# The vegetation of inselbergs in the Comoé National Park (Ivory Coast)

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ABSTRACT

POREMBSKI, S. & G. BROWN (1995). The vegetation of inselbergs in the Comoé National Park (Ivory Coast). *Candollea* 50: 351-365. In English, English and French abstracts.

Plant communities of inselbergs in the Comoé National Park are described. Inselbergs are prominent landscape elements, typically with large areas of exposed rock. Their vegetation differs floristically, physiognomically and with regard to life-form spectrum from that of surrounding areas. *Poaceae*, *Cyperaceae* and *Fabaceae* comprise the most species rich families. Widespread Sudano-Zambezian elements are particularly common. In contrast to other regions, no endemics occur on inselbergs. Therophytes account for over 60% of species. Inselberg vegetation is homogeneous, pointing to deterministic influences exerted by harsh environmental conditions. Stochasticity is expressed by large numbers of vagrant species recorded only on single inselbergs. Rock outcrops harbour species threatened with extinction in the Ivory Coast, like *Burmannia madagascariensis*. Their conservation is of importance for maintaining the genetic diversity of rare species.

RÉSUMÉ

POREMBSKI, S. & G. BROWN (1995). La végétation des inselbergs du Parc National de la Comoé (Côte d'Ivoire). *Candollea* 50: 351-365. En anglais, résumés anglais et français.

Les groupements végétaux des inselbergs dans le Parc National de la Comoé sont décrits. Les inselbergs sont des éléments caractéristiques du paysage, comportant souvent de grands affleurements rocheux nus. Leur végétation se distingue de celle qui les entoure floristiquement, physionomiquement ainsi que par son spectre biologique. Les familles les plus importantes sont: *Poaceae, Cyperaceae* et *Fabaceae*. Des éléments soudano-zambéziens, largement répandus, sont dominants. Par contraste avec d'autres régions, les endémiques sont absentes des inselbergs étudiés. Les thérophytes sont abondamment représentés (60% des espèces). La végétation des inselbergs est homogène, ce qui indique l'influence déterminante des conditions extrêmes du milieu. Les influences stochastiques sont représentées par des espèces qui sont répandues dans beaucoup d'associations végétales et qui n'apparaissent que sur un seul inselberg. Sur les affleurements rocheux, on trouve beaucoup d'espèces menacées d'extinction en Côte-d'Ivoire, comme par exemple *Burmannia madagascariensis*. Leur conservation est importante afin de maintenir la diversité génétique des espèces rares.

*KEY-WORDS:* Comoé National Park — Conservation — Inselbergs — Insular biota — Ivory Coast — Species richness.

## Introduction and study area

The Comoé National Park is situated in the north-east of the Ivory Coast near the border of Burkina Faso to the north and Ghana to the east. Although no settlements are found within the boundaries of the National Park, fires attributable to anthropogenic sources are frequent during the dry season. Most of the 11.500 km$^2$ National Park is located at an altitude of 200 to 300 m

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asl., but several low mountain ranges with gentle slopes such as Mts. Potrou (625 m) also occur. Geologically, the study area belongs to the Precambrian shield which is composed of a basement complex of Archaean rocks (WILSON, 1968). In general, granites and gneisses are the predominant rock types, but greenstone belts are found in the vicinity of the larger rivers such as the Comoé. Isolated outcrops of granite usually appear as shield-inselbergs, protruding to a maximum height of 20 m above the surrounding landscape. Dome-shaped inselbergs belonging to the "bornhardt-type" occur only rarely, and rocky outcrops consisting of large boulders ("koppje"-type), a widespread feature in East Africa, are completely missing. The small shield-inselbergs are estimated to be up to 0.5 million years old (SANDER, Cologne, pers. comm.), and the larger dome-shaped inselbergs are considerably older. A detailed survey of the geomorphology of inselbergs is given by BREMER & JENNINGS (1978).

Situated between 8°5'-9°6'N and 3°1'-4°4'W, the climate of the extreme northern part of the National Park can be classified as belonging to the "secteur soudanais", whereas that of the central and southern areas can be assigned to the "secteur subsoudanais" (ELDIN, 1971). Detailed data on the climate of the "secteur soudanais" are not available. However, the higher evaporational water deficit of this northern area provides the main distinction between the climate of the more southerly "secteur subsoudanais". In the latter, the dry season extends from November to March/April, and alternates with a rainy season from may to October. During this time, monthly precipitation exceeds 100 mm, with rainfall for the whole year ranging from 900 to 1200 mm. However, considerable variation of the annual rainfall is a marked feature of the general climatic situation. Mean annual temperatures are in the range of 26-28°C. From January to March, the dry-hot harmattan results in daytime temperatures in excess of 40°C, whilst air humidity drops to below 20%. During the night, temperatures can fall to below 10°C, and this sudden decrease is occasionally accompanied by dew. Descriptions of the major types of vegetation have been provided by ADJANOHOUN & AKÉ ASSI (1967), CESAR (1978), BARTHLOTT & LEIPOLD (1979) and POILECOT (1991). GUILLAUMET & ADJANOHOUN (1971) have presented a general overview of the distribution of plant formations in the Comoé National Park in their vegetation map of the Ivory Coast, and two main zones of vegetation can be recognized: 1. Guinea region (mosaic zone comprising forests and savanna occupying the southern third of the area); 2. Sudan region (several types of woodland and savanna covering the central and northern parts). According to GUILLAUMET & ADJANOHOUN (1971), the most important types of vegetation, based on the size of the area they occupy, include savanna, woodland and several types of forest. Less important in terms of their extent, but harbouring many characteristic species, are temporary pools, ferricretes (known locally as "bowal", pl. "bowé"), termite mounds and inselbergs.

The vegetation of Ivorian inselbergs in the central and southern regions of the country has been described by ADJANOHOUN (1964), BONARDI (1966) and SCHMIDT (1973). A first country-wide survey of the inselberg vegetation has been provided by POREMBSKI & BARTHLOTT (1992, 1993). Being terrestrial ecosystems which are sharply delimited from the surrounding landscape, inselbergs have proven to be suitable models for studying the mechanisms responsible for maintaining species diversity (BARTHLOTT & al., 1993). An important aim of the present study is to provide a