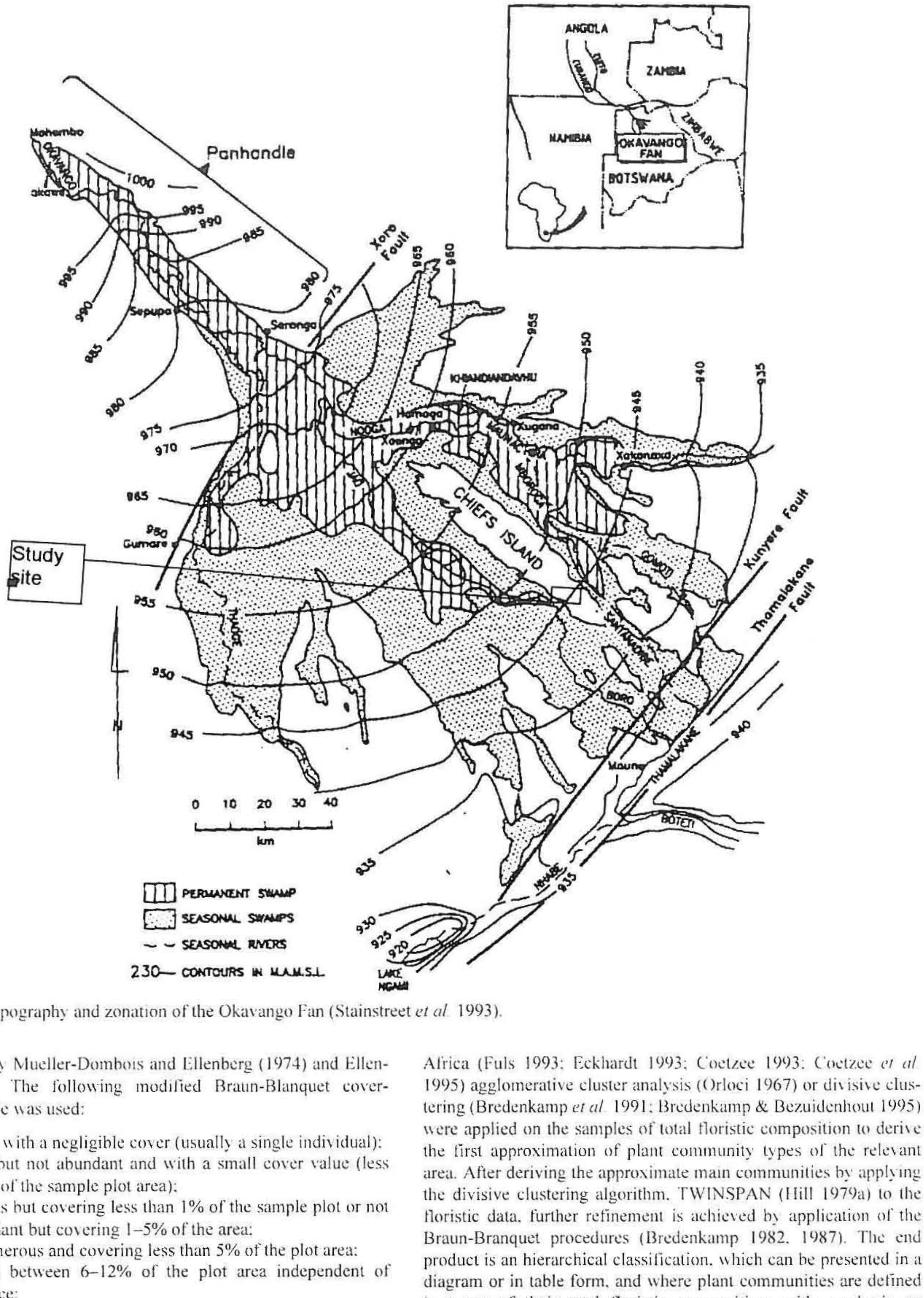


**Figure 1** Topography and zonation of the Okavango Fan (Stainstreet *et al.* 1993).

modification by Mueller-Dombois and Ellenberg (1974) and Ellenbroek (1987). The following modified Braun-Blanquet cover-abundance scale was used:

- r very rare with a negligible cover (usually a single individual);
- \+ present but not abundant and with a small cover value (less than 1% of the sample plot area);
- 1 numerous but covering less than 1% of the sample plot or not so abundant but covering 1–5% of the area;
- 2a very numerous and covering less than 5% of the plot area;
- 2b covering between 6–12% of the plot area independent of abundance;
- 2m covering between 13–25% of the plot area independent of abundance;
- 3 covering 26–50% of the plot independent of abundance;
- 4 covering 51–75% of the plot independent of abundance;
- 5 covering 76–100% of the independent of abundance.

