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# HERBACEOUS VEGETATION OF SEASONALLY WET HABITATS ON INSELBERGS AND LATERITIC CRUSTS IN WEST AND CENTRAL AFRICA

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**Abstract:** Inselbergs, mountain ridges and lateritic crusts are characteristic landscape elements in many tropical regions. They are of great interest from a botanical point of view. Their vegetation is relatively uniform and differs from the surrounding vegetation. The first synopsis of herbaceous vegetation of seasonally wet or inundated habitats on rocks, inselbergs, mountain ridges and lateritic crusts in several bioclimatic zones of tropical West Africa and Atlantic Central Africa is presented. A classification of 43 partial data sets, based on 378 relevés, resulted in four associations and several rankless communities, grouped into four different classes (*Drosero-Xyridetea*, *Afrotrilepidetea pilosae*, *Lycopodietea cernui* and *Microchloetea indicae*). Plant communities from Atlantic Central Africa and West Africa are very distinct from a floristic point of view; in an ordination, they are clearly separated. The *Drosero indicae-Utricularietalia subulatae* (*Drosero-Xyridetea*) comprises ephemeral vegetation in rock pools and depressions over lateritic crusts. It contains the *Eriocaulo pumili-Ophioglossion gomezianum*, which combines communities with short-lived plant species in small pools on rock outcrops and in shallow depressions over laterite, and the *Genliseo africanae-Sporobolion pauciflori*, which colonizes similar habitats but is geographically restricted to few mountains in Guinea, Sierra Leone and Liberia. Mats of monocotyledonous plants (*Afrotrilepidetea pilosae*, *Afrotrilepidetalia pilosae*) are very widespread in humid parts of tropical West Africa. They colonize gentle slopes and are often close to communities of the *Drosero-Utricularietalia subulatae*. Three alliances can be distinguished: West African alliances *Cyanotido lanatae-Afrotrilepidion pilosae* and *Spermacoco hepperanae-Afrotrilepidion pilosae*, and an Atlantic Central African *Oreonesiono testui-Afrotrilepidion pilosae*. Small-scale alterations of the ecological situation often result in a mosaic-like pattern of the plant communities. Especially small inselberg and rock outcrop habitats are often affected by heavy fluctuations of their environmental and climatic conditions. Besides regular short-term dynamics, there are also long-term vegetation dynamics with cycles spanning several years.

**Keywords:** *Afrotrilepidetea pilosae*, *Drosero-Xyridetea*, Ephemeral flush vegetation, Mat vegetation, Phytogeography, Rock outcrops, Syntaxonomy

## INTRODUCTION

West Africa contains large areas with flat landforms. Inselbergs and mountain ridges rise abruptly from the surrounding plains. Although they cover only a small part of the total surface, they are very old and stable environments. These often monolithic mountains have considerable importance, for example as grazing areas for livestock, deposits of mineral resources or holy places and assumed homes of mountain spirits. Often, they are fairly undisturbed because of their inaccessibility.

Inselbergs, mountain ridges and lateritic crusts consist of several, clearly distinct habitats. They are ecologically isolated from surrounding areas and are often considered as model systems for island ecology (POREMBSKI & BARTHLOTT 2000a). Their plant species show adaptations to particular growth conditions, e.g. to drought stress and heat ("xeric islands" in a more humid surrounding, SZARZYNSKI 2000). Five to ten habitats have been differentiated, depending on the author. POREMBSKI & BARTHLOTT (2000a) provided instructive colour plates of these habitats and gave general information about plant-environment relationships on inselbergs. POREMBSKI et al. (1994, 2000a) gave descriptions of typical, physiognomically defined habitats on inselbergs.

Rock surfaces and drainage channels are colonized by green algae, cyanobacteria and lichens. Seasonally wet or inundated habitats such as seasonally water-filled pools (= rock pools), shallow, soil-filled depressions and gentle to steep slopes are colonized by herbaceous, non-woody vegetation. Wet flush vegetation, ephemeral flush vegetation (a term introduced by RICHARDS 1957), and mats of monocotyledonous plants (= mat vegetation) are differentiated based on their morphological and biological characteristics. Dry habitats on slopes are typically colonized by sward communities, dominated by *Poaceae*. Free-floating vegetation (e.g. with *Lemna* and *Spirodela*) exists in ponds. Some habitats on inselbergs provide better soil conditions and enable woody plants to grow, e.g. in rock crevices or on some summits. Here, the predominant vegetation formations are shrubby fringes and saxicolous forests (PARMENTIER 2003).

The first locally based studies dealing with vegetation on West African inselbergs were published by ADAM (1947), JAEGER (1950) and SCHNELL (1951–52) and, for example, TATON (1948) and LÉONARD (1950) for Central Africa. The first records of ephemeral vegetation in rock pools and lateritic depressions came from Mali (MONOD 1954, RAYNAL & RAYNAL 1961) and Nigeria (HAMBLER 1964). KNAPP (1966) was the first to propose a phytosociological class *Eriocaulo-Utricularietea* (nomen nudum) for this kind of vegetation. He listed some characteristic species, but did not provide phytosociological records. A first overview of West African inselberg vegetation, with only very rudimentary species lists for different habitats, came from POREMBSKI & BARTHLOTT (1992). POREMBSKI (2000) provided a good introduction to vegetation on West African inselbergs but only short species lists. He did not include complete species lists or synoptic tables that would allow a direct floristic comparison. The data were not sufficient to allow a detailed ecological analysis of the floristic composition at a larger scale. The first phytosociological studies of *Afrotrilepis* mats including data from Benin, the Côte d'Ivoire and Equatorial Guinea and of herbaceous fringes in Atlantic Central Africa were published recently (PARMENTIER et al. 2006, PARMENTIER & MÜLLER 2006).

Despite the mentioned local studies, a synopsis of inselberg vegetation in the whole region based on complete species lists of habitats and vegetation-plot data is still missing. The aim of this paper is therefore to present a first synopsis of herbaceous vegetation of seasonally wet habitats on inselbergs, mountain ridges and lateritic crusts. A syntaxonomical scheme of inselberg vegetation based on all available species lists and relevés is presented. I discuss the geographical distribution and the ecological factors of the plant communities. The main questions are the following: Which plant species, life forms and functional types are

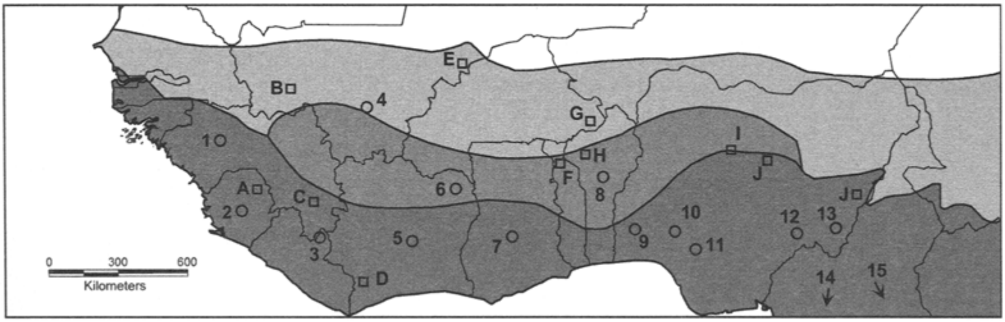

Fig. 1. Origin of the data on herbaceous vegetation of rock habitats on inselbergs and lateritic crusts. From south to north in different grey intensities: Guinean, South Sudanian and North Sudanian zones. Authors and localities (circles), used in Appendix: 1 – SCHNELL (1952), Guinea; 2 – GLEDHILL (1970), Sierra Leone; 3 – SCHNELL (1951–52), Guinea; ADAM (1971), Liberia; 4 – ABERLIN (1986), Mali; 5 – ADJANOHOUN (1964), DÖRRSTOCK et al. (1996), POREMBSKI et al. (1996b), Côte d'Ivoire; 6 – POREMBSKI & BARTHLOTT (1997), Côte d'Ivoire; 7 – HALL (1971a), Ghana; 8 – OUMOROU & LEJOLY (2003a,b), Benin; 9 – HAMBLER (1964), Nigeria; 10 – ISICHEI & LONGE (1984), Nigeria; 11 – RICHARDS (1957), Nigeria; 12 – HALL & MEDLER (1975), Nigeria; 13 – HEPPER (1966), Nigeria; 14 – PARMENTIER (2001), PARMENTIER et al. (2001), Equatorial Guinea; REITSMA et al. (1992), Gabon; 15 – TATON (1948), DR Congo. Studies with data from several countries (not shown): KNAPP (1973). Further studies, not included in Appendix (rectangles): A – COLE (1967), Sierra Leone; B – JAEGER (1950, 1959), Mali; C – SCHNELL (1961), Guinea; D – POREMBSKI & BROWN (1995), POREMBSKI et al. (1996a), Côte d'Ivoire; E – JAEGER & WINKOUN (1962), Mali; F – TCHAMIE & BOURAIMA (1997), Togo; G – WITTIG et al. (2000), Burkina Faso; H – TENTE & SINSIN (2002), Benin; I – AYO OWOSEYE & SANFORD (1972), Nigeria; J – HALL (1971b), Nigeria. Not shown are: ADAM (1970), JAEGER & ADAM (1971), KERSHAW (1968) and SCHNELL (1957).

characteristic over broader ecological gradients? What ecological and phytogeographical patterns can be observed within the studied region and compared with some other tropical regions? After the classification, description and ecological characterization of the plant communities, I briefly discuss the spatial mosaics and the vegetation dynamics.

## STUDY AREA AND HABITATS

Geographically, this synthesis is restricted to the tropical parts of West Africa, stretching from Senegal to Nigeria (Fig. 1), completed by parts of Atlantic Central Africa. Bioclimatically, the study area is divided into the North Sudanian, the South Sudanian and the Guinean-Congolian zone (modified after WHITE 1983). These three bioclimatic zones are congruent with the following phytogeographical regions: Sudanian centre of endemism, Guinean-Congolian / Sudanian transition zone and Guineo-Congolian centre of endemism (WHITE 1983). Because of the lack of available data, the Sahelian zone and the tropical parts of the Sahara were excluded.

The highest mountains within the study area are the Loma Mountains in Sierra Leone (1948 m), the Nimba Mountains in the border area of Guinea and Liberia (1752 m) and the mountains in the border area of Nigeria and Cameroon (Vogel Peak 2042 m, Bamenda

Mountains 2710 m). Many mountains do not exceed an altitude of 1000 m; e.g. the highest peak in Burkina Faso reaches only 749 m (Ténakourou in SW Burkina Faso) and that of Togo 986 m (Pic Baumann in S Togo).

The rainfall regime in West Africa is controlled by the Intertropical Convergence Zone (ITC) and therefore the rainy season is, depending on the latitudinal position, from April/July to September/October. Mean annual precipitation declines from south to north, with the dry period becoming more and more accentuated in this direction (Guinean-Congolian zone up to 2,000 mm and more, South Sudanian zone ca. 1,500 mm, North Sudanian zone < 1,000 mm).

This synthesis is limited to herbaceous, non-woody vegetation of seasonally wet or inundated habitats on inselbergs, mountain ridges and lateritic crusts. These habitats include seasonally water-filled rock pools, shallow, soil-filled depressions, and gentle to steep mountainous slopes with a thin organic layer (ephemeral flush habitats). "Seasonal" means that there is an annual change of wet and dry conditions, the wet season being the growing season. Rock pools are of variable depth and receive overland flow and subsurface water. They can be irregularly shaped or round to oval. They are colonized by cryptogams, short-living herbs and free-floating plants. Shallow, soil-filled depressions are very similar to rock pools, varying in size and depth. Typically, the soil depths range between 2 and 20 cm (POREMBSKI et al. 2000a). Some of the depressions are of anthropogenic origin (grinding holes, see e.g. HAMBLER 1964). Depending on the soil depth, such habitats are colonized by therophytes, geophytes and short-lived herbs. The ephemeral flush habitat is typically found on gentle to steep slopes with a thin organic layer. Water is provided by runoff and interflow; substrate accumulation is often biogenic. The vegetation of ephemeral flush habitats is very dynamic and rich in carnivorous plants and monocotyledons. All these habitats are typically found on sandstone and granitic rocks (Fig. 2). Free-floating vegetation, cryptogamous vegetation, the vegetation of open rock surfaces, drainage channels and rock crevices were not included in this study. Fringes, dense sward communities and the grass layers of mountain savannas were also excluded.

