Diversity and Dynamics of Plant Communities in Niger River Valley (W Regional Park)

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1. Introduction

The “W” Regional Park covers an area adjacent to the border of Benin, Burkina Faso and Niger (Fig. 1). The park hosts diverse flora and fauna. The large part of plant communities of this area remain poorly understood and only few reports on this subject are available (Garba, 1985; Boudouresque, 1995 and Couteron et al. 1992).

The objective of this work was to characterize plant communities along the Niger River bank during the flooding period and the dry season. These two periods play important roles in the ecosystem dynamics.

2. Materials and methods

The “W” Regional Park is located in the West African north-sudanian zone (Fig. 1; White, 1983) and covers an area of 1.024.280 ha. The average annual rainfall is 704.7 ± 180 mm with an average temperature of 37 °C (Fig. 2). This park includes several Precambrian geological structures. In the river valley, the soil is of clayey gley/pseudo-gley type. The banks of this river host a “special vegetation” called “bourgou” by the local population in reference to “bourgoutiere” commonly used in the literature for this type of vegetation (Dulieu, 1989). The phytosociological investigation was conducted in several sites located in this area from 2002 to 2003 during the flooding period and the dry season. Each releve included the complete list of species with their abundance-dominance coefficients (Braun Blanquet, 1932).

Data analysis was performed with Canoco software (ter Braak and Smilauer. 1998). For the different plant communities that were studied, the specific diversity indices of Shannon and Weaver (1949 in Legendre and Legendre, 1998) and Pielou equitability index were calculated.
Fig. 1. "W" national park in West Africa

Fig. 2. Ombrothermic curve of Tapoa station (Niger)
The nomenclature after identification of species is referred to in Lebrun and Storck (1991-1997). The reported species were represented by *herbarium specimens* available in the herbaria of the UAM and ULB (BRLU).

### 3. Results

Detrended Correspondance Analysis was performed on a matrix of 42 relevés and 116 species. The first Axis reflected a gradient of water depth (Fig. 3). Near the origin of this axis were located the groups of plants adapted to deep water conditions occurring during flooding period while the dry season plant groups were positioned on its positive side.

The syntaxons described were:

- *Polygono senegalensis Echinochloetum colonae ass. nova*,
- *Eichhornietum crassipedis* Vanderlyst 1931,
- *Leptochloo coerulescentis Stachytarphetetum angustifoliae ass. nova*,
- *Cyperetum maculati* Mandango 1982.

![Fig. 3. Plant communities' classification in the banks of Niger River valley](image_url)
3.1 Polygono senegalensis Echinochloetum stagninae ass. nova

Polygono Echinochloetum stagninae was defined by 13 relevés and 22 species of which four were specific to this association: Echinochloa stagnina, Polygonum senegalensis, Lemn paucicostata and Azolla pinnata (Table 1). Water depth may exceed 2 m. The pH was neutral and close to 7. The distribution of the biological types showed the predominance of therophytes (33.3%) followed by hydrophytes (28.6%) and phanerophytes (28.6%). Regarding the phytogeographical units, results showed the dominance of species with paleotropical distribution (33.33%) followed by pantropical species (28.57%) and Sudan-Zambezian species (23.81%). The number of species per releve varied from 2 to 17 with an average of 4.19 ± 1.86. The Shannon diversity index was 2.69 and the maximum diversity index up to 4.64 while the Pielou equitability was 0.57.
### Table 1. Polygono Echinochloetum stagninae ass. nov. & Eichhornietum crassipedis.

| Other species                      | A | B |
|-----------------------------------|---|---|
| Pterocarpus santalinoides DC.     |   |   |
| Acacia ataxacantha                |   |   |
| Albizia zygia                     |   |   |
| Sesbania sesban                   | + | 0.2 I |
| Mitragyna inermis                 |   |   |
| Dichrostachys cinerea             |   |   |
| Ipomomea rubens                   | + | 0.2 I |
| Mimosa pigra                      |   |   |
| Paspalum scrobicularum            |   |   |
| Phaseolus lunatus                 |   |   |
| Luffa cylindrica                  |   |   |
| Vetiveria nigritana               |   |   |
| Phyllanthus reticulathus          | + | 0.2 I |
| Taccaceae apiculata               |   |   |
| Cynodon dactylon (L.) Pers.       |   |   |
| Merremia hederacea                |   |   |
| Ipomoea blepharophylla            |   |   |
| Dorstenia sp.                     |   |   |
| Cerathophyllum demersum            |   |   |
| Utricularia stellaris L.f.        |   |   |
| Ipomoea aquatica                  |   |   |