In phytosociological work done in the savanna (Bredenkamp 1982, 1987; Brown *et al.* 1995) and grassland biomes of South Africa (Fuls 1993; Eckhardt 1993; Coetzee 1993; Coetzee *et al.* 1995) agglomerative cluster analysis (Orloci 1967) or divisive clustering (Bredenkamp *et al.* 1991; Bredenkamp & Bezuidenhout 1995) were applied on the samples of total floristic composition to derive the first approximation of plant community types of the relevant area. After deriving the approximate main communities by applying the divisive clustering algorithm, TWINSPAN (Hill 1979a) to the floristic data, further refinement is achieved by application of the Braun-Branquet procedures (Bredenkamp 1982, 1987). The end product is an hierarchical classification, which can be presented in a diagram or in table form, and where plant communities are defined in terms of their total floristic composition, with emphasis on indicator or diagnostic species.

In this study the cover-abundance data were then captured in TURBO(VEG), a software package for input, processing, and presentation of phytosociological data (Hennekens 1996a). The data were then subjected to a two-way indicator species analysis (TWINSPAN), (Hill 1979a) in MEGATAB, a visual editor for phytosociological tables (Hennekens 1996b). After construction of a phytosociological table (Bonyongo 1999), a synoptic table was constructed by calculating the constancy value for each species in each plant community, thus reducing each community to a single column in the table, with the matrix representing percentage constancy. This synoptic table was exported to an Excell spread sheet for reproduction purposes (Table 1).

## Results

The TWINSPAN classification followed by Braun-Blanquet procedures divided the floodplain vegetation into three major types, which include eight communities, of which five were further divided into sub-communities. A total of ninety-nine species were recorded from which fifty-five were used in the phytosociological table and consequently the synoptic table (Table 1) and forty-four were classified as rare species which are not included in Table 1. The eight communities and their sub-communities are the following:

A *Cyperus articulatus*—*Schoenoplectus corymbosus* Vegetation Type
1 *Cyperus articulatus*—*Schoenoplectus corymbosus* community
1.1 Typicum sub-community
1.2 *Cyperus articulatus*—*Alternanthera sessilis* sub-community
2 *Alternanthera sessilis*—*Ludwigia stolonifera* community
2.1 *Alternanthera sessilis*—*Nymphaea nouchali* sub-community
2.2 *Alternanthera sessilis*—*Pentodon pentandrus* sub-community
3 *Miscanthus junceus*—*Digitaria scalarum* community
3.1 *Miscanthus junceus*—*Panicum repens* sub-community
3.2 *Miscanthus junceus*—*Ethulia conyzoides* sub-community
4 *Paspalidium obtusifolium*—*Panicum repens* community

B *Setaria sphacelata*—*Eragrostis inamoena* Vegetation Type
5 *Setaria sphacelata*—*Eragrostis inamoena* community
6 *Veteveria nigritiana*—*Setaria sphacelata* community
6.1 Typicum sub-community
6.2 *Veteveria nigritiana*—*Imperata cylindrica* sub-community
7 *Imperata cylindrica*—*Setaria sphacelata* community

C *Sporobolus spicatus* Vegetation Type
8 *Sporobolus spicatus* community
8.1 Typicum sub-community
8.2 *Sporobolus spicatus*—*Cynodon dactylon* sub-community

### Description of the plant communities

Vegetation of the seasonal floodplains of the Okavango Delta is mainly dominated by herbaceous species with seedlings of some woody species appearing rarely in secondary floodplains. All species groups mentioned in the description of the communities refer to Table 1. The distribution gradient of the plant communities is illustrated in Figure 2.

### A. *Cyperus articulatus*—*Schoenoplectus corymbosus* Vegetation Type

This Vegetation Type is situated close to the permanent water of the river, is frequently inundated by intensive flooding, occurs where the water is deepest and remains flooded for the longest period of time. This Vegetation Type is characterised by species group A, (Table 1), which includes the sedges *Cyperus articulatus* and *Schoenoplectus corymbosus*. Various plant communities were identified:

1 *Cyperus articulatus*—*Schoenoplectus corymbosus* community
This is the typical plant community of this Vegetation Type. This community is extremely poor in species and is entirely dominated by the sedges *Cyperus articulatus* and *Schoenoplectus corymbosus* (species group A). When fully grown, these two species may reach heights ranging from 0.75–1.50 m. The species of