## METHODS

### Available data

Various areas of tropical West and Atlantic Central Africa and the vegetation types of the above mentioned habitats are differently well studied. Accordingly, data quality varies from region to region and between certain habitats. The original data set comprised 68 units (species lists, single or combined relevés, depending on the authors) with 679 taxa. During the analysis, 25 units were removed, because they were dominated by woody species, originated from other than the included habitats or were incomplete or fragmentary (where indicated in the original descriptions). The latter had been studied at an inappropriate period of time, e.g. during the dry season when therophytes are normally not visible. From the remaining 43 units, 28 units originated from West Africa and 15 from the Atlantic parts of Central Africa (origins of data see Fig. 1 and Appendix). The following countries were represented: Benin, Côte d'Ivoire, Equatorial Guinea, Gabon, Ghana, Guinea, Liberia, Nigeria, Mali, and Sierra Leone; no adequate data were available for Burkina Faso, the Gambia, Guinea-Bissau, Senegal, and Togo. Other local studies (indicated by letters in Fig. 1), which did not contain any relevant species lists or relevés, or dealt with woody vegetation, were not included in the data set. However, they provided valuable information about inselberg vegetation in general.

## Data processing

Percentage frequency values have been calculated from the authors' tables. It was necessary to use the frequency values instead of the original data sets to obtain a standardized data set. This approach follows MÜLLER & DEIL (2005) who used it in their synopsis of West African lake vegetation. The data were put into a TURBOVEG database (HENNEKENS & SCHAMINÉE 2001). The synoptic table (Appendix) documents 43 vegetation types, considered as rank-free operational units at the beginning of the floristic classification. These 43 units are originally based on 364 relevés (176 from West Africa and 188 from Central Africa) and 14 additional species lists from West Africa. For better legibility, the frequency values were transformed into 10 constancy classes (1: 1–10%, 2: 10–20%, 3: 20–30% etc.).

The delimitation of some plant communities and their syntaxonomic position must remain open for the time being. From what we know currently about the distribution, sociology and ecology of many African plant species, it cannot be decided whether a taxon can be considered as a characteristic or differential species in the sense of the Braun-Blanquet approach. In the synoptic table (Appendix), the sociological value of the species is mostly based upon the behaviour that exists in the data set. I therefore prefered to use the term "diagnostic species" (= DS) (see also MÜLLER & DEIL 2005).

A TWINSPAN analysis (HILL 1979) and several correspondence analyses (CA, DCA) were performed with the floristic data set (presence-absence data, no downweighting of rare species) to check the manual floristic-sociological classification and to illuminate the relationships between the groups. For the ordination, CANOCO for Windows 4.5 was used (TER BRAAK & ŠMILAUER 2002).

In the following, the plant communities and their hierarchical arrangement into classes, orders and alliances is presented and discussed, taking into account publications and data from other parts of Africa.

## Nomenclature

I follow LEBRUN & STORK (1991–1997) for names of vascular plants and ALSTON (1959) for pteridophytes. The few liverworts and mosses were named according to WIGGINTON (2002) and O'SHEA (2003). Naming and typification of the plant communities and syntaxa of higher rank follow the rules of the International Code of Phytosociological Nomenclature (WEBER et al. 2000).

## RESULTS

Plant communities were grouped into three large blocks, one comprising the communities of rock pools and shallow depressions, another including mat vegetation with *Afrotrilepis pilosa*. The last, smaller block comprised open pioneer communities, dominated by therophytes. Some units do not fit into the syntaxonomical scheme. The communities from Atlantic Central Africa were clearly separated from those of West Africa.

## SYNTAXONOMICAL CONSPECTUS

- *Drosero-Xyridetea* SCHMITZ 1988
  - *Drosero indicae-Utricularietalia subulatae* J. MÜLLER ord. nov.
    - *Eriocaulo pumili-Ophioglossion gomezianum* J. MÜLLER et DEIL 2005
      - *Dopatrio senegalense-Marsileetum polycarpae* J. MÜLLER et DEIL 2005
      - *Isoëto nigritianae-Ophioglossetum gomezianum* J. MÜLLER et DEIL 2005
      - *Lindernia schweinfurthii-Xyris capensis* community
      - *Isoëtes aequinoctialis* community
    - *Genliseo africanae-Sporobolion pauciflori* J. MÜLLER all. nov.
      - *Utriculario subulatae-Eriocauletum pumili* SCHNELL ex J. MÜLLER 2007
- *Afrotrilepidetea pilosae* (KNAPP 1966) DECOCQ 2006
  - *Afrotrilepidetalia pilosae* (KNAPP 1966) DECOCQ 2006
    - *Cyanotido lanatae-Afrotrilepidion pilosae* OUMOROU et POREMBSKI 2006
      - *Selaginella njam-njamensis* community
      - *Andropogon africanus* community
    - *Spermacoco hepperanae-Afrotrilepidion pilosae* J. MÜLLER all. nov.
      - *Spermacoco hepperanae-Afrotrilepidetum pilosae* J. MÜLLER ass. nov.
      - *Andropogon africanus-Ophioglossum costatum* community
      - *Sporobolus festivus-Microchloa indica* community
    - *Oreonesiono testui-Afrotrilepidion pilosae* PARMENTIER 2006
- *Lycopodietea cernui* SCHMITZ (1971) 1988
  - *Kalanchoetalia crenatae* SCHMITZ 1988
    - *Kalanchoion crenatae* LEBRUN 1947
      - *Cyanotis lanata* community
- *Microchloetea indicae* SCHMITZ (1971) 1988
  - *Sporoboletalia festivi* LEBRUN 1947
    - *Ilysanthion* TATON 1949
      - *Lindernia pulchella-Aeollanthus repens* community
      - *Lindernia madiensis-Abildgaardia congolensis* community

### Vegetation of nutrient-poor, seasonally inundated depressions

#### ***Drosero-Xyridetea*** **(Appendix, columns 1–10)**

Characteristic species according to SCHMITZ (1988): *Xyris straminea*, *Eriocaulon pumilum*, *Xyris capensis*

The class *Drosero-Xyridetea* occupies nutrient-poor habitats with regular periods of flooding and wetting: seasonally inundated lateritic depressions, ephemeral wet rocky slopes and rock pools on inselbergs. These habitats are best developed in humid climates. In addition to specialists with narrow ecological ranges, the communities also include widespread and generalist wetland species. Besides representatives of the families *Eriocaulaceae* and *Xyridaceae*, there are representatives of the *Droseraceae*, *Lentibulariaceae*, *Scrophulariaceae* and fern genera, all being typical for nutrient-poor, moist or wet habitats in tropical Africa. The distribution area of the class covers the whole study area from Guinea and

Fig. 2. Vegetation complex on a rock outcrop in the Chaîne de Banfora, SW Burkina Faso. Ephemeral vegetation with *Cyanotis lanata*, *Drosera indica*, and *Ophioglossum costatum*; small rock pools with *Dopatrium longidens*; a rock crevice with tall grasses (*Andropogon gayanus*, *Diheteropogon amplectens*), in the background a species-rich scrub savanna with e.g. *Burkea africana*, *Lannea microcarpa*, *Pterocarpus erinaceus*, and *Terminalia macroptera* (Photo: Marco Schmidt).

Sierra Leone in the west to Nigeria in the east and Gabon in the south. Within the class *Drosero-Xyridetea*, two orders can be distinguished: Central African *Sphagno-Xyridetalia* DUVIGNEAUD & SYMOENS 1951, which is dominated by perennial species and peat mosses (outside the study area and not included in Appendix), and West African *Drosero indicae-Utricularietalia subulatae*. The two orders are clearly separated by their ecology and distribution.

## Ephemeral vegetation in rock pools and depressions over lateritic crusts in West Africa

### *Drosero indicae-Utricularietalia subulatae* ord. nov. hoc loco

Typus: *Eriocaulo pumili-Ophioglossion gomezianum* J. MÜLLER & DEIL 2005

Diagnostic species: *Drosera indica*, *Lindernia schweinfurthii*, *Ophioglossum costatum*, *O. reticulatum*, *Utricularia pubescens*, *U. subulata*, *Xyris anceps*

Whereas the Central African order *Sphagno-Xyridetalia* encompasses mire vegetation, the West African order *Drosero indicae-Utricularietalia subulatae* comprises ephemeral vegetation of rock pools and depressions over lateritic crusts. The diagnostic species from the families *Droseraceae*, *Lentibulariaceae*, and *Ophioglossaceae* are widespread species of

Fig. 3. Dominance stand of *Ophioglossum costatum* on a shallow, water-saturated soil over rock in the Chaîne de Banfora, SW Burkina Faso (Photo: Marco Schmidt).

nutrient-poor, wet habitats. They are all low growing and colonize temporarily damp or wet habitats over sandstone or granite (Fig. 3). They root in a thin organic layer or directly in a cyanobacterial crust. As a rule, they have large distribution areas in the Palaeotropical region or are pantropical species. *Lindernia schweinfurthii* (*Scrophulariaceae*) typically grows in moist pockets of rock outcrops. The *Drosero indicae-Utricularietalia subulatae* is distributed in Liberia, Guinea, Sierra Leone, and impoverished stands are documented for the Côte d'Ivoire, Ghana, Mali and Nigeria. Considering the distribution areas of the diagnostic species, a larger area of distribution in West Africa (and beyond?) can be assumed. According to available data, two alliances are clustered into the *Drosero indicae-Utricularietalia subulatae*: *Eriocaulo pumili-Ophioglossion gomezianum* and *Genliseo africanae-Sporobolion pauciflori*.

### ***Eriocaulo pumili-Ophioglossion gomezianum*** **J. Müller et Deil 2005 (Appendix, columns 1–7)**

Diagnostic species: *Crinum zeylanicum*, *Hydrolea glabra*, *Micrageria filiformis*, *Ophioglossum gomezianum*, *Panicum tenellum*, *Sopubia parviflora*, *Sporobolus pectinellus*

The *Eriocaulo pumili-Ophioglossion gomezianum* combines communities with short-lived plant species in small pools on rocky outcrops and in shallow, temporary waterfilled depressions over lateritic crusts in West Africa. The alliance is documented for the Côte d'Ivoire and Mali, and impoverished stands from Benin and Nigeria. The communities are well characterized by a set of small-growing, often annual species (exception: *Crinum zeylanicum*), adapted to nutrient-poor conditions. *Sporobolus pectinellus* and *Sopubia parviflora* are annuals of shallow soils and damp grasslands of West and Central Africa. *Ophioglossum gomezianum* is a Sudano-Zambezian species of moist savannas near the coast and of inland savannas on damp soils over rocks. Through species like *Drosera indica*, *Eriocaulon pumilum*, *Utricularia subulata*, *Xyris straminea* and *X. capensis* the *Eriocaulo pumili-Ophioglossion gomezianum* can be included in the *Drosero indicae-Utricularietalia subulatae*. So far, two associations and two rankless communities are grouped into this alliance.

### ***Dopatrio senegalense-Marsileetum polycarpae*** **J. MÜLLER et DEIL 2005 (Appendix, column 1)**

Diagnostic species: *Eriocaulon afzelianum*, *E. plumale*, *E. xeranthemoides*, *Marsilea polycarpa*

The *Dopatrio senegalense-Marsileetum polycarpae* colonizes small, periodically flooded depressions over lateritic crusts. The association is documented for the Côte d'Ivoire only. The stands are very open, not exceeding 70 cm in height. Some taller-growing ruderal species indicate a higher degree of human disturbance than it is the case for the *Isoëto-Ophioglossetum* (see below). *Dopatrium senegalense* also colonizes sandstone outcrops.

### ***Isoëto nigritianae-Ophioglossetum gomezianum*** **J. MÜLLER et DEIL 2005 (Appendix, column 2)**

Diagnostic species: *Isoëtes nigritiana*, *Ophioglossum thomasii*, *Utricularia prehensilis*

The *Isoëto nigritianae-Ophioglossetum gomezianum* forms the vegetation of small rock pools on Ivorian granitic inselbergs. The diagnostic species of the higher syntaxa are well represented. *Isoëtes nigritiana*, *Utricularia prehensilis* and less frequently *Ophioglossum thomasii* join them. In Africa, *Isoëtes nigritiana* is limited exclusively to such habitats with seasonally wet soils. *Ophioglossum thomasii* is typical for wet, gravelly soils and is known from the Côte d'Ivoire and Ghana to Uganda. Appendix, column 3 shows a habitat-based species list from an ephemeral flush vegetation, combined from three inselbergs in the South Sudanian zone of the Côte d'Ivoire (POREMBSKI & BARTHLOTT 1997). The habitats are gentle slopes with a shallow soil layer, where water continuously seeps during the rainy season. Its floristic composition resembles the *Dopatrio senegalense-Marsileetum polycarpae* and the *Isoëto nigritianae-Ophioglossetum gomezianum* (*Eriocaulon afzelianum* and *Isoëtes nigritiana* are both present), however it is much poorer in species.