| ALC: Average Land Cover, PC: Presence Coefficient |

3.2 *Eichhornietum crassipedis* Vanderlyst 1931

*Eichhornietum crassipedis* Vanderlyst 1931 was distributed along the linear fringe of the Niger River bank. Water depth was quite similar as for *Polygono senegalensis Echinochloetum stagninae*, since they colonized the same stations.
The distribution of biological types revealed the predominance of hydrophytes (40%), followed by therophytes (20%) and microphanerophytes (20%). The helophytes represented only 10%. Regarding the phytogeographical distribution results showed the dominance of cosmopolitan species. The *Eichhornietum crassipedis* association consisted of 10 relevés and 17 species. The average number of species per relevé was 4. The Shannon diversity index was 2.34 and Pielou equitability 0.57. These values indicated a very small number of dominant species within the plant community.

### 3.3 Leptochloa Stachytarphetetum angustifolii ass. nova association

*Leptochloa coerulescensis* *Stachytarphetetum angustifolii* developed in the late dry season and beginning of the rainy season on the banks of the river that were sufficiently dewatered to allow the development of an herbaceous layer. It corresponded to a more or less continuous linear strip along the banks that were battered by the waves.

This syntaxon was defined by 10 relevés and 34 species of those three were specific to the association: *Stachytarpheta angustifolia*, *Leptochloa coerulescens*, *Cardiospermum halicacabum* (Table 2). The raw distribution of biological types showed that helophytes were dominant (58% -73%), followed by therophytes (25%) and hydrophytes (22%) in the pondered distribution. Species of Sudanian distribution represented only 8% of the spectrum. As for the weighted spectrum, it was largely dominated by the species of Sudanese-Zambezian distribution (59.4%), species of Sudanian (9%) and Afrotropical species distribution (8.79%). The number of species per survey varied from 3 to 13 with an average of 7.6 ± 3.2. The Shannon diversity index was 3.6 and the maximum diversity index 4.9. The equitability index of Pielou was 0.74. These results suggest an equal distribution and overlap between species.

### 3.4 Cyperetum maculati Mandango 1982 association

*Cyperetum maculati* grows in the dry season on the sandbanks of the river's main channel. *Cyperus maculatus* form clumps of variable size. It is a rhizomatous species which is completely submerged during flooding periods. During this period of prolonged immersion, the plants were represented by perennial rhizomes. The floristic association has many annuals germinating on wet sand (Table 2). The association was defined by 10 relevés and 39 species of which seven were specific to this association: *Cyperus maculatus*, *Cleome viscosa*, *Glinus lotoides*, *Glinus oppositifolius*, *Cassia occidentalis*, *Trianthema portulacastrum* and *Bergia suffruticosa*.

*Cyperetum maculati* Mandango 1982 was represented by open herbaceous vegetation in dense clumps. The biological types distribution was dominated by therophytes and hydrophytes respectively 43.8% and 28.1%. The weighted distribution was represented by therophytes and phanerophytes with respectively 37.8% and 36.3% followed by hydrophytes (24.8%). The raw phytogeographical units distribution was dominated by paleotropical species (30.3%), followed by species of Sudanese-Zambezian distribution (27.27%) and pantropical species (24.24%). Other types showed low phytogeographic values. For this group, the number of species per survey varied from 5 to 18 with an average of 7.3 ± 4.42. The Shannon diversity index was 3.14 with a maximum diversity index of 5.24. Pielou equitability index value was 0.64. These results support the conclusion that recovery is evenly distributed between species.
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#### Table: Plant Communities

| C. A. D. | N° 24 25 26 27 28 29 30 31 32 33 | N° auteurs 306 307 308 312 274 275 346 337 342 343 344 329 332 333 318 328 340 322 | Area (m²) 10 10 10 10 10 10 10 10 10 10 | Land cover (%) 27 89 56 41 100 77 65 24 83 25 100 100 100 19 59.5 42 |
|----------|---------------------------------|-------------------------------------|---------------------------------|---------------------------------|