**Table 1** Synoptic table of the floodplain vegetation in the Okavango Delta (% constancy)

| Vegetation Type | | | | | A | | | | | B | | C | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| **Plant community** | 1.1 | 1.2 | 2.1 | 2.2 | 3.1 | 3.2 | 4 | 5 | 6.1 | 6.2 | 7 | 8.1 | 8.2 |
| **Species Group A** | | | | | | | | | | | | | |
| Cyperus articulatus | 100 | 100 | 93 | 50 | 40 | 90 | 85 | 24 | | | | | |
| Schoenoplectus corymbosus | 93 | 89 | 53 | | 20 | 80 | 73 | 16 | 5 | | 16 | | |
| **Species Group B** | | | | | | | | | | | | | |
| Cyperus sp. | 20 | 11 | | 10 | | | | 8 | | | 4 | | |
| Schizodium cornutum | 20 | 11 | | | | | 19 | | | | | | |
| **Species Group C** | | | | | | | | | | | | | |
| Alternanthera sessilis | 7 | 89 | 100 | 100 | 13 | 60 | | | | | | | |
| Ethulia conyzoides | 27 | 78 | 80 | 80 | | 70 | | | | | | | |
| Potamogeton thunbergii | | 56 | 40 | 50 | | | | | | | | | |
| Nymphaea nouchali | 7 | 44 | 67 | 10 | | | 12 | | | | | | |
| **Species Group D** | | | | | | | | | | | | | |
| Vossia cuspidata | 20 | | 60 | 70 | 20 | 40 | | | | | | | |
| Digitaria debilis | | | 53 | 50 | 47 | 80 | 8 | 16 | 19 | 100 | 4 | | |
| **Species Group E** | | | | | | | | | | | | | |
| Ludwigia stolonifera | | | 73 | 100 | | 10 | | | | | | | |
| Polygonum meisnerianum | | | 27 | 70 | 7 | 20 | | | | | | | |
| Leersia hexandra | 7 | | 60 | 70 | 13 | | 23 | | 5 | | 8 | | |
| Oryza longistaminata | 7 | | 33 | 70 | | | 19 | | | | | | |
| Ludwigia leptocarpa | | | 53 | 40 | | | 0 | | | | | | |
| **Species Group F** | | | | | | | | | | | | | |
| Eleocharis dulcis | | | 40 | | | | | | | | | | |
| Persicaria limbata | 7 | | 33 | 10 | 13 | | 8 | 8 | 5 | | | | |
| **Species Group G** | | | | | | | | | | | | | |
| Pentodon pentandrus | | | 13 | 90 | | 50 | | | | | | | |
| Pycnostachys coerulea | | | 20 | 80 | | 10 | | | | | | | |
| Brachiaria arrecta | | | 20 | 50 | | | 4 | 4 | | | 16 | | |
| Brachiaria humidicola | | | | 20 | 13 | 20 | | | | | | | |
| **Species Group H** | | | | | | | | | | | | | |
| Miscanthus junceus | | | | 10 | 100 | 100 | | 8 | | | 8 | | |
| Digitaria scalarum | | | | | 80 | 60 | | | | | | | |
| Nidorella resedifolia | | | 7 | 10 | 47 | 50 | | | | | | | |
| Cycnium tubulosum | | | | | 7 | 10 | | 12 | 19 | | | | |
| Brachiaria dura | | | | | 13 | 10 | | 4 | | | | | |
| **Species Group I** | | | | | | | | | | | | | |
| Cyperus dives | | | 7 | 20 | 40 | | 19 | 8 | | | 16 | | 17 |
| **Species Group J** | | | | | | | | | | | | | |
| Paspalidium obtusifolium | 20 | | 73 | 40 | 40 | 50 | 100 | 16 | | | | | |
| **Species Group K** | | | | | | | | | | | | | |
| Panicum repens | 27 | | 7 | | 67 | 10 | 88 | 72 | 19 | | 32 | 5 | |
| Acroceras macrum | | | | 20 | 87 | 50 | 65 | 32 | 10 | 25 | | | |
| Eragrostis lappula | | | | | 47 | | 23 | 48 | | | | | |
| **Species Group L** | | | | | | | | | | | | | |
| Setaria sphacelata | | | 7 | | 7 | | | 96 | 90 | 50 | 80 | | |
| Eragrostis cilianensis | | | | | | | 8 | 36 | 19 | 25 | 24 | 5 | 17 |
| Eragrostis inamoena | | | | | 33 | | 19 | 100 | 19 | | 32 | | |
| **Species Group M** | | | | | | | | | | | | | |
| Urochloa trichopus | | | | | | | 8 | 36 | 33 | 100 | | 5 | |
| Chloris virgata | | | | | 13 | | 19 | 36 | 24 | 25 | | | |
| Sida cordifolia | | | | | | | 12 | 20 | 19 | | | | |
| Corchorus olitorius | 7 | | | | 7 | | 4 | 36 | 19 | | | | |
| Pechuel-loeschea leubnitziae | | | | | 13 | | | 24 | 19 | | | | |
| Hibiscus sp. | 13 | | | | | | 27 | 20 | 29 | | | | 17 |
| **Species Group N** | | | | | | | | | | | | | |
| Digitaria eylesii | | | | | | | | 16 | | | 4 | | |
| Aristida stipoides | | | | | | | | 16 | | | | | 17 |
| Acacia tortilis | | | | | | | | 20 | | | | | 17 |
| **Species Group O** | | | | | | | | | | | | | |
| Vetiveria nigritana | | | | | | | | 4 | 100 | 100 | 8 | | |
| Setaria verticillata | | | | | 7 | | | 8 | 33 | 25 | | 5 | |
| **Species Group P** | | | | | | | | | | | | | |
| Imperata cylindrica | 7 | | | | | | | | 10 | 100 | 100 | | |
| **Species Group Q** | | | | | | | | | | | | | |
| Vernonia glabra | 33 | 78 | 13 | 20 | 80 | 50 | 27 | 24 | 48 | | 32 | | |
| Kohautia sp. | | 11 | | | 13 | 10 | 4 | | 14 | | 16 | 11 | |
| Gomphocarpus sp. | 13 | 22 | | 10 | 33 | | | 4 | 5 | | 4 | | |
| **Species Group R** | | | | | | | | | | | | | |
| Sporobolus spicatus | | | | | | | | | | | | 100 | 100 |
| **Species Group S** | | | | | | | | | | | | | |
| Cynodon dactylon | | | | | | | | | 5 | 25 | 24 | 5 | 83 |
| Gisekia sp. | | | | | | | | 16 | 10 | | | | 67 |
| Amaranthus thunbergii | | | | | | | 12 | 16 | 10 | | | 11 | 83 |
| Hermbstaedtia odorata | | | | | | | | 4 | 10 | | | 5 | 50 |
| Sporobolus acinifolius | | | | | | | | | | | | | 50 |