### ***Lindernia schweinfurthii-Xyris capensis*** **community (Appendix, column 4)**

(incl. *Xyris straminea-Scirpus briziformis* community sensu HAMBLER 1964)

The *Lindernia schweinfurthii-Xyris capensis* community was observed in Central Mali by ABERLIN (1986) in episodically waterfilled rock depressions with a very thin weathered layer. MÜLLER & DEIL (2005) interpreted it as the northern, impoverished form (= marginal association) of the *Isoëto nigritianae-Ophioglossetum gomezianum*. *Desmodium hirtum* is a prostrate herb, widespread in tropical Africa. *Lindernia schweinfurthii*, which is treated as a diagnostic species of the community by MÜLLER & DEIL (2005), should be better treated as a diagnostic species of the order. Two local plant communities without diagnostic species on a regional scale are for now grouped together with the *Lindernia schweinfurthii-Xyris capensis* community because of their floristic similarity. First, HAMBLER (1964) recorded a *Xyris straminea-Scirpus briziformis* community from rocky outcrops in W Nigeria (Appendix, column 5). It colonizes very thin soils, which are more or less permanently flooded during the rainy season. *Xyris straminea* and *Scirpus briziformis* form an upper stratum, *Utricularia* ssp., *Ophioglossum gomezianum*, *Drosera indica* and other low-growing species form a lower stratum. Second, Appendix, column 6 shows a total species list of damp grasslands from six inselbergs in Benin (OUMOROU & LEJOLY 2003b). Unfortunately, the authors did not give any further information on the habitat. *Dopatrium longidens* (*Scrophulariaceae*) is typical for wet places. According to HAMBLER (1964) and POREMBSKI et al. (2000a), this species is a specialist of shallow seasonal pools and colonizes man-made grinding holes.

### ***Isoëtes aequinoctialis*** **community (Appendix, column 7)**

The *Isoëtes aequinoctialis* community, documented in the Accra plains by HALL (1971a), is relatively rich in species. Stands of this community colonize sandy, rarely flooded soils which receive surface water from adjacent inselbergs. *Isoëtes aequinoctialis* is a good diagnostic species. *Xyris anceps* can also be found in rice fields and mangroves.

### ***Genliseo africanae-Sporobolion pauciflori*** **all. nov. hoc loco (Appendix, columns 8–10)**

Typus: *Utriculario subulatae-Eriocauletum pumili* SCHNELL ex J. MÜLLER 2007

Diagnostic species: *Cyanotis longifolia* var. *longifolia*, *Cyperus digitatus* subsp. *auricomus*, *Genlisea africana*, *Ilysanthes barteri*, *Polygala clarkeana*, *Rhytachne rottboellioides*, *Sporobolus pauciflorus*, *Utricularia reflexa*

The new alliance *Genliseo africanae-Sporobolion pauciflori* is the second alliance of the order *Drosero indicae-Utricularietalia subulatae*. In contrast to the *Eriocaulo pumili-Ophioglossion gomezianum*, this alliance is geographically restricted to a few mountainous areas in Guinea, Sierra Leone and Liberia. The diagnostic species have their ecological optimum in habitats over iron pans and in wet grasslands; most of them are widespread in tropical Africa. This fact in mind, it seems astonishing why the alliance is so far only recorded from the above mentioned three countries. Plant communities of the *Genliseo africanae-Sporobolion pauciflori* have similar ecological requirements to those of the *Eriocaulo pumili-Ophioglossion gomezianum*. They form short-lived, low-growing (up to 10 cm in height) stands in small depressions over rocks or laterite with only a thin organic layer. By our current state of knowledge, the alliance comprises one association.

### ***Utriculario subulatae-Eriocauletum pumili*** **SCHNELL ex J. MÜLLER 2007 (Appendix, column 8–10)**

Typus relevé: SCHNELL (1951–1952), page 382, no. 1

(syn: groupement à *Eriocaulon pumilum* et *Utricularia subulata* SCHNELL 1951/52 nom. inval., Art. 3c; *Utricularieto-Eriocauletum pumili* SCHNELL 1952 nom inval., Art. 2)

The *Utriculario subulatae-Eriocauletum pumili* was first described by SCHNELL (1951–1952) from the Nimba Mountains (Liberia and Guinea). Stands in small basins were documented with two relevés (Appendix, column 8). The description of this plant community as an association by SCHNELL (1952) is not valid because he did not choose a typus relevé; therefore the *Utriculario subulatae-Eriocauletum pumili* is validated here; the original orthography is corrected according to Art. 41b. It forms low-growing stands (up to 10 cm in height) and colonizes seasonally inundated ponds in rock depressions and over lateritic crusts. The soil has a depth of only 1–2 cm. The association cannot be placed into the order *Sporoboletalia festivi* as proposed by Schnell, although there are some common species. As probable characteristic species, SCHNELL (1951–1952) mentions *Drosera indica*, *Utricularia subulata*, and some low-growing *Poaceae*, *Xyridaceae* and *Cyperaceae*. It turns out that the name-giving species, chosen by Schnell, should be better considered as diagnostic species of the order and class. Specific diagnostic species for the association are not available. A species list in Appendix, column 9, from a small pond with a thin organic layer over laterite from the Nimba Mountains, documented by ADAM (1971), is floristically identical with Schnell's association. Appendix, column 10, shows a species list from a low-growing stand in the Guinean Fouta Djalon Mountains (SCHNELL 1952). The habitat and spatial structure of this vegetation is very similar to the *Utriculario subulatae-Eriocauletum pumili*. However, it is much poorer in species, and the diagnostic species of the alliance are not present.

## Mats of monocotyledonous plants with *Afrotrilepis pilosa* on inselbergs

***Afrotrilepidetea pilosae* (KNAPP 1966) DECOCQ 2006 (Appendix, columns 11–23)**
Diagnostic species: see order

Plant communities of the class *Afrotrilepidetea pilosae* (resurrection plant communities) are very widespread in humid parts of tropical West Africa. *Afrotrilepis pilosa* (*Cyperaceae*) is distributed in West and Central Africa from Senegal to Nigeria southwards to Equatorial Guinea and Gabon. It can be presumed that the distribution range of the *Afrotrilepidetea pilosae* is identical with the species' distribution range. Plant communities of the *Afrotrilepidetea pilosae* are best developed in the Guinean and South Sudanian zones, and are impoverished in the drier areas of the North Sudanian zone.

The poikilohydrous *Afrotrilepis pilosa* is a pioneer on bare rock surfaces. It can be very variable in its habit and morphology. It colonizes mostly gentle slopes on inselbergs and forms mats through horizontally spreading basal branching. Organic material, other soil particles and surface and rain water are collected in these mats. A tightly knitted root system prevents soil erosion so that other plant species can establish. Destruction of the canopy by fire supports this process (HAMBLER 1964). One of the first species is *Cyanotis lanata* (*Commelinaceae*). KNAPP (1973) mentioned *Afrotrilepis-Cyanotis* rock vegetation and HAMBLER (1964) provided a detailed description of its ecological situation. *Afrotrilepis pilosa* mats are generally relatively uniform, species-poor communities that contain many geophytes. *Euphorbia unispina* occurs in *Afrotrilepis pilosa* mats as one of the very few succulents on inselbergs; a vicariant species in Central Africa is *Euphorbia letestui*. Another characteristic feature is the presence of epiphytic orchids, e.g. *Calyptrochilum christyanum*, *Polystachya dolichophylla*, *P. microbambusa*, *P. pseudodisa* and *Tridactyle tridactylites*

(RICHARDS 1957, POREMBSKI 2000). Some bryophytes are documented from *Afrotrilepis pilosa* mats: *Brachymenium acuminatum*, *B. exile*, *Bryum argentum*, *Fissidens atroviridis*, *Hyophila involuta*, *Philonotis imbricatula*, *Riccia discolor* and *R. moenkemeyeri* (FRAHM et al. 1996). So far, the class *Afrotrilepidetea pilosae* comprises one order:

### *Afrotrilepidetalia pilosae* (KNAPP 1966) DECOCQ 2006

Diagnostic species: *Afrotrilepis pilosa*

The order *Afrotrilepidetalia pilosae* is characterized by *Afrotrilepis pilosa*. *Cyanotis lanata* (distributed from Senegal to Ethiopia, southwards to Mozambique), one of the most frequent plant species in West African inselberg vegetation, and the small therophyte *Lindernia exilis* (distributed in West and Central Africa to Somalia) have their ecological optimum in this order. However, they cannot be used as diagnostic species, because they also appear frequently in other syntaxa. Plant communities of the *Afrotrilepidetalia pilosae* are in a close spatial neighbourhood to communities of the order *Drosero indicae-Utricularietalia subulatae* (see above). Species of the latter order can often be found in relevés of the *Afrotrilepidetalia pilosae* (see Appendix). This can be the result of a zonation pattern, or an artefact due to heterogeneous sampling plots. From an ecological point of view, these two groups are clearly separated. Additionally, tiny grasses of the class *Microchloetea indicae* appear in some plant communities of the *Afrotrilepidetalia pilosae* as accompanying species at open microsites. For the time being, the *Afrotrilepidetalia pilosae* has three alliances: the two West African alliances *Cyanotido lanatae-Afrotrilepidion pilosae* and *Spermacoco hepperanae-Afrotrilepidion pilosae*, the latter following the first in a succession, and an Atlantic Central African alliance *Oreonesiono testui-Afrotrilepidion pilosae*.

### *Cyanotido lanatae-Afrotrilepidion pilosae* OUMOROU & POREMBSKI 2006 (Appendix, columns 11–17)

No diagnostic species known.

This alliance includes pioneer communities that succeed to plant communities of the *Spermacoco hepperanae-Afrotrilepidion pilosae* if they are not regularly burnt. The succession can continue to vegetation dominated by trees. A syntaxonomical description of this alliance was published last year, based on data from Benin and the Côte d'Ivoire (PARMENTIER et al. 2006). Besides these two countries, the alliance is known from Guinea and Nigeria. *Afrotrilepis pilosa* germinates immediately if enough moisture is available (HAMBLER 1964). Depending on the slope, the further development of the mats may vary: on steep slopes, the growth of the mats is along their lower edge; the mats tend to become crescent-shaped. On gentle slopes, the mats remain more or less circular. Generally, mat growth is most active at the edges.

### *Selaginella njam-njamensis* community (Appendix, column 11)

On granitic outcrops in W Nigeria and in Benin, the poikilohydrous, creeping *Selaginella njam-njamensis* forms large patches of mats on bare rocks, co-occurring with *Afrotrilepis pilosa*. The distribution area of *Selaginella njam-njamensis* extends to East Africa.

Besides the *Selaginella njam-njamensis* community, a handful of other plant communities from the Côte d'Ivoire, Guinea and Nigeria can be placed into this alliance. They are documented with species lists (not included into the conspectus): Appendix, column 12 documents a mat on the Carter Peak in Nigeria (RICHARDS 1957). Single mat patches have widths of 8 m or more, contain epiphytic orchids and the moss *Syrrhopodon armatus* (*Calymperaceae*), and are later colonized by bushes. Columns 13 and 15 represent species lists from Ivorian mats (POREMBSKI & BARTHLOTT 1997), for which detailed ecological information is not available. Column 14 is a species list of a very open, low-growing damp grassland over laterite in Guinea (SCHNELL 1952). Two communities already lead to communities of the *Spermacoco hepperanae-Afrotrilepidion pilosae* as later stages in the succession:

### ***Andropogon africanus* community (Appendix, column 16)**

Grass mats with *Andropogon africanus* (= *A. linearis*), described by HAMBLER (1964) from W Nigeria, are floristically very similar to *Afrotrilepis pilosa* mats. The name-giving grass *Andropogon africanus* forms tussocks and colonizes the upper parts of the *Afrotrilepis pilosa* mats where drainage water enters. The species, distributed in tropical Africa, is typical for floodplains and other shallow, inundated soils. It develops with the first rains, earlier than the adjacent ephemeral flush vegetation (*Drosero indicae-Utricularietalia subulatae* communities, see above). Normally, *Andropogon africanus* is burnt in the dry season.

Finally, Appendix, column 17 is based on a constancy table from *Afrotrilepis pilosa* mats from several Ivorian inselbergs (POREMBSKI et al. 1996b). Floristically, it stands between the first group of communities (columns 11–16) and the communities of the *Spermacoco hepperanae-Afrotrilepidion pilosae* (columns 18–23). The list is rich in species, maybe because it combines species lists from several inselbergs (separate lists from single stands are not available). Central parts of the *Afrotrilepis pilosa* mats are usually free of accompanying species. *Spermacoce hepperana* and *Aeollanthus pubescens* are not present. POREMBSKI & BARTHLOTT (1992) mention some further occurrences of *Afrotrilepis pilosa* mats from Guinean inselbergs.