#### Cyperetum maculati Mandango 1982

| Cyperus maculatus Böck. | - + + 3 4 3 - - - + | 15 | IV | - - - - - - - + | 0.3 1 |
|--------------------------|----------------------|----|----|-----------------|-------|
| Glinus lotoides L.       | + + - - + + + - 1   | 2  | IV | - - - - - 1    | 2 1.8 II |
| Mollugo nudicaulis       | + 4 3 + - - - - 11 | III | - - - - - - - - |
| Glinus oppositifolius (L.) A. DC. | + - - - + + + | 1 | III | - - - - - - + | 0.3 1 |
| Cleome viscosa L.        | 2 2 2 - - - - - - 5 | II | - - - - - - - - |
| Trianthema portulacastrum (L.) | - - - + - - + | 1 | II | - - - - - - - - |
| Bergia sufruticosa (Del.) Fenzl. | + - - - + - - - + | 1 | II | - - - - - - - - |
| Cassia occidentalis L.   | - - - + - - - 4 | 7 | II | - - - - - - - - |
| Heliotropium indicum L.  | - - - - + + + + | 1 | II | - - - - - - + | 0.7 II |

#### Leptochloo Stachytarphetetum angustifolieae ass. nova

| Stachytarpha angustifolia Mold. | - - - - - - - - - - 3 | 3 | 3 3 3 2 | 1 | 19 | IV |
| Leptochloa coerulescens Steud. | - - - - - - - - - + 1 | II | - - 3 3 3 + | - 3 | 17 | III |
| Albizia zygia (DC.) J. F. Mocer. | - - - - - - - - - + 2 | - | + 2 | - + 2 | - - | 4 | III |
| Cardio spermum halicacabum L. | - - - - - - - - - - | - | - - | 2 | 3 | - - | 5.8 | II |
| Coldenia procumbens L.       | - - - - + - - - - | I 3 | - - - - - - | - | 4.2 | I |
| Hyparrhenia involucrata      | - - - - - - - - - - | - | - - | - - | - + | 0.3 | I |
| Stapf. var involucrata      | - - - - - - - - - - | - | - - | - - | + + | 0.3 | I |
| Eragrostis atrovirens (Desf.) Steud. | - - - - - - - - - - | - | - - | - - | - | + | 0.3 | I |

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| Other species                                                                 | C     | D     |
|-------------------------------------------------------------------------------|-------|-------|
| Morelia senegalensis A. Rich.                                                | -     | + 3   |
| Pterocarpus santalinoides DC.                                                 | -     | 3     |
| Vitex chrysanocarpa Planch. ex Benth.                                        | -     | +     |
| Flueggea virosa (Rxb. ex Wild.) Voigt                                        | -     | -     |
| Cola laurifolia Mast.                                                         | -     | -     |
| Taccazea apiculata Oliv.                                                     | +     | -     |
| Merremia hederacea Burm. f.                                                   | -     | +     |
| Diospyros mespiliformis Hochst. ex. A. DC.                                   | +     | -     |
| Celtis toka (Forssk.) Hepper et Wood.                                        | +     | -     |
| Hyptis spicigera Lam.                                                        | -     | +     |
| Corchorus tridens L.                                                         | -     | -     |
| Tamarindus indica L.                                                         | -     | -     |
| Mitragyna inermis                                                            | 3     | 2     |
| Ipomomea rubens                                                               | -     | +     |
| Mimosa pigra                                                                  | -     | +     |
| Cynodon dactylon (L.) Pers.                                                   | -     | +     |
| Polygonum senegalense Eichhornia crassipes (Mart.) Solms Laub.               | -     | +     |