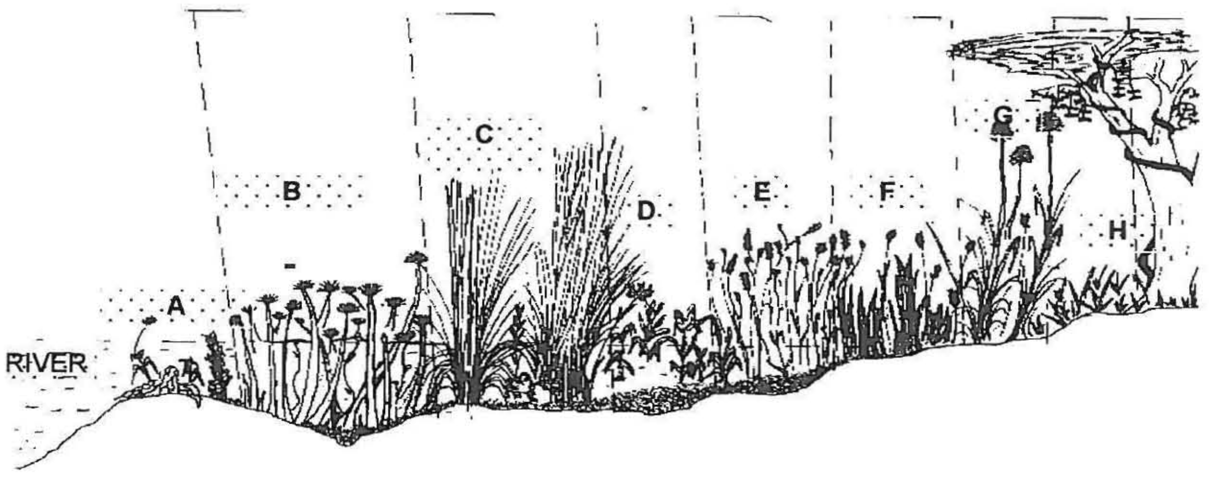


**Figure 2** Schematic cross-section showing the location of vegetation communities in relation to each other and the channel. A = *Alternanthera sessilis—Ludwigia stolonofera* community; B = *Cyperus articulatus—Schoenoplectus corymbosus* community; C = *Miscanthus junceus—Digitaria scalarum* community; D = *Paspalidium obtusifolium—Panicum repens* community; E = *Setaria sphacelata—Eragrostis inamoena* community; F = *Imperata cylindrica—Setaria sphacelata* community; G = *Veteveria nigritiana—Setaria sphacelata* community; H = *Sporobolus spicatus* community.

species group B are diagnostic, though they occur with very low constancy (Table 1). The forb *Vernonia glabra*, (species group Q), is, however, often conspicuously present. The average number of species per sample plot is only 5 (Bonyongo 1999).