### ***Spermacoco hepperanae-Afrotrilepidion pilosae* all. nov. hoc loco (Appendix, columns 18–23)**

Typus: *Spermacoco hepperanae-Afrotrilepidetum pilosae* (typification see below)

Diagnostic species: *Aeollanthus pubescens*, *Aeschyoneme lateritica*, *Andropogon africanus*, *Ascolepis protea*, *Canscora decussata*, *Fimbristylis bisumbellata*, *Hibiscus scotellii*, *Indigofera deightonii*, *Microchloa kunthii*, *Nemum spadiceum*, *Scilla sudanica*, *Solenostemon latifolius*, *Spermacoce hepperana*, *Tripogon minimus*

Communities of the alliance *Spermacoco hepperanae-Afrotrilepidion pilosae* represent later succession stages of *Afrotrilepis pilosa* mats. They are known from Benin, Sierra Leone and the Côte d'Ivoire; they are richer in species than the pioneer communities and can be two-layered. These communities assemble short-lived therophytes, geophytes and hemicryptophytes. In a later phase, they may be colonized by woody species, of which the most important is *Hymenodictyon floribundum* (*Rubiaceae*), a small tree up to 8 m height, which is typical for open places and inselbergs. The floristic composition of the *Spermacoco hepperanae-Afrotrilepidion pilosae* is characterized by low-growing annuals and some perennials. *Poaceae* (*Andropogon africanus*, *Tripogon minimus*) and *Cyperaceae* prevail. Some of the diagnostic species are savanna species, e.g. *Scilla sudanica*. *Solenostemon latifolius* and *Tripogon minimus* have their ecological emphasis on rocks and *Hibiscus scotellii* is almost completely restricted to inselbergs. So far, the alliance comprises one association, documented for Benin. Several other plant communities are of only local importance.

### ***Spermacoco hepperanae-Afrotrilepidetum pilosae* ass. nov. hoc loco (Appendix, column 18–19)**

(syn.: groupement à *Afrotrilepis pilosa* et *Cyanotis lanata* sensu OUMOROU & LEJOLY 2003a).

Typus relevé: OUMOROU & LEJOLY (2003a), Table 2, No. 10

Diagnostic species: *Aeollanthus pubescens*, *Afrotrilepis pilosa*, *Spermacoce hepperana*

The *Spermacoco hepperanae-Afrotrilepidetum pilosae* is a two-layered community poor in species that represents the xeric vegetation of the alliance. Its spatial structure is dominated by *Afrotrilepis pilosa* and *Cyanotis lanata*. *Spermacoce hepperana* is constantly present. 10 of 14 plant species found are therophytes. *Aeollanthus pubescens*, a slightly fleshy annual, is a West African floristic element. In some places *Hymenodictyon floribundum* is present. Column 19 shows a species list from stands of xeric grasslands from inselbergs of Benin (OUMOROU & LEJOLY 2003b). Unfortunately, detailed ecological information is missing and individual relevés are not available. Because of its floristic similarity, it can be placed into the *Spermacoco hepperanae-Afrotrilepidetum pilosae*.

Four plant communities, documented in columns 20–23, are transitions between communities of the *Spermacoco hepperanae-Afrotrilepidion pilosae* and those of the *Eriocaulo pumili-Ophioglossion*. Stands of plant communities of both alliances are very often in the direct neighbourhood. Appendix, column 20 shows a species list from Sierra Leone, which is rich in species and contains several bulbous and tuberous species. However, the diagnostic species of the *Spermacoco hepperanae-Afrotrilepidion pilosae* are to a large extent missing. The stands colonize damp bogs on iron hardpans where sand and gravel can accumulate. GLEDHILL (1970) stated that some of the species, including *Afrotrilepis pilosa*, are more typical for granitic exposures.

The *Andropogon africanus-Ophioglossum costatum* community sensu OUMOROU & LEJOLY (2003a) (Appendix, column 21) is floristically quite heterogeneous: it contains diagnostic species of at least three phytosociological classes: the actual rock pool community (inundated rock pool with only very shallow soils, *Eriocaulo pumili-Ophioglossion*), an *Afrotrilepis pilosa* mat (which floristically corresponds exactly to the *Spermacoco hepperanae-Afrotrilepidetum pilosae*), and finally therophytic grasses, transgressive species from the class *Microchloetea indicae*, growing in a circular belt around the other species. OUMOROU & LEJOLY (2003a) explain this heterogeneity by variation in soil depth, which may vary between 1 and 10 cm within the sampling plot, thus covering the whole ecological range of the studied vegetation.

Like the *Andropogon africanus-Ophioglossum costatum* community, the *Sporobolus festivus-Microchloa indica* community sensu OUMOROU & LEJOLY (2003a) (Appendix, column 22) is floristically heterogeneous. The chosen sampling size of 35 $m^2$ is much too large for this kind of vegetation. Because of *Sporobolus festivus* and *Microchloa indica*, the authors place it into the class *Microchloetea indicae*. However, the community grows on temporarily inundated, very shallow soils and dries up completely during the dry season. It should be better placed into the *Spermacoco hepperanae-Afrotrilepidion* (*Spermacoco hepperanae-Afrotrilepidetum pilosae*), with *Sporobolus festivus* and *Microchloa indica* being taken as transgressive species. Its edges are colonized by rock pool species.

Appendix, column 23 represents relevés of ephemeral flush vegetation from Ivorian inselbergs (DÖRRSTOCK et al. 1996). With a total of 95 plant species, the list is very rich in species. A profile drawing in DÖRRSTOCK et al. (1996) shows the ecological heterogeneity of the studied sites, which results in a floristic and structural heterogeneity: the original relevés unite diagnostic species of three classes: *Drosero-Xyridetea*, *Afrotrilepidetea pilosae* and *Microchloetea indicae*.

## Plant communities of local interest that cannot be put into the existing syntaxonomical scheme (Appendix, columns 24–27)

Some plant communities, all documented by species lists from Mali, Nigeria and Guinea, cannot be put into the existing syntaxonomical scheme, because the plant species, considered as diagnostic species of the mentioned syntaxa, are missing. Currently, these plant communities are of only local interest, and they are not included into the syntaxonomical conspectus. When more data are available, it should be checked whether they form repetitive units in several regions, or whether they are species assemblages of only stochastic character. They include a seasonal rock dome community from Nigeria presented in Appendix, column 24 (ISICHEI & LONGE 1984), a relatively heterogenous stand of marsh vegetation over rock outcrops in the Mambila Plateau in Nigeria (HEPPER 1966, Appendix, column 25), herbaceous vegetation of rock exposures on the Obudu Plateau in SE Nigeria (HALL & MEDLER 1975, Appendix, column 26), and a low-growing damp grassland from Guinea (SCHNELL 1952, Appendix, column 27).

## Plant communities from Atlantic Central Africa

The West African vegetation units are compared with plant communities from parts of Atlantic Central Africa (Equatorial Guinea, Gabon and the DR Congo). They are very distinct from a floristic point of view. The ordination (Fig. 4, see below) underlines their floristic independence.

## Atlantic Central African *Afrotrilepis pilosa* mats

### *Oreonesiono testui-Afrotrilepidion pilosae* PARMENTIER 2006 (Appendix, columns 28–39)

Diagnostic species, according to PARMENTIER et al. (2006): *Eragrostis invalida*, *Eriosema parviflorum*, *Habenaria procera* var. *gabonensis*, *Oreonesion testui*, *Pellaea holstii*, *Polystachya gabonensisa*

The Atlantic Central African alliance *Oreonesiono testui-Afrotrilepidion pilosae* is vicariant to the two West African alliances of the *Afrotrilepidetalia pilosae*. Diagnostic species from West Africa are almost completely missing; *Afrotrilepis pilosa* is one of the few common species. Even at the genus level, there are not many common genera (e.g. *Utricularia*). However, the *Oreonesiono testui-Afrotrilepidion pilosae* exhibits an identical life-form spectrum and colonizes identical habitats. It contains a cluster of plant species which appear – within the presented data set – only there (e.g. *Antherotoma irvingiana*, *Habenaria procera* var. *gabonensis*, *Loudetiopsis glabrata*, *Oreonesion testui*, and *Utricularia andongensis*). PARMENTIER (2001) and PARMENTIER et al. (2001) give detailed information on the ecology and phytogeography of these plant communities, therefore they are not further treated here.

## Pioneer vegetation of rocky screes in tropical Africa

### *Lycopodietea cernui, Kalanchoetalia crenatae, Kalanchoion crenatae* (Appendix, column 40)

SCHMITZ (1988) described the *Kalanchoion crenatae* alliance of rocky and gravelly screes from mountainous regions of the DR Congo. He put a *Cyanotis lanata* community ("association à *Cyanotis lanata*" TATON 1949, Appendix, column 40) into this alliance. This community is poor in species and typically colonizes coarse weathered material in only weakly inclined granitic depressions. There are many common plant species with the *Sporoboletalia festivi*; often this *Cyanotis lanata* community is found in spatial contact to communities of the *Sporoboletalia festivi*; *Cyanotis lanata* is at the same time often present in *Afrotrilepis pilosa* communities.

## Pioneer vegetation of seasonally wet soils over granitic rocks in Central Africa

### *Microchloetea indicae, Sporoboletalia festivi, Ilysanthion* (Appendix, columns 41, 42)

The Central African order *Sporoboletalia festivi* LEBRUN 1947 consists of four alliances. One of them, the *Ilysanthion* TATON 1949, is documented in Appendix with two communities. First, the *Lindernia pulchella-Aeollanthus repens* community ("association à *Ilysanthes pulchella* [= *Lindernia pulchella*] et *Aeollanthus repens*" TATON 1949) in column 41 colonizes thin soil layers in depressions over granite. The stands reach 10 cm heights. It is characterized by *Lindernia pulchella* and *Aeollanthus repens* and by species of higher syntaxa (*Sporobolus festivus*, *Microchloa indica*). Second, the *Lindernia madiensis-Abildgaardia congolensis* community ("association à *Ilysanthes trichotoma* [= *Lindernia madiensis*] et *Bulbostylis polytricha* [= *Abildgaardia congolensis*]" TATON 1949) in column 42 colonizes habitats with deeper soils than the *Lindernia pulchella-Aeollanthus repens* community. It follows that community in the succession. Its open stands reach heights of up to 20 cm.

KNAPP (1966) proposes a West African class *Ilysanthetea gracilis* (nomen nudum) for xerophilous, annual grasslands (Appendix, column 43). His deductively found species list has strong floristic similarities to the *Lindernia madiensis-Abildgaardia congolensis* community and can be clustered with it. There are only weak floristic connections to West African annual grasslands.

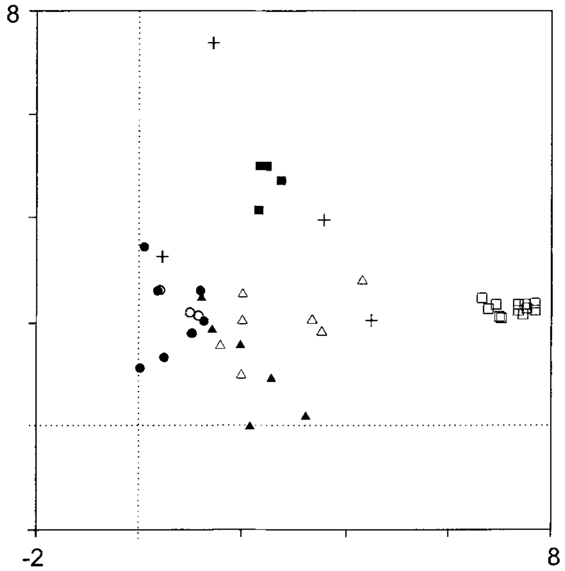

Fig. 4. DCA of herbaceous ephemeral vegetation of inselberg and laterite habitats (43 samples, 212 taxa, downweighting of rare species, shown are axes 1 and 2). Eigenvalues (cumulative percentage variance): axis 1: 0.923 (8.5), axis 2: 0.597 (13.9), total inertia 10.941. ● – *Eriocaulo pumili-Ophioglossion gomezianum*, ○ – *Genliseo africanae-Sporobolion pauciflori* (both *Drosero-Xyridetea*), ▲ – *Spermacoco hepperanae-Afrotrilepidion pilosae*, △ – *Cyanotido lanatae-Afrotrilepidion pilosae* (both *Afrotrilepidetea pilosae*), + – communities of unclear syntaxonomical position, □ – *Oreonesiono testui-Afrotrilepidion pilosae* (*Afrotrilepidetea pilosae*), ■ – *Kalanchoetalia crenatae* (*Lycopodietea cernui*) and *Sporoboletalia festivi* (*Microchloetea indicae*) from Central Africa.

## Ordination of the floristic data set

A first ordination analysis included 43 units with 245 taxa. The total inertia (sum of all eigenvalues) of 11.55 indicated a very high floristic heterogeneity within the data set. After removing all taxa that appeared only once, the sum of all eigenvalues was 10.91 (43 units, 212 taxa). In Fig. 4, the vegetation units are marked with different symbols according to the results of the classification, presented in Appendix. One cluster with the vegetation units of the Central African alliance *Oreonesiono testui-Afrotrilepidion pilosae* is clearly separated from the other units. This underlines the sharp floristic contrast to West African alliances of the *Afrotrilepidetea pilosae*. Units of the classes *Drosero-Xyridetea*, *Afrotrilepidetea pilosae* and *Sporoboletalia festivi* / *Kalanchoion crenatae* can be recognized as further clusters, however, they are less clearly separated.