Average Land Cover, CP: Coefficient de présence

Table 2. Cyperetum maculati Mandango 1982 & Leptochlos- Stachytarphetum angustifolii ass. nov
3.5 Synsystematique

| class               | Order            | Alliance                      | Associations                                                                 |
|---------------------|------------------|-------------------------------|-------------------------------------------------------------------------------|
| Phragmitea Tüxen & Preising 1942 | Papyretalia Lebrun 1947 | Echinochoion crusis-pavonis Léonard 1950 | Leptochlo-Stachytarphetosum angustifoliae ass. nov. |
|                     |                  | Jussieuium Léonard 1950       | Polygone senegalense Echinochoetum stagninea ass. nov.                        |
| Potametea pectinati Tüxen & Preising 1942 | Nymphaeetalia loti Lebrun 1947 | Nymphaeion micranthae E. Boud. 1995 | Eichhornietum crassipes Venderlyst 1931 |
| Ruderali-manihotetalia (Léonard in Taton 1949) Schmitz 1988 | Amarantho-Ecliptetalia Schmitz 1971 | Ecliption albae Lebrun 1947 | Cyperetum maculati Mandango 1982 |

4. Discussion

The initial phase of the bourgoutiere included Leptochloa coerulescens, Echinochloa stagnina, Echinochloa pyramidalis, Cyperus cylindrostachyus, Saciolepis africana and Stachytarpheta angustifolia. These plant species were progressively established in the late dry season and early rainy season. Leptochloa coerulescens bear fruits during this period. This phase corresponded to the ecological amplitude of Leptochloa-Stachytarphetetum angustifoliae. With the increase in water level, Polygonum senegalense and Echinochloa stagnina actively developed by vegetative propagation.

The optimal phase or aquatic prairie of bourgoutiere corresponded to Polygono Echinochoetum stagninae. The group covered a broad variable on the shores of the river. During the dry season, Echinochloa stagnina as Polygonum senegalense fall on the dewatered river banks. At that time, both species have spread their seeds. In the riverbed, Cypretum maculata Mandango 1982 was subject to strong variations in relation to alternating periods of flood and dry period. During the dry period characterized with a low water flow in the river, the species happened to complete its cycle. The start of this cycle, as and when the water recedes, is characterized by buds on the stolons. The flooding period was characterized by a progressive invasion by water hyacinth and resulted in the formation of Eichhornietum crassipes. This determined syntaxon pollution of aquatic stressed environments (Brendonck et al. (2003)).
These stations were characterized by variability of plant communities determined by the river water regime (Duvigneaud, 1946). Indeed, this group was not identified by Atta and Danjimo (2003) in the same river valley during the dry season. Gradually, as the water level dropped, hydrophytes population declined and progressively replaced by therophytes. This resulted in a decrease of the number of species.

5. Conclusion

Bougoutières vegetation plays an important role in the ecosystem of the W regional park. Apart from *Eichhornietum crassipedis*, the different syntaxons provide forage and habitat for wildlife. These syntaxons were characterized by low diversity indices in relation to dominance effects between species and disturbance (fire bank, harvested biomass) related to human activities.