This community covers large areas of the floodplain where extensive seasonal flooding occurs during 6–8 months per year, depending on the intensity of the flooding and the annual rainfall in the catchment of the Angolan highlands and the Delta. This community is mainly located in the depressions of the floodplains (Figure 2) where the flooding depth ranges from 0.50–1.0 m when floods are high during July–September and ranges between 0.20–0.45 m during the rainy season in summer.

Grazing pressure is low in the centre of the zone where the water is deep, thus allowing the sedges to escape grazing. However, this community is heavily grazed at its edges where the water is shallower and ungulates have easy access. When the water recedes at the end of the flooding season, the vegetation is heavily utilised and trampled by ungulates, thus resulting in a thick layer of organic sedge peat.

1.1 The Typicum sub-community

This sub-community is entirely dominated by the sedges *Cyperus articulatus* and *Schoenoplectus corymbosus* (species group A), and represents the typical sub-community of the *Cyperus articulatus—Schoenoplectus corymbosus* community. Characteristically the species of species group C are absent or poorly (low cover and low constancy) represented. Other species that may be found in this sub-community include *Paspalidium obtusifolium* (species group J) and *Vernonia glabra* (species group Q). This sub-community is located towards the edges of the main community in shallower water, away from the main channel and is, therefore, also the most severely grazed of the two sub-communities. In most cases it borders on the *Paspalidium obtusiflolium —Panicum repens* community.

1.2 *Cyperus articulatus—Alternanthera sessilis* sub-community

This sub-community is also dominated by *Cyperus articulatus* (Species group A) though the presence of the forbs *Alternanthera sessilis, Ethulia conyzoides Potomagetum thumbergii* and *Nymphaea nouchali* (species group C), are diagnostic. This vegetation is located in deeper water in the centre of the depressions where inundation periods are longest, causing a habitat for the aquatics *Potamogeton thunbergii* and *Nymphaea nouchalli.* Due to deep water this area is not grazed, as it is inaccessible for most ungulates.

2. *Alternanthera sessilis—Ludwigia stolonifera* community

This community is characterised by species group E which includes the hygrophylic forbs *Ludwigia stolonifera, Ludwigia leptocarpa*, and *Polygonum meismerianum* and also the hygrophylic grasses *Leersia hexandra* and *Oryza longistaminata*. Other species that may be considered as differential are those of species group C, namely *Alternanthera sessilis, Ethulia conyzoides, Potamogeton thunburgii* and *Nymphaea nouchalli. Vossia cuspidata*, and *Digitaria debilis* (species group D) and *Paspalidium obtusifolium* (species group J) are also prominently present. The average number of species per sample plot is 11 (Bonyongo 1999).

The community is always situated adjacent to the channel (Figure 2) where depth of water may be deeper than 1 m when the river is in flood (June–July) and up to 0.50 m during the rainy season (during the summer months). This is the wettest part of the primary floodplain. Duration of inundation ranges between 6 to 8 months, including the rainy season. However, by the end of the dry season when the vegetation is not inundated, it may be so heavily utilised by grazers that most of the soil surface becomes bare. This community is divided into two sub-communities.

2.1 *Alternanthera sessilis—Nymphaea nouchali* sub-community

This sub-community occurs in the deepest water and is characterised by the presence of species from species group F. The water lily *Nymphaea nouchali* (species group C) is characteristically present with high cover abundance values (Bonyongo 1999). Dominant species are *Alternanthera sessilis* (species group C) and *Ludwigia stolonifera* (species group E). Other common species include *Ethulia conyzoides* and *Potamogeton thunburgii* (species group C), *Vossia cuspidata* (species group D), *Leersia hexandra* (species group E), and *Cyperus articulatus* (species group A).

2.2 *Alternanthera sessilis—Pentodon pentandrus* sub-community

This sub-community is located in somewhat shallower water towards the edge of the *Alternanthera sessiles—Ludwigia stolonifera* community. In most cases it borders on the somewhat elevated *Cyperus articulatus-Schoenoplectus corymbosus* community. The species of group G are diagnostic and include *Pentodon pentandrus, Pycnostychys coerolea, Brachiaria humidicola* and *Brachiaria arrecta. Alternanthera sessilis* (species group C), *Ludwigia stolonifera* (species group E) and *Pentodon pentandrus* (species group G) are dominant in this sub-community (Bonyongo 1999). Other common species include the hygrophylic grasses *Oryza longistaminata*, and *Leersia hexandra* (species group E).