*Abildgaardia hispidula*, *Afrotrilepis pilosa*, *Cyanotis lanata*, *Drosera indica*, *Lindernia exilis*, *Ophioglossum costatum*, *Scirpus briziformis*, *Sporobolus festivus*, *Utricularia subulata*, *Xyris straminea* and *Habenaria procera* var. *gabonensis* turned out to be the most important species within the data set. In the presented classification, six of them are considered as diagnostic species for higher syntaxa and two of them are important accompanying species. *Afrotrilepis pilosa*, *Cyanotis lanata*, *Drosera indica* and *Xyris straminea* are the four most important diagnostic species within the data set. Three of them define the classes *Drosero-Xyridetea* and *Afrotrilepidetea pilosae*.

To assess the relationships within the West African units, a second DCA was performed without the units from Central Africa (DCA, 23 units, 133 active taxa, Fig. 5). The two alliances within the *Drosero-Xyridetea*: *Eriocaulo pumili-Ophioglossion gomezianum* and *Genliseo africanae-Sporobolion pauciflori* are arranged along the first axis and are clearly separated. Along the first axis, there is a transition from the vegetation units of the *Drosero-Xyridetea* to the alliances of the *Afrotrilepidetea pilosae*. This transition is built by heterogeneous units, which is made obvious in Appendix. However, the centre of the *Afrotrilepidetea pilosae* is separated from the centre of the *Drosero-Xyridetea* along the first axis, with *Drosera indica*, *Xyris straminea* and other species on the left side and *Afrotrilepis pilosa* and *Cyanotis lanata* on the right side. At the same time, we can see the succession from the species-poor, pioneer units of the *Cyanotido lanatae-Afrotrilepidion pilosae* (right) to the units of the *Spermacoco hepperanae-Afrotrilepidion pilosae* (centre) along the first axis.

## DISCUSSION

### General remarks

The available data set allows us to propose a first phytosociological synopsis. The classification, based on floristic similarity, is supported by ordination techniques. Four associations and several rankless plant communities can be grouped into four phytosociological classes: *Drosero-Xyridetea*, *Afrotrilepidetea pilosae*, *Lycopodietea cernui* and *Microchloetea indicae*. The plant communities are arranged along a gradient of increasing soil depth. Water and nutrient availability depend on the soil depth. The syntaxa are ecologically and floristically well characterized, however, some units are heterogeneous. In such a case, we can assume that either the studied stand is a zonation complex between two or more plant communities or the plot size used for sampling was too large. At many sites, small-scale alterations of the ecological situation result in a mosaic-like pattern of the plant communities. As in other regions (PARMENTIER et al. 2005), species composition on a local scale is best explained by edaphic conditions. This mosaic of different soil depths has already been discussed by POREMBSKI (2000). For example, ephemeral flush vegetation with the genera *Eriocaulon*, *Ophioglossum*, *Utricularia* and *Xyris* colonizes the edges of *Afrotrilepis pilosa* mats. As a rule, dry places with a thin organic layer are colonized by low-growing annuals. In ephemeral wetland habitats, therophytic life forms and short life cycles are advantageous, whereas sandy or gravelly soils support perennial species. POREMBSKI (2000) showed that the predominance of annuals related to the total flora of an inselberg is less pronounced in the more humid rainforest region.

The presented vegetation units are astonishingly homogeneous on a large scale. The relevés and species lists from locations up to more than 2000 km away from each other can be grouped into a few syntaxa. POREMBSKI & BARTHLOTT (1992) studied floristic differences between single inselbergs of different countries. They did not find differences in plant diversity between the climatic zones, however, inselberg floras further in the north (e.g. in the North Sudanian zone, JAEGER & WINKOUN 1962) were shown to be poorer in species. Appendix shows that the floristic contrast is sharper in the longitudinal direction with decreasing precipitation from the south to the north than in the latitudinal direction. In the northern parts of the study area, some plant communities loose their diagnostic species, e.g.

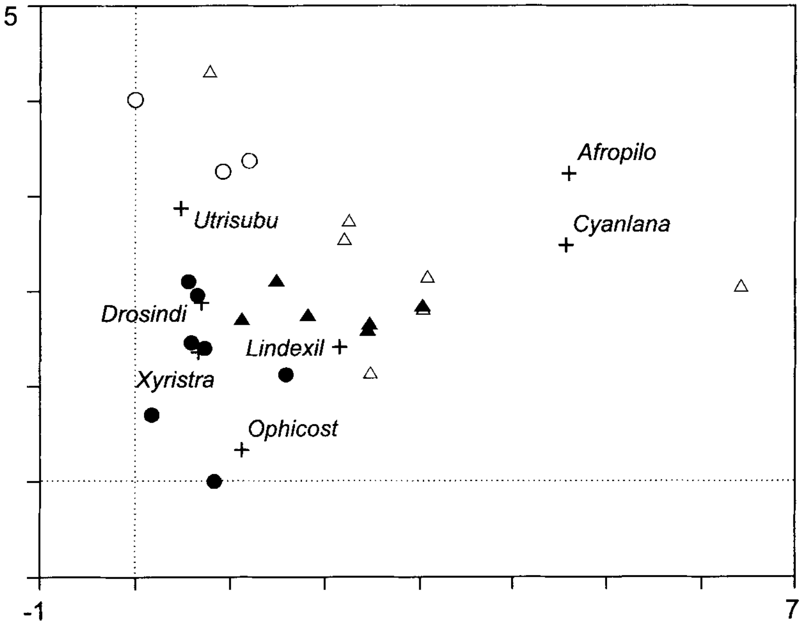

Fig. 5. DCA of the West African relevés (23 samples, 133 taxa, shown are axes 1 and 2). Eigenvalues (cumulative percentage variance): axis 1: 0.685 (10.6%), axis 2: 0.462 (17.7%), total inertia 6.483. ● – *Eriocaulo pumili-Ophioglossion gomezianum*, ○ – *Genliseo africanae-Sporobolion pauciflori* (both *Drosero-Xyridetea*), ▲ – *Spermacoco hepperanae-Afrotrilepidion pilosae*, △ – *Cyanotido lanatae-Afrotrilepidion pilosae* (both *Afrotrilepidetea pilosae*). Furthermore, the positions of the seven most important species are shown.

*Afrotrilepis pilosa*. Wittig et al. (2000) mentioned a *Cyanotis lanata* community without *Afrotrilepis pilosa* in small sandstone crevices of the Chaîne de Gobnangou in SE Burkina Faso. On the contrary, wet flush vegetation is richer in species in the savanna zone than in the rainforest zone (Porembski 2000).

There are only very few data from the North Sudanian zone and practically none from the Sahelian zone, although quite a lot of phytosociological studies were done in these zones. Jaeger & Winkoun (1962) provided some occasional observations from the Sahelian Hombori Mountains in Mali: they mentioned herbaceous vegetation in seasonal rock pools on the summits of these sandstone inselbergs but without indicating the observed species.

Many of the plant species in the described syntaxa are specialists (Porembski & Barthlott 1992). Reitsma et al. (1992) suggested that inselbergs could be refugia for xerophytes, however, the proportion of endemic species is low (see list provided in Porembski 2000). Many ruderals or neophytes are present and widespread savanna elements are well represented (but see situation in other floristic regions, e.g. Porembski 1996 for Malawi). *Afrotrilepis pilosa* mats are dominated by Guineo-Congolian elements whereas Sudano-Zambezian species make up the largest part of ephemeral flush vegetation (Porembski et al. 1994). Regarding the represented families, the almost complete absence of representatives of *Asteraceae*, *Crassulaceae* and *Gesneriaceae*, which are important constituents of inselbergs in East Africa (Porembski 1996), is remarkable.

## Ephemeral flush vegetation

Rock outcrop communities can be considered as azonal vegetation types (POREMBSKI et al. 1996a). Their appearance and structure is determined by the substrate and not by the climatic situation. POREMBSKI et al. (1996a) qualified this opinion by saying that ephemeral flush vegetation is only weakly developed in the rainforest zone. RICHARDS (1957) mentioned ephemeral flush vegetation with *Drosera indica*, *Utricularia* ssp. and *Xyris straminea* (*Drosero indicae-Utricularietalia subulatae*) as widely distributed in Nigeria and Cameroon. Records from rock pools in the North Sudanian zone are much rarer and are of only rudimentary character (e.g. Kita Mountains, JAEGER 1950; Bandiagara Mountains, JAEGER & WINKOUN 1962). The species pool of exclusive rock pool species is small (RAYNAL & RAYNAL 1961); many common hydrophytes are always present.

Ephemeral flush vegetation is not limited to West and Central Africa: in Madagascar, this vegetation type is rich in species and contains many African or pantropical elements (FISCHER & THEISEN 2000); important genera, common with West Africa, are *Bulbostylis*, *Cyperus*, *Eriocaulon*, *Scleria*, and *Xyris*. In both regions, the carnivorous genera *Drosera*, *Genlisea* and *Utricularia* are typical elements. Carnivory is seen as an adaptation to soil nutrient (N, P, S) deficiency. Representatives of the genus *Lindernia* are very important elements in East African rock pool vegetation (SEINE & BECKER 2000) and play significant roles in South America (DEIL 2005). MONOD (1954) stressed the fact that there are remarkable ecological parallels between *Drosero indicae-Utricularietalia subulatae* communities and Mediterranean *Isoëtion* communities.

MÜLLER & DEIL (2005) underlined the striking parallels between African and South American rock outcrop communities in ecology, life forms, and floristic composition at the genus level. A vicarious class to the African *Drosero-Xyridetea* was outlined by GALÁN DE MERA (1995) and GALÁN DE MERA et al. (2002) for Latin America, the *Xyridetea savanensis*. Detailed information about this dwarf turf vegetation on oligotrophic, temporary inundated white sands are available for example from French Guiana (RAYNAL-ROQUES & JÉRÉMIE 1980) and Colombia (DUIVENVOORDEN & CLEEF 1994).

## *Afrotrilepis pilosa* mats

Plant colonization in *Afrotrilepis pilosa* mats is affected by short-term variation in water-availability (POREMBSKI et al. 1995). *Afrotrilepis pilosa* is a desiccation tolerant species. This adaptation is very characteristic on inselbergs but very rarely developed in vascular plants (POREMBSKI & BARTHLOTT 2000b). In the Loma Mountains there is a second *Afrotrilepis* species, joining *Afrotrilepis pilosa*: the local endemic *Afrotrilepis jaegeri* (JAEGER 1971). A second noteworthy species from the Loma Mountains, mentioned for temporal pools, is *Utricularia tetraloba*, distributed in Guinea and Sierra Leone (JAEGER & ADAM 1971). The phytogeographical significance of the Loma Mountains was highlighted by JAEGER (1976). Some orophytic species, in West Africa limited to these mountains, have disjunct ranges and reappear on inselbergs in Cameroon.

A second desiccation-tolerant vascular plant species is *Xerophyta* (= *Vellozia*) *schnizleinia* var. *occidentalis* (KERSHAW 1968). It colonizes granitic outcrops in N Nigeria (AYO OWOSEYE & SANFORD 1972). Whereas *Afrotrilepis pilosa* is limited to areas with a relatively short dry season, *Xerophyta schnizleinia* dominates in northern regions of Nigeria with a longer dry season. Like *Afrotrilepis pilosa*, *Xerophyta schnizleinia* forms large mats on gentle slopes and recovers within a few days when water becomes available. Unfortunately, there are no relevés or other documentations of these *Xerophyta schnizleinia* mats.

*Cyanotis lanata* is very widespread in tropical Africa and in some areas it occurs in roadside vegetation (SEINE et al. 2000) and other kinds of sun-exposed habitats. *Cyanotis arachnoidea*, a related species, is a common mat-forming species on rainforest inselbergs (POREMBSKI 2000), nevertheless it is documented in our data set only once. In Atlantic Central Africa, it often forms monospecific mats (PARMENTIER, in litt.).

Not only in West and Atlantic Central Africa but also in other African regions, we can find mat-forming vegetation on mountainous slopes and inselbergs (POREMBSKI 2000). Mat-forming elements are always representatives of the families *Cyperaceae* and *Velloziaceae*. The most important mat-forming species in East Africa and in Madagascar is *Coleochloa setifera* (*Cyperaceae*), a vicariant to *Afrotrilepis pilosa*. Poikilohydrous *Velloziaceae* are typical elements of East African inselbergs, e.g. *Xerophyta schnizleinia* var. *schnizleinia* and var. *somaliensis* and *X. splendens*.