6. Acknowledgments

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7. List of species

| Species                  | Family       |
|--------------------------|--------------|
| Abrus precatorius L.     | Fabaceae     |
| Acacia ataxacantha DC.   | Mimosaceae   |
| Albizia zygia (DC.) J.F. Macbr. | Mimosaceae   |
| Azolla pinnata R. Brown var pinnata | Azollaceae   |
| Bergia suffruticosa (Del.) Fenzl | Elatinaceae  |
| Caperonia fistulosa Beille | Euphorbiaceae |
| Cardiospermum halicacabum L. | Sapindaceae  |
| Cassia occidentalis L.   | Ulmaceae     |
| Celtis toka | (Forssk.) Hepper & Wood | Ceratophyllaceae |
| Ceratopteris cornuta     | Adianthaceae  |
| Cleome viscosa L.        | Capparaceae   |
| Cola laurifolia Mast.    | Sterculiaceae |
| Coldenia procumbens L.   | Boraginaceae  |
| Commelina benghalensis L.| Commelinaceae |
| Corchorus tridens L.     | Tiliaceae     |
| Cynodon dactylon (L.) Pers. | Poaceae      |
| Cyperus dilatatus Schum. & Thonn. | Cyperaceae   |
| Cyperus maculatus Boeck. |             |
Dactyloctenium aegyptium (L.) P. Beauv. Poaceae
Dichrostachys cinerea (L.) Wight & Arn. Poaceae
Diospyros mespiliformis Hochst. ex A. DC. Ebenaceae
Eichhornia crassipes (Mart.) Solms Poaceae
Echinocloa crus-pavonis (Kunth) Schult. Poaceae
Echinocloa obtusiflora Stapf Poaceae
Echinocloa stagnina (Retz.) P. Beauv. Poaceae
Eichhornia natans (P. Beauv.) Solms-Laub. Pontederiaceae
Eleusine indica (L.) Gaertn. Poaceae
Eragrostis atrovirens (Desf.) Trin. ex Steud. Poaceae
Eragrostis tremula Hochst. ex Steud. Poaceae
Fluegga virosa (Roxb. ex Willd.) Voigt Aizoaceae
Glinus lotoides L. Aizoaceae
Glinus oppositifolius (L.) DC. Aizoaceae
Heliotropium indicum L. Boraginaceae
Hyparrhenia involucrata Stapf Poaceae
Hyptis spicigera Lam. Lamiaceae
Indigofera hirsuta L. Fabaceae
Ipomoea aquatica Forssk. Convolvulaceae
Ipomoea blepharophylla Hall. f. Convolvulaceae
Ipomoea rubens Choisy Convolvulaceae
Lemna paucicostata Hegelm. ex Engelm. Lemnaceae
Leptochloa caerulescens Steud. Poaceae
Cleome viscosa L. Capparaceae
Ludwigia octovalvis (Jacq.) Raven Onagraceae
Luffa cylindrica (L.) M.J. Roem. Cucurbitaceae
Merremia hederacea (Burm. f.) Hallier f. Convolvulaceae
Mimosa pigra L. Mimosaceae
Mitragyna inermis (Willd.) O. Ktze. Rubiaceae
Mollugo nudicaulis Lam. Molluginaceae
Morelia senegalensis A. Rich. ex DC. Rubiaceae
Nymphaea lotus L. Nymphaeaceae
Oryza longistaminata A. Chev. & Roehr. Poaceae
Oryza sativa L. Poaceae
Paspalum scrobiculatum L. Poaceae
Phaseolus lunatus L Fabaceae
Phyllanthus reticulatus Poir. Euphorbiaceae
Polygonum senegalense Meisn. Polygonaceae
Pterocarpus santalinoides DC. Fabaceae
Sacciolepis africana C.E. Hubbard & Snowden Poaceae
Sacciolepis ciliocincta (Pilger.) Stapf. Poaceae
Sesbania leptocarpa DC. Fabaceae
Sesbania sesban (L.) Merr. Fabaceae
Stachytarpha angustifolia (Mill.) Vahl

Tacazzea apiculata Oliv.

Tamarindus indica L.

Trianthema portulacastrum L.

Utricularia stellaris L.f.

Vetiveria nigritana (Benth.) Stapf

Verbenaceae

Asclepiadaceae

Caesalpiniaceae

Aizoaceae

Lentibulariaceae

Poaceae

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White F., 1983. - The vegetation map of Africa. A description memoir, Unesco, Natural Resources Research 20 January -1356.
The ecosystems present a great diversity worldwide and use various functionalities according to ecologic regions. In this new context of variability and climatic changes, these ecosystems undergo notable modifications amplified by domestic uses of which it was subjected to. Indeed the ecosystems render diverse services to humanity from their composition and structure but the tolerable levels are unknown. The preservation of these ecosystemic services needs a clear understanding of their complexity. The role of research is not only to characterise the ecosystems but also to clearly define the tolerable usage levels. Their characterisation proves to be important not only for the local populations that use it but also for the conservation of biodiversity. Hence, the measurement, management and protection of ecosystems need innovative and diverse methods. For all these reasons, the aim of this book is to bring out a general view on the function of ecosystems, modelling, sampling strategies, invading species, the response of organisms to modifications, the carbon dynamics, the mathematical models and theories that can be applied in diverse conditions.

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