3. *Miscanthus junceus—Digitaria scalarum* community

*Miscanthus junceus*, which is a tall-growing (3 m) aquatic perennial grass. *Digitaria scalarum* as well as *Nidorella residifolia*, *Cycnium tubulosom* and *Brachiaria dura* (species group H) are the diagnostic species in this community. Common species are *Digitaria debilis* (species group D), *Cyperus articulatus* (species group A), *Paspalidium obtusifolium* (species group J), *Panicum repens*, *Acroceres macrum*, *Eragrostis lappula* (species group K), and *Vernonia glabra* (species group Q). An average of 10 species were recorded per sample plot (Bonyongo 1999).

This community is located within the primary floodplain, often occurring as a narrow belt between the seasonally flooded *Paspalidium obtusifolium—Panicum repens* community, the *Cyperus articulatus—Schoenoplectus corymbosus* community and the *Alternanthera sessilis—Ludwigia stolonifera* community (Figure 2). *Miscanthus junceus* is not utilised by herbivores except that elephants dig up the roots during the dry season when forage is scarce. In this community *Acroceras macrum* and *Panicum repens* (species group K) grow in the spaces between the *Miscanthus junceus* compact tussocks. These two grasses are heavily utilised by lechwe and other herbivores during the rainy season and even during flooding. *Digitaria scalarum* grows within the *Miscanthus junceus* thickets thus earning valued protection from herbivores.

3.1 *Miscanthus junceus—Panicum repens* sub-community

*Miscanthus junceus* (species group H), is the dominant species, and the tall growing *Cyperus dives* (species group I) is diagnostic, while *Eragrostis lappula* and *Panicum repens* (species group K) and *Eragrostis inamoena* (species group L) may be considered as differential species for this sub-community. *Acroceras macrum*, (species group K) *Digitaria debilis* (species group D), *Digitaria scalarum* (species group H) and *Vernonia glabra* (species group Q) are the dominant species of this sub-community (Bonyongo 1999).

This sub-community is located on the edges of the *Miscanthus junceus—Digtaria scalarum* community that occurs in the shallow waters of secondary floodplains.

3.2 *Miscanthus junceus—Ethulia conyzoides* sub-community

This sub-community is characterised by the absence of *Cyperus dives* (species group I) while the absence of *Eragrostis lappula*, *Panicum repens* (species group K) and *Eragrostis inamoena* (species group L) may be considered as of diagnostic value. Other species that differentiate this sub-community from the *Miscanthus junceus—Panicum repens* sub-community are *Ethulia conyzoides* and *Alternanthera sessilis* (species group C). Common species include *Cyperus articulatus*, *Schoenoplectus corymbosus* (species group A), *Vossia cuspidata* (species group D), *Digitaria scalarum* (species group H), *Acroceras macrum* (species group K), *Vernonia glabra* (species group Q) and *Paspalidium obtusifolium* (species group J). This sub-community is located adjacent to the *Alernanthera sessilis—Ludwigia stolonifera* community, in shallower water on somewhat elevated terraces that are not inundated for long periods.

4. *Paspalidium obtusifolium—Panicum repens* community

Characteristic for this community are the high cover values of *Paspalidium obtusifilium* (species group J). *Panicum repens* is very prominent towards the edges of this community while *Paspalidium obtusifilium* dominates in the centre of the community. Other common species include *Cyperus articulatus*, *Schoenoplectus corymobosus* (species group A) *Panicum repens* and *Acroceras macrum* (species group K). The average number of species per sample plot is 8 (Bonyongo 1999).

This community is found in depressions in the secondary floodplains which are far from the main channel and which often do not receive river fed floods but frequently get inundated during the rainy season. In dry years flooding may be restricted to the lower part of the zone or may not occur at all. When floods do occur the flooding depth ranges from 0.20–0.50 m in the centre of the depressions. This community is the driest variation of the *Cyperus articulatus—Schoenoplectus corymbosus* Vegetation Type. It occupies the shallower depressions bordering the *Cyperus articulatus—Schoenoplectus corymbosus* community and the *Setaria sphacelata—Eragrostis inamoena* community (Figure 2). In some cases it borders the *Miscanthus junceus—Digitaria scalarum* community. There is a large transitional zone between this community and the seasonally wet *Cyperus articulatus—Schoenoplectus corymbosus* community. *Panicum repens* remains green during the dry season, thus attracting heavy utilisation from resident lechwe herds and other herbivores. This extensive grazing leaves much of the soil uncovered by the end of the dry season. When the rains or floods come, *Paspalidium obtusifolium* and *Panicum repens* start growing vigorously, thus attracting lechwe and other herbivores. Grazing occurs throughout the year. During flooding and early dry season, grazing is restricted to lechwe, but as the soils dry up and become harder, large animals such as buffalo, zebra, tsesebe, impala and wildebeest utilise the area.