Neotropical mat vegetation in South America is more diverse than the African. The mat-forming species belong to the families *Bromeliaceae* and *Velloziaceae*. As in Africa, epiphytic orchids colonize the mat-forming species.

## Vegetation dynamics and succession

Small inselberg and rock outcrop habitats are often affected by heavy fluctuations of their environmental and climatic conditions. Phenological fluctuations changing the structure and species number of vegetation stands can be mainly observed in ephemeral flush vegetation, which is a highly seasonal vegetation type. In contrast, the species number in *Afrotrilepis pilosa* mats is relatively unaffected by the rainfall regime (POREMBSKI & BARTHLOTT 1997, POREMBSKI et al. 2000b). Seasonal or phenological phenomena were rarely studied in West Africa (but see HAMBLER 1964, POREMBSKI & BARTHLOTT 1997). ISICHEI & LONGE (1984) found distinct phenological differences concerning species number and the dominance patterns of plant species in a rock community in Nigeria: at the beginning of the growing season, ephemeral species, e.g. *Lindernia exilis*, dominated and were later replaced by perennials. Both the number of species and the number of individuals declined after a peak at the beginning of the growing season.

Besides regular short-term dynamics, there are also long-term vegetation dynamics with cycles spanning several years (POREMBSKI et al. 2000b). The mean turnover rate in ten years on Ivorian inselbergs is 17% (KRIEGER et al. 2003); climatic disturbances are seen as the major driving forces determining community dynamics.

With a gradual accumulation of soil particles and organic material, succession takes place in ephemeral flush vegetation. Unfortunately, this phenomenon was also rarely studied in West Africa. More information is available on the succession of *Afrotrilepis pilosa* mats. Some authors consider *Afrotrilepis pilosa* dominated communities on shallow soils as stable, fire-maintained ecosystems (PARMENTIER et al. 2006). Others postulate a first succession from species-poor pioneer stands (*Cyanotido lanatae-Afrotrilepidion pilosae*) to communities of the *Spermacoco hepperanae-Afrotrilepidion*. The succession continues to grasslands. A *Loudetia togoensis* grassland is documented from Nigeria and Burkina Faso on shallow habitats that are still damp or inundated during the rainy season (RICHARDS 1957, WITTIG et al. 2000). As a result of burning, *Loudetia arundinacea* can invade *Afrotrilepis pilosa* mats (RICHARDS 1957). PARMENTIER (2003) described a species-poor *Loudetiopsis glabrata* grassland on humid slopes of Equatorial Guinean inselbergs.

Depending on the location and accessibility, herbaceous, seasonally wet vegetation on mountains, inselbergs and lateritic crusts are differently influenced by humans. Traditional taboos are still followed in some areas. Already ADAM (1970) and HALL (1971b) focused on the negative influence of human activities, e.g. growing population numbers, grazing pressure and mining activities on mountainous vegetation.

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## REFERENCES

ABERLIN J.-P. (1986): Les abris humides sous roches au Mali central. *Feddes Repert.* 97: 697–704.

ADAM J. (1947): La végétation de la région de la source du Niger. *Ann. Géogr.* 56: 192–200.

ADAM J.-G. (1970): État actuel de la végétation des Monts Nimba au Libéria et en Guinée. *Adansonia, Sér. 2,* 10: 193–211.

ADAM J.-G. (1971): La botanique. In: INSTITUT FONDAMENTAL D'AFRIQUE NOIRE (ed.), *Le Massif des monts Loma. Recherches géographiques, botaniques et zoologiques,* Mémoires IFAN 86. IFAN, Dakar.

ADJANOHOUN E.J. (1964): *Végétation des savanes et des rochers découverts en Côte d'Ivoire Centrale.* Mémoires ORSTOM 7, ORSTOM, Paris.

ALSTON A.H.G. (1959): *The ferns and fern-allies of West Tropical Africa. A supplement to the second edition of the Flora of West Tropical Africa.* Crown Agents for Oversea Governments and Administrations, London.

AYO OWOSEYE J. & SANFORD W.W. (1972): An ecological study of *Vellozia schnitzleinia*, a drought-enduring plant of northern Nigeria. *J. Ecol.* 60: 807–817.

COLE N.H.A. (1967): Ecology of the Montane Community at the Tingi Hills in Sierra Leone. *Bull. IFAN, sér. A,* 29: 904–924.

DEIL U. (2005): A review on habitats, plant traits and vegetation of ephemeral wetlands – a global perspective. *Phytocoenologia* 35: 533–705.

DÖRRSTOCK S., POREMBSKI S. & BARTHLOTT W. (1996): Ephemeral flush vegetation on inselbergs in the Ivory Coast (West Africa). *Candollea* 51: 407–419.

DUIVENVOORDEN J.F. & CLEEF A.M. (1994): Amazonian savanna vegetation on the sandstone plateau near Araracuara, Colombia. *Phytocoenologia* 24: 197–232.

FISCHER E. & THEISEN I. (2000): Vegetation of Malagasy inselbergs. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions,* Springer, Berlin, Heidelberg, pp. 259–276.

FRAHM J.-P., POREMBSKI S., SEINE R. & BARTHLOTT W. (1996): Moose von Inselbergen aus Elfenbeinküste und Zimbabwe. *Nova Hedwigia* 62: 177–189.

GALÁN DE MERA A. (1995): Ensayo sintaxonómico sobre las comunidades vegetales acuáticas del Perú. *Arnaldoa* 3: 51–58.

GALÁN DE MERA A., ROSA V.M. & CÁCERES C. (2002): Una aproximación sintaxonómica sobre la vegetación del Perú. Clases, ordenes y alianzas. *Acta Bot. Malacit.* 27: 75–103.

GLEDHILL D. (1970): The vegetation of superficial ironstone hardpans in Sierra Leone. *J. Ecol.* 58: 265–274.

HALL J.B. (1971a): Observations on Isoetes in Ghana. *Bot. J. Linn. Soc.* 64: 117–139.

HALL J.B. (1971b): Environment and vegetation on Nigeria's highlands. *Vegetatio* 23: 339–359.

HALL J.B. & MEDLER J.A. (1975): Highland vegetation in south-eastern Nigeria and its affinities. *Vegetatio* 29: 191–198.

HAMBLER D.J. (1964): The vegetation of granitic outcrops in Western Nigeria. *J. Ecol.* 52: 573–594.

HENNEKENS S.M. & SCHAMINÉE J.H.J. (2001): TURBOVEG, a comprehensive data base management system for vegetation data. *J. Veg. Sci.* 12: 589–591.

HEPPER F.N. (1966): Outline of the vegetation and flora of Mambila Plateau, Northern Nigeria. *Bull. IFAN, sér. A*, 28: 91–127.

HILL M.O. (1979): *TWINSPAN – A FORTRAN program for arranging multivariate data in an ordered two way table by classification of the individuals and attributes*. Cornell University, Ithaca.

ISICHEI A.O. & LONGE P.A. (1984): Seasonal succession in a small isolated rock dome plant community in western Nigeria. *Oikos* 43: 17–22.

JAEGER P. (1950): Aperçu sommaire de la végétation du Massif de Kita (Soudan Français). *Rev. Int. Bot. Appl. Agric. Trop.* 30: 501–506.

JAEGER P. (1959): Les plateaux gréseux du Soudan occidental. Leur importance phytogéographique. *Bull. IFAN, sér. A*, 21: 1147–1159.

JAEGER P. (1971): Etude sur l'écologie et la signification phytogéographique de l'*Afrotrilepis jaegeri*, Cypéracée saxicole endémique des Monts Loma (Sierra-Leone). *Mitt. Bot. Staatssamml. München* 10: 618–621.

JAEGER P. (1976): Le massif des monts Loma (Sierra Leone) – Son importance phytogéographique. *Boissiera* 24: 473–475.

JAEGER P. & ADAM J.-G. (1971): Aperçu succinct sur la flore et la végétation de l'étage culminal des Monts Loma (Sierra Leone). *Mitt. Bot. Staatssamml. München* 10: 478–483.

JAEGER P. & WINKOUN D. (1962): Premier contact ave la flore et la végétation du plateau de Bandiagara. *Bull. IFAN, sér. A*, 24: 69–111.

KERSHAW K.A. (1968): A survey of the vegetation in Zaria province, N. Nigeria. *Vegetatio* 15: 244–268.

KNAPP R. (1966): Höhere Vegetationseinheiten von West-Afrika unter besonderer Berücksichtigung von Nigeria und Kamerun. *Geobot. Mit.* 34: 1–16.

KNAPP R. (1973): *Die Vegetation von Afrika – unter Berücksichtigung von Umwelt, Entwicklung, Wirtschaft, Agrar- und Forstgeographie*. Gustav Fischer, Stuttgart.

KRIEGER A., POREMBSKI S. & BARTHLOTT W. (2003): Temporal dynamics of an ephemeral plant community: species turnover in seasonal rock pools on Ivorian inselbergs. *Pl. Ecol.* 167: 283–292.

LEBRUN J.-P. & STORK A.L. (1991–1997): *Énumération des plantes a fleurs d' Afrique tropicale. 1–4*. Jardin Botanique, Geneve.

LÉONARD J. (1950): Botanique du Congo belge. I. Les groupements végétaux. In: *Encyclopédie du Congo belge 1*, Éditions Bieleveld, Brussels, pp. 345–389.

MONOD T. (1954): Sur une florule soudanaise hygrophile. *Bull. IFAN, sér. A*, 16: 309–320.

MÜLLER J.V. & DEIL U. (2005): The ephemeral vegetation of seasonal and semi-permanent ponds in tropical West Africa. *Phytocoenologia* 35: 327–388.

O'SHEA B.J. (2003): Checklist of the mosses of sub-Saharan Africa (version 4, 12/03). *Trop. Bryol. Res. Rep.* 4: 1–182.

OUMOROU M. & LEJOLY J. (2003a): Écologie, flore et végétation de l'inselberg Sobakpérou (nord-Bénin). *Acta Bot. Gallica* 150: 65–84.

OUMOROU M. & LEJOLY J. (2003b): Aperçu de la végétation de quelques inselbergs du Bénin. *Syst. Geogr. Pl.* 73: 215–236.

PARMENTIER I. (2001): Premieres études sur la diversité végétale des inselbergs de Guinée Equatoriale continentale. *Syst. Geogr. Pl.* 71: 911–922.

PARMENTIER I. (2003): Study of the vegetation composition in three inselbergs from continental Equatorial Guinea (Western Central Africa): effects of site, soil factors and position relative to forest fringe. *Belg. J. Bot.* 136: 63–72.

PARMENTIER I., LEJOLY J. & NGUEMA N. (2001): La végétation des inselbergs de Piedra Nzas (Guinée Équatoriale continentale). *Acta Bot. Gallica* 148: 341–365.

PARMENTIER I. & MÜLLER J.V. (2006): Grasslands and herbaceous fringes on inselbergs in Atlantic central Africa. *Phytoceonologia* 36: in press.

PARMENTIER I., OUMOROU M., POREMBSKI S., LEJOLY J. & DECOCQ G. (2006): Ecology, distribution and classification of xeric monocotyledonous mats on inselbergs in West Africa and Atlantic central Africa. – Do the inselberg species' socio-ecology and distribution differ according to the surrounding matrix vegetation? *Phytocoenologia* 36: in press.

PARMENTIER I., STÉVART T. & HARDY O.J. (2005): The inselberg flora of Atlantic Central Africa. I. Determinants of species assemblages. *J. Biogeogr.* 32: 685–696.

POREMBSKI S. (1996): Notes on the vegetation of inselbergs in Malawi. *Flora* 191: 1–8.

POREMBSKI S. (2000): West African inselberg vegetation. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 177–211.

POREMBSKI S. & BARTHLOTT W. (1992): Struktur und Diversität der Vegetation westafrikanischer Inselberge. *Geobot. Kolloq.* 8: 69–80.

POREMBSKI S. & BARTHLOTT W. (1997): Seasonal dynamics of plant diversity on inselbergs in the Ivory Coast (West Africa). *Bot. Acta* 110: 466–472.

POREMBSKI S. & BARTHLOTT W. (eds.) (2000a): *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions. Ecological studies 146.* Springer, Berlin, Heidelberg.

POREMBSKI S. & BARTHLOTT W. (2000b): Granitic and gneissic outcrops (inselbergs) as centers of diversity for desiccation-tolerant vascular plants. *Pl. Ecol.* 151: 19–28.

POREMBSKI S., BARTHLOTT W., DÖRRSTOCK S. & BIEDINGER N. (1994): Vegetation of rock outcrops in Guinea: granite inselbergs, sandstone table mountains and ferricretes – remarks on species numbers and endemism. *Flora* 189: 315–326.

POREMBSKI S., BECKER U. & SEINE R. (2000a): Islands on islands: Habitats on inselbergs. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 49–67.

POREMBSKI S. & BROWN G. (1995): The vegetation of inselbergs in the Comoé National Park (Ivory Coast). *Candollea* 50: 351–365.

POREMBSKI S., BROWN G. & BARTHLOTT W. (1995): An inverted latitudinal gradient of plant diversity in shallow depressions on Ivorian inselbergs. *Vegetatio* 117: 151–163.

POREMBSKI S., BROWN G. & BARTHLOTT W. (1996b): A species-poor tropical sedge community: *Afrotrilepis pilosa* mats on inselbergs in West Africa. *Nordic J. Bot.* 16: 239–245.

POREMBSKI S., SEINE R. & BARTHLOTT W. (2000b): Factors controlling species richness of inselbergs. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 451–481.

POREMBSKI S., SZARZYNSKI J., MUND J.-P. & BARTHLOTT W. (1996a): Biodiversity and vegetation of small-sized inselbergs in a West African rain forest (Tai, Ivory Coast). *J. Biogeogr.* 23: 47–55.

RAYNAL J. & RAYNAL A. (1961): Observations botaniques dans la région de Bamako. *Bull. IFAN, sér. A*, 23: 994–1027.

RAYNAL-ROQUES A. & JÉRÉMIE J. (1980): Un marécage saxicole a *Isoetes* et *Ophioglossum* en Guyane française. *Adansonia, Sér. 2*, 19: 403–412.

REITSMA J.M., LOUIS A.M. & FLORET J.-J. (1992): Flore et végétation des inselbergs et dalles rocheuses: premiere étude au Gabon. *Adansonia, Sect. B*, 14: 73–97.

RICHARDS P.W. (1957): Ecological notes on West African vegetation. I. The plant communities of the Idanre Hills, Nigeria. *J. Ecol.* 45: 563–577.

SCHMITZ A. (1988): Revision des groupements végétaux décrits du Zaire, du Rwanda et du Burundi. *Ann. Mus. Roy. Afrique Centr., Sci. Econ.* 17: 1–277.

SCHNELL R. (1951–1952): Végétation et flore des Monts Nimba (Afrique occidentale française). *Vegetatio* 3: 350–406.

SCHNELL R. (1952): Contribution a une étude phytosociologique et phytogéographique de l'Afrique occidentale: les groupements et les unités géobotanique de la région guinéenne. In: MONOD T. & SCHNELL R. (eds.), *Mélanges Botaniques*, Mém. IFAN 18, Dakar, pp. 41–236.

SCHNELL R. (1957): Remarques sur les forets des montagnes ouest-africaines (Guinée et Côte d'Ivoire) et leur individualisation floristique. *Bull. Jard. Bot. État* 27: 279–287.

SCHNELL R. (1961): Contribution a l'étude botanique de la Chaîne de Fon (Guinée). *Bull. Jard. Bot. État* 31: 15–54.

SEINE R. & BECKER U. (2000): East and Southeast Africa. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 213–235.

SEINE R., POREMBSKI S. & BECKER U. (2000): Phytogeography. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 435–449.

SZARZYNSKI J. (2000): Xeric islands: Environmental conditions on inselbergs. In: POREMBSKI S. & BARTHLOTT W. (eds.), *Inselbergs. Biotic diversity of isolated rock outcrops in tropical and temperate regions*, Springer, Berlin, Heidelberg, pp. 37–48.

TATON A. (1948): La colonisation des roches granitiques de la region de Nioka (Haut-Ituri – Congo belge). *Vegetatio* 1: 317–332.

TCHAMIE T. & BOURAIMA M. (1997): Les formations végétales du Plateau Soudou-Dako dans la chaîne de l'Atakora et leur évolution récente (Nord Togo). *J. Bot. Soc. Bot. France* 3: 83–94.

TENTE B. & SINSIN B. (2002): Diversité et structure des formations arborescentes du secteur Perma-Toucountouna dans la chaîne de l'Atacora (Bénin). *Etud. Florist. Vég. Burkina Faso* 6: 31–42.

TER BRAAK C.J.F. & ŠMILAUER P. (2002): *CANOCO Reference Manual and CanoDraw for Windows User's guide: Software for Canonical Community Ordination (version 4.5)*. Microcomputer Power, Ithaca.

WEBER H.E., MORAVEC J. & THEURILLAT J.P. (2000): International Code of Phytosociological Nomenclature. 3rd edition. *J. Veg. Sci.* 11: 739–768.

WHITE F. (1983): *The vegetation of Africa. A descriptive memoire to accompany the UNESCO/AETFAT/UNSO vegetation map of Africa*. UNESCO, Paris.

WIGGINTON M.J. (2002): Checklist and distribution of the liverworts and hornworts of sub-Saharan Africa, including the East African Islands. *Trop. Bryol. Res. Rep.* 3: 1–88.

WITTIG R., HAHN-HADJALI K. & THIOMBIANO A. (2000): Les particularités de la végétation et de la flore de la chaîne du Gobnangou dans le Sud-Est du Burkina Faso. *Etud. Florist. Vég. Burkina Faso* 5: 49–64.

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## APPENDIX

Synoptic table of herbaceous vegetation of seasonally wet habitats on inselbegs and lateritic crusts in West and Atlantic Central Africa. Numbers from 1 to 10 indicate constancy classes (1: 1–10%, 2: 10–20%, 3: 20–30% etc.). DS – diagnostic species; companions occurring only once are omitted. Bibliographic references: 1 – ADJANOHOUN (1964: Table 13); 2 – ADJANOHOUN (1964: Table 14); 3 – POREMBSKI & BARTHLOTT (1997: Table 1: 2); 4 – ABERLIN (1986: 699); 5 – HAMBLER (1964: 582); 6 – OUMOROU & LEJOLY (2003b: 229); 7 – HALL (1971a: Table 3); 8 – SCHNELL (1951–1952: 382); 9 – ADAM (1971: 120); 10 – SCHNELL (1952: 195); 11 – HAMBLER (1964: 587); 12 – RICHARDS (1957: 568); 13 – POREMBSKI & BARTHLOTT (1997: Table 1: 3); 14 – SCHNELL (1952: 195); 15 – POREMBSKI & BARTHLOTT (1997: Table 1: 1); 16 – HAMBLER (1964: 580); 17 – POREMBSKI et al. (1996b: Table 1); 18 – OUMOROU & LEJOLY (2003a: Table 2, G5); 19 – OUMOROU & LEJOLY (2003b: 228); 20 – GLEDHILL (1970: Appendix (d)); 21 – OUMOROU & LEJOLY (2003a: Table 2, G7); 22 – OUMOROU & LEJOLY (2003a: Table 2, G6); 23 – DÖRRSTOCK et al. (1996: Table 2); 24 – ISICHEI & LONGE (1984: Appendix); 25 – HEPPER (1966: 105); 26 – HALL & MEDLER (1975: 194); 27 – SCHNELL (1952: 195); 28 – PARMENTIER (2001: 915); 29 – PARMENTIER et al. (2001: Table 2, A1); 30 – PARMENTIER et al. (2001: Table 2, A2); 31 – PARMENTIER et al. (2001: Table 2, A3); 32 – PARMENTIER et al. (2001: Table 2, C1); 33 – REITSMA et al. (1992: Appendix, A-1); 34 – PARMENTIER et al. (2001: Table 2, B); 35 – PARMENTIER et al. (2001: Table 2, C2); 36 – PARMENTIER et al. (2001: Table 2, C3); 37 – REITSMA et al. (1992: Appendix, A-2); 38 – PARMENTIER (2001: 915); 39 – PARMENTIER (2001: 915); 40 – TATON (1948: Table 1, 10–13); 41 – TATON (1948: Table 1, 1–9); 42 – TATON (1948: Table 2); 43 – KNAPP (1973: 265).

| Column number | 1 | 2 | 3 | 4 | 5 | 6 | 7 | 8 | 9 | 10 | 11 | 12 | 13 | 14 | 15 | 16 | 17 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| Number of relevés / species lists | 2 | 3 | 1 | 1 | 1 | 1 | 4 | 2 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 1 | 10 |
| Number of species | 38 | 36 | 15 | 19 | 7 | 19 | 34 | 17 | 28 | 12 | 15 | 17 | 3 | 15 | 11 | 9 | 15 |
| **DS of *Drosero indicae-Utricularietalia subulatae* and *Drosero-Xyridetea*** | | | | | | | | | | | | | | | | | |
| *Xyris straminea* | 6 | 10 | 10 | . | 10 | 10 | . | 10 | 10 | . | . | . | . | . | . | . | . |
| *Eriocaulon pumilum* | 6 | 4 | . | . | . | . | . | 10 | 10 | . | . | . | . | . | . | . | . |
| *Xyris capensis* | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Drosera indica* | 6 | 10 | 10 | 10 | 10 | 10 | 3 | 6 | 10 | 10 | . | . | . | . | . | . | . |
| *Utricularia subulata* | . | 10 | 10 | . | . | 10 | 3 | 10 | 10 | 10 | . | . | . | . | . | . | . |
| *Ophioglossum costatum* | 6 | 4 | 10 | . | . | 8 | 3 | . | . | . | . | . | . | . | 10 | . | . |
| *Utricularia pubescens* | . | . | 10 | . | . | . | . | 10 | 10 | . | . | . | . | . | . | . | . |
| *Lindernia schweinfurthii* | . | . | . | 10 | 10 | 10 | . | . | . | . | 10 | . | . | . | . | . | . |
| *Xyris anceps* | . | . | . | . | . | . | 3 | . | . | 10 | . | . | . | 10 | . | . | . |
| *Ophioglossum reticulatum* | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . |
| **DS of *Eriocaulo pumili-Ophioglossion gomezianum*** | | | | | | | | | | | | | | | | | |
| *Sopubia parviflora* | 6 | 4 | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Ophioglossum gomezianum* [incl. var. *latifolium*] | 10 | 10 | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . |
| *Hydrolea glabra* | 6 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Crinum zeylanicum* | 6 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Panicum tenellum* | . | 4 | 10 | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . |
| *Micrageria filiformis* | 6 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sporobolus pectinellus* | . | 10 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eriocaulon afzelianum* | 10 | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Marsilea polycarpa* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eriocaulon xeranthemoides* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eriocaulon plumale* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Isoëtes nigritiana* | . | 10 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Utricularia prehensilis* | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Ophioglossum thomasii* | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Desmodium hirtum* | . | . | . | 10 | . | 8 | . | . | . | . | . | . | . | . | . | . | . |
| *Dopatrium longidens* | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . | . |
| *Isoëtes aequinoctialis* | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . |
| **DS of *Genliseo africanae-Sporobolion pauciflori*** | | | | | | | | | | | | | | | | | |
| *Genlisea africana* | . | . | . | . | . | . | . | 10 | 10 | . | . | . | . | . | . | . | . |
| *Sporobolus pauciflorus* | . | . | . | . | . | . | . | 6 | 10 | . | . | . | . | . | . | . | . |
| *Rhytachne rottboellioides* | . | . | . | . | . | . | . | 6 | . | . | . | . | . | 10 | . | . | . |
| *Ilysanthes barteri* | . | . | . | . | . | . | . | 6 | 10 | 10 | . | . | . | . | . | . | . |
| *Cyanotis longifolia* var. *longifolia* | . | . | . | . | . | . | . | 6 | 10 | . | . | . | . | . | . | . | . |
| *Polygala clarkeana* | . | . | . | . | . | . | . | 10 | 10 | . | . | . | . | . | . | . | . |