**B *Setaria sphacelata—Eragrostis inamoena* Vegetation Type**

This Vegetation Type is characterised by species group L (Table 1). The area occupied by this community can be described as a temporarily flooded area with shallow water, situated just above the flood line. In period of low floods this area does not get inundated, and it seems that it does not depend much on flooding for maximum productivity. During larger river fed floods, this area floods only after most of the depressions are flooded and filled with water. The area is inundated during the rainy season but due of its elevation, rain water quickly drains off into the adjacent *Paspalidium obtusifolium—Panicum repens* community in the depressions, leaving only a thin layer of water ranging from 0.10–0.25 m. The area is utilised by lechwe during the growing season. Utilisation seems to be moderate but may become heavy during the dry season, with the occasional visits by bulk grazers like buffalo, zebra and wildebeest and probably hippopotamus.

5. *Setaria sphacelata—Eragrostis inamoena* community

This community is also situated within the secondary floodplains usually bording the *Paspalidium obtusifolium—Panicum repens* community and *Vetiveria nigritana—Setaria sphacelata* community (Figure 2). The high cover-abundance of *Setaria sphacelata* and *Eragrotis inamoena* (species group L) as well as the presence of *Digitaria eylesii*, *Aristida stipoides* and small individuals, mostly seedlings, of the tree *Acacia tortilis* (species group N), are diagnostic for this community. Other species present in this community include *Panicum repens*, *Acroceras macrum Eragrostis lappula*, (species group K). The average number of species per sample plot is 9 (Bonyongo 1999).

6. *Vetiveria nigritana—Seteria sphacelata* community

The diagnostic species of this community are the tall (2 m) and dominant grass *Vetiveria nigritana* and *Setaria verticillata* (species group O). Other common species include the annual grass *Setaria sphacelata* (species group L) and the forb *Vernonia glabra* (species group Q). Species such as *Urochloa trichopus*, *Chloris virgata* (species group M) may occur scattered throughout the range of this community. The average number of species per sample plot is 7 (Bonyongo 1999).

This community forms a belt around the floodplain, just above the floodline, linking the floodplains with the woodlands. It boarders the *Imperata cylindrica—Setaria sphacelata* community and *Eragrostis inamoena—Setaria sphacelata* community (Figure 2). Evidence of little utilisation of the dominating grass *Vetiveria nigritana* is sometimes noticeable when it starts developing new tillers at the beginning of the growing season. This community gets temporarily flooded during the rainy season but it may get flooded for a longer spell during years of extremely high floods.

This community is subdivided into two sub-communities:

6.1 Typicum sub-community

Dominated by *Vetiveria nigritana* (species group O) this vegetation represents the typical community. It is located towards the transition zone between the main community and *Eragrostis innamoena—Setaria sphacelata* community (Figure 2).

6.2 *Vetiveria nigritana—Imperata cylindrica* sub-community

*Imperata cylindrica* (species group P) is differential for this sub-community. It occurs towards the transition zone between the typical sub-community and the *Imperata cylidrica—Setaria sphacelata* community.

7. *Imperata cylindrica—Setaria sphacelata* community

The dominant and diagnostic species in this community is the perennial grass *Imperata cylindrica* (species group P). *Setaria sphacelata* and *Eragrostis inamoena* (species group L) are other common species found in this species-poor community. The average number of species per sample plot is only 5 (Bonyongo 1999). This community occupies the upper parts of the floodplains above the floodline and is not flooded annually (Figure 2). It may, however, be temporarily flooded during the rainy season after heavy showers. No evidence of utilisation by large herbivores was noticed in this community but termite activity is high during the dry season. However, heavy utilisation was noticed after a fire.

### B. *Sporobolus spicatus* Vegetation Type

This Vegetation Type occupies the highest parts of the floodplain above the floodline (Figure 2) and is, therefore, considered to be the driest of the floodplain communities. The diagnostic species is *Sporobolus spicatus* (species group R).

8. *Sporobolus spicatus* community

The only diagnostic species in this community is *Sporobolus spicatus* (species group R), which forms extended mono-dominant stands. The average number of species per sample plot is only 3 (Bonyongo 1999). In most cases it borders the *Eragrostis inamoena—Setaria sphacelata* community and the *Imperata cylindrica—Setaria sphacelata* community (Figure 2). With such a high elevation, flooding is rare in this community. Evidence of grazing has been observed in the dry season. Utilisation of this species is mostly quite low, however, evidence of heavy utilisation was noticed during extremely dry years.