| 18 | 19 | 20 | 21 | 22 | 23 | 24 | 25 | 26 | 27 | 28 | 29 | 30 | 31 | 32 | 33 | 34 | 35 | 36 | 37 | 38 | 39 | 40 | 41 | 42 | 43 |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 4 | 1 | 1 | 4 | 3 | 43 | 1 | 1 | 1 | 1 | 34 | 15 | 8 | 5 | 3 | 13 | 3 | 2 | 7 | 73 | 31 | 22 | 4 | 9 | 15 | 1 |
| 14 | 31 | 61 | 30 | 24 | 65 | 21 | 18 | 5 | 5 | 7 | 28 | 32 | 17 | 35 | 34 | 32 | 25 | 43 | 27 | 11 | 12 | 11 | 21 | 52 | 15 |
| . | . | . | 10 | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 8 | 7 | 9 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 10 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 |
| . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 6 | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | 9 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 5 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 6 | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| *Cyperus digitatus* subsp. *auricomus* | . | . | . | . | . | . | . | 6 | 10 | . | . | . | . | . | . | . | . |
| *Utricularia micropetala* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **DS of *Afrotrilepidetalia pilosae* and *Afrotrilepidetea pilosae*** | | | | | | | | | | | | | | | | | |
| *Afrotrilepis pilosa* | . | . | . | . | . | . | . | 6 | . | . | 10 | 10 | 10 | 10 | . | . | 10 |
| *Cyanotis lanata* | . | 10 | . | . | . | . | . | 6 | 10 | . | 10 | 10 | . | . | 10 | 10 | 7 |
| *Lindernia exilis* | . | 7 | 10 | . | . | 8. | . | . | . | . | 10 | . | 10 | . | 10 | . | 5 |
| *Selaginella njam-njamensis* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . |
| **DS of *Spermacoco hepperanae-Afrotrilepidion pilosae*** | | | | | | | | | | | | | | | | | |
| *Andropogon africanus* | . | . | . | . | . | 10 | . | . | . | . | 10 | . | . | . | . | 10 | . |
| *Fimbristylis bisumbellata* | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 |
| *Spermacoce hepperana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Aeollanthus pubescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Tripogon minimus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Solenostemon latifolius* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Hibiscus scotellii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Indigofera deightonii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . |
| *Canscora decussata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Scilla sudanica* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Microchloa kunthii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Aeschyoneme lateritica* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Nemum spadiceum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Ascolepis protea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Probable DS of central African *Afrotrilepis pilosa*-mats** | | | | | | | | | | | | | | | | | |
| *Habenaria procera* var. *gabonensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Oreonesion testui* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pellaea holstii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eriosema parviflorum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eragrostis invalida* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polystachya gabonensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Calvoa pulcherrima* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Clappertonia polyandra* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Ipomoea involucrata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Loudetiopsis glabrata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Otomeria micrantha* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solenostemon* sp. | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Scleria melanotricha* | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . |
| *Gladiolus unguiculatus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Justicia lazarus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Scleria spiciformis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sphaerocyperus* sp. | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lannea nigritana* var. *nigritana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Utricularia andongensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Vigna gracilis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Phymatodes scolopendria* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Asparagus drepanophyllus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Antherotoma irvingiana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Emilia lisowskiana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Jasminum dichotomum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Nephrolepis biserrata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Phyllanthus odontadenius* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solenangis scandens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solenostemon mannii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Urera trinervis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Costus lucanusianus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Epistemma rupestre* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Eremomastax speciosa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pellaea doniana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Psychotria peduncularis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Pityrogramma calomelanos* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **DS of *Lycopodietea cernui* and *Microchloetea indicae*** | | | | | | | | | | | | | | | | | |
| *Kalanchoe crenata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Microchloa indica* | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Sporobolus festivus* | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | 3 |
| *Bryum argenteum* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | 10 | . |

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| . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 10 | 10 | 10 | 8 | 10 | 7 | . | . | . | . | 10 | 10 | 10 | 10 | 4 | 4 | . | . | . | . | . | . | . | . | . | . |
| 10 | 6 | . | . | 10 | 5 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | 9 | . | . |
| 3 | . | . | 10 | 10 | 5 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 8 | 4 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 6 | 10 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 10 | 10 | 10 | 6 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 8 | 10 | . | 10 | 10 | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 6 | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 8 | 8 | . | 6 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 3 | 10 | . | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 8 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 6 | . | 6 | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 6 | . | 8 | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 6 | . | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 8 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 10 | . | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 3 | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | 10 | . | . | . | 8 | 2 | . | 7 | 8 | 2 | . | 2 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | 10 | 10 | 10 | 4 | 4 | 4 | . | 2 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | 10 | 10 | 10 | 10 | 2 | 6 | 6 | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 10 | . | 10 | 7 | 4 | 4 | . | 6 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | . | 2 | 10 | . | . | 2 | . | . | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | 10 | 4 | 9 | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | 4 | 2 | 4 | 10 | . | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | 6 | . | 10 | 9 | 4 | . | 4 | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 4 | 8 | . | 10 | . | 4 | 6 | 6 | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 4 | 4 | 10 | 4 | . | 10 | . | 2 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 4 | 4 | 10 | 7 | . | 4 | 6 | . | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | 10 | 6 | 9 | 7 | . | 10 | 6 | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 7 | . | . | . | . | . | . | . | 10 | . | . | 6 | . | 2 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | 10 | 8 | 4 | 10 | . | . | 4 | 6 | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | 10 | . | 2 | . | 8 | 1 | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | 4 | 7 | 7 | . | 8 | . | 6 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 4 | . | 10 | . | . | 10 | 6 | 4 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | 4 | . | 4 | . | 2 | 10 | 3 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | . | 10 | . | . | 10 | . | . | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | 10 | . | . | . | . | . | 4 | . | 4 | . | 2 | . | 2 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | 4 | . | 7 | 8 | . | . | 2 | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 4 | 2 | . | . | . | 2 | 10 | 6 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | 5 | . | . | . | 6 | 2 | . | 10 | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | 10 | . | 2 | . | 4 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | 2 | . | 10 | . | . | . | 6 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | 2 | . | 4 | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 | 10 | 2 | 4 | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | 4 | . | 4 | 7 | . | . | . | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | 4 | . | 7 | 7 | . | . | . | . | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | 7 | . | . | 10 | . | 3 | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | 7 | . | . | 6 | 2 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | 8 | . | . | . | 2 | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | 4 | . | . | . | . | 1 | . | 10 | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | 4 | . | 6 | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | 4 | . | . | . | 8 | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | 2 | . | . | . | 2 | 6 | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 | . | . | . | . | . | . | 8 | 2 | . | . |
| . | . | . | 10 | 10 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 6 | 10 | 10 |
| . | . | . | 10 | 10 | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 6 | 8 | 7 | 10 |
| . | . | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 7 | 5 | . |

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| **DS for central African communities** | | | | | | | | | | | | | | | | | |
| *Aspilia subpandulata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Mariscus dubius* subsp. *coloratus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Loudetia arundinacea* | . | 4 | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Aeollanthus repens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Solenostemon platostomoides* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lindernia madiensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Lindernia pulchella* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Abildgaardia congolensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Asplenium stuhlmannii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 |
| *Brachiaria scalaris* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bryoerythrophyllum machadoanum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Widespread wetland species** | | | | | | | | | | | | | | | | | |
| *Rhamphicarpa fistulosa* | . | . | . | 10 | . | 3 | . | . | . | . | . | . | . | . | . | . | . |
| *Hygrophila senegalensis* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Schoenoplectus senegalensis* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Cyperus podocarpus* | . | . | 10 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Dopatrium senegalense* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Nymphaea lotus* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bacopa crenata* | . | 4 | . | . | . | . | 8 | . | . | . | . | . | . | . | . | . | . |
| **Ricefield species** | | | | | | | | | | | | | | | | | |
| *Cyperus pustulatus* | 10 | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Lipocarpha filiformis* | . | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . |
| *Pycreus macrostachyos* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Trees** | | | | | | | | | | | | | | | | | |
| *Hymenodictyon floribundum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| **Companions** | | | | | | | | | | | | | | | | | |
| *Abildgaardia hispidula* | . | 4 | . | 10 | . | . | . | 6 | . | . | 10 | . | . | . | . | . | . |
| *Scirpus briziformis* | . | . | . | . | 10 | 8 | . | . | 10 | 10 | . | . | . | 10 | . | . | . |
| *Neurotheca loeselioides* | . | 4 | . | . | . | . | . | . | 10 | . | . | . | . | 10 | . | . | . |
| *Pycreus capillifolius* | . | . | . | 10 | . | . | . | 6 | 10 | 10 | . | . | . | . | . | . | . |
| *Cassia mimosoides* | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Spermacoce ruelliae* | 10 | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 1 |
| *Schizachyrium brevifolium* | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Panicum griffonii* | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . |
| *Ascolepis capensis* | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Bacopa floribunda* | . | . | 10 | . | . | . | 8 | . | . | . | . | . | . | . | . | . | . |
| *Eriocaulon remotum* | . | . | . | . | . | . | . | . | . | 10 | . | . | . | 10 | . | . | . |
| *Sporobolus infirmus* | . | . | . | . | . | . | . | 6 | 10 | . | 10 | . | . | . | . | 10 | . |
| *Cyperus cuspidatus* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . |
| *Utricularia spiralis* | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . |
| *Utricularia tortilis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Burmannia madagascariensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| **Further rare species** | | | | | | | | | | | | | | | | | |
| *Utricularia arenaria* | . | 10 | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . |
| *Kyllinga pumila* | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Loudetia togoensis* | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Anagallis pumila* | . | . | . | . | . | 6 | 8 | . | . | . | . | . | . | . | . | . | . |
| *Sopubia simplex* | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . | . |
| *Oldenlandia goreensis* | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Pycreus pumilus* | . | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . |
| *Kyllinga erecta* | . | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . |
| *Cyperus haspan* | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Chaetolepis gentianoides* | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . |
| *Polygala arenaria* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Paspalum scrobiculatum* | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Loudetiopsis kerstingii* | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Rhytachne gracilis* | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Loudetia simplex* | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Mesanthemum prescottianum* | . | 4 | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . |
| *Monocymbium ceresiiforme* | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Spermacoce filifolia* | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Schizachyrium sanguineum* | . | . | . | . | . | 6 | 6 | . | . | . | . | . | . | . | . | . | . |
| *Utricularia firmula* | . | . | . | . | . | 6 | 3 | . | . | . | . | . | . | . | . | . | . |

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| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 4 | 10 | 10 |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | 9 | 2 | . |
| . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | 10 | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | 8 | 8 | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 8 | 3 | 5 | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 7 | 10 |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 9 | 2 | . |
| . | . | . | . | . | 7 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 8 | 10 |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 4 | 10 | 10 |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 7 | 3 | 10 |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 5 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 10 | . | . | . | 4 | . | . | . | . | . | . | . | 4 | . | 4 | . | . | 6 | . | . | . | 10 | . | . | . | . |
| . | . | 10 | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 3 | 3 | 10 |
| . | . | 10 | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 6 | . | 5 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | 7 | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | 5 | . |
| . | . | . | . | . | 4 | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 6 | 10 |
| . | 6 | . | . | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 6 | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 3 | . | . | . | . | . | 2 | . | 7 | . | . | 8 | . | . | . | 10 | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 5 | . | . | . | . | . | . |
| . | 3 | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | 7 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 8 | . | 6 | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

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| *Aspilia angustifolia* | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . | . |
| *Rotala tenella* | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . | . |
| *Vigna filicaulis* | . | . | . | . | . | . | 6 | . | . | . | . | . | . | . | . | . | . |
| *Lipocarpha chinensis* | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Lobelia djurensis* | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . |
| *Murdania simplex* | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . | . | . |
| *Eriocaulon togoense* | . | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . |
| *Ludwigia abyssinica* | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Cyclocarpa stellaris* | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . | . | . |
| *Anadelphia macrochaeta* | . | . | . | . | . | . | . | . | . | 10 | . | . | . | 10 | . | . | . |
| *Philonotis hastata* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | 10 | . |
| *Portulaca foliosa* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . |
| *Cyperus squarrosus* | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . | . |
| *Calyptrochilum christyanum* | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Mariscus* sp. | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Andropogon tectorum* | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Arthropteris orientalis* | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Solenostemon monostachyus* | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Indigofera welwitschii* | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| *Abildgaardia abortiva* | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . |
| *Loudetiopsis tristachyoides* | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . |
| *Merremia pinnata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Mollugo nudicaulis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . |
| *Pancratium trianthum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . |
| *Abildgaardia coleotricha* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 2 |
| *Virectaria multiflora* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Indigofera hirsuta* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Rhytachne triaristata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Dipcadi viride* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Utricularia stanfieldii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Crotalaria glauca* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Desmodium ramosissimum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Nephrolepis undulata* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Polystachya albescens* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Hymenodictyon biafranum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Aspilia rudis* subsp. *rudis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Selaginella myosurus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sterculia tragacantha* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Euphorbia letestui* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Dalbergia afzeliana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Cissus dinklagei* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Memecylon collinum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Indigofera welwitschii* var. *remotiflora* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Panicum pusillum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Microsorium punctatum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Brillantaisia vogeliana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Tricarpelema africanum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Diodia sarmentosa* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Microgramma owariensis* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Strychnos campicola* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Heterotis rupicola* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Olea capensis* subsp. *hochstetteri* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Tristemma hirtum* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Cyperus laxus* subsp. *buchholzii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Scleria boivinii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Kinghamia nigritana* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Oldenlandia herbacea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Sporobolus stapfianus* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Urginea bequaertii* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| *Kohautia coccinea* | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |

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| . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 7 | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 10 | . | . | . | . | . |
| . | . | . | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 3 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | . | . | . | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| 3 | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| 3 | . | . | . | 4 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | 8 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | 6 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | 1 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . |
| . | . | 10 | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 3 | . |
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| . | . | . | . | . | . | . | . | . | . | . | 4 | 2 | . | . | . | . | . | . | . | . | . | . | . | . | . |
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| . | . | . | . | . | . | . | . | . | . | . | . | . | . | . | 6 | . | 6 | . | . | . | . | . | . | . | . |
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