This community is sub-divided into two sub-communities:

8.1 Typicum sub-community

The only diagnostic in this sub-community is *Sporobolus spicatus*, thus representing the typical community. This sub-community is found on high ground close to the channel.

8.2 *Sporobolus spicatus—Cynodon dactylon* sub-community

In this sub-community, the diagnostic species are *Cynodon dactylon*, *Amaranthus thunbergii*, *Sporobolus acinifolius*, *Hermbstaedtia odorata* and *Gisekia species* (species group S). *Sporobolus spicatus* (species group R) is still the dominant species (Bonyongo 1999). This sub-community occurs close to the woodlands, away from the flooded areas and is frequently visited by lechwe which graze weedy species such as *Amaranthus thunbergii*.

## Discussion

Although the survey was done when most of the plant species were at their flowering stage, some of the species were difficult to identify because of differences in flowering time. For example, *Sorghum* species which were not recorded, later showed up to be strongly associated with the *Eragrostis innamoena—Setaria sephacelata* community and the *Veteveria nigritiana—Imperata cylindrica* community. There might be more such species. However, this problem was also experienced by other researchers employing the floristic approach (Perkins 1997).

As stated before, the most important factor determining the species composition of the vegetation of the seasonal floodplains is the timing and duration of the seasonal flooding (Ellenbroek 1987). Because of its dependence on an annually changing amount of rainfall in the catchment area in Angola, the flooding regime is also the driving force of the dynamics of the vegetation. This phenomenon sometimes interferes with classification and blurs the possibility for recognition of plant communities (Ellenbroek 1987) as the communities may shift due to changes in habitats.

It must be emphasised, however, that plant communities in the Okavango Delta have existed for centuries, though they shift around in space and time to the areas suitable for them, depending on the prevailing environmental conditions. Channel blockage aggravating channel abandonment is still reported to be a common phenomenon in various parts of the Okavango Delta (McCarthy 1993; McCarthy *et al.* 1991, 1992). The blockages, therefore, result in changes in water flow. As a result some floodplains fail to receive water or receive very little water, while others are deeply inundated. Consequently, vegetation of the seasonal floodplains changes once regular flooding ceases. Seasonal flooding seems to be the major determinant as well as the major driving force of the seasonal floodplain vegetation. It is, therefore, possible that the species composition at a certain site at the time of survey was different from what it used to be in the past and might be different in future, depending on the flooding regimes. This further proves as well as emphasises the importance of a sound long-term vegetation monitoring programme to allow and facilitate comparison. Fossil evidence has shown that the present vegetation in Europe, for example, has no long history in the quartenary, but just temporary aggravation resulting from particular environmental and historical factors (Miles 1979). Such might be the case with the vegetation of the Okavango Delta floodplains.

In view of the fact that vegetation is dynamic, with pronounced spatial and temporal variation (Miles 1979), it is essential that classification studies of this nature be extended to a number of sites within the Delta to get a more comprehensive picture. However, visits to different parts of the Delta revealed that a similar scenario exists in various parts of the Delta. Therefore, one can argue that these results are representative, bearing in mind that flooding and factors such as utilisation of floodplain resources by wildlife as well as anthropogenic activities which influence vegetation in different ways, vary in space and time.

## Conclusion

The application of the Braun-Blauquet approach in phytosociological research in various ecosystems in South Africa (Bredenkamp 1982, 1987; Brown *et al.* 1995; Coetzee 1993; Coetzee *et al.* 1995; Fuls 1993; Eckhardt 1993; Perkins 1997), was also successfully applied in the phytosociological study of the floodplain vegetation of the Okavango Delta in the Nxaraga lagoon area. However, the application of this method in the floodplains of the Okavango is hampered by the mere fact that such kind of work has not been done extensively in the Okavango Delta, and other ecosystems in Botswana, thus leaving the researcher with no comparable reference on the Okavango Delta. It would be interesting to compile a formal syntaxonomy for the vegetation of the Okavango Delta, with the application of the Braun-Blanquet approach. For this, more work will have to be done.

Since very little is known about the phytosociology of the vegetation of the floodplains of the Okavango Delta, the description and ecological interpretation of the identified plant communities contributes significantly to the understanding and knowledge of floodplain vegetation. These results provide baseline information for further phytosociological investigations. The classification resulted in identification of plant communities which can be related to environmental factors such as elevation, distance from the channel, flooding frequency and duration and soil physical and chemical properties.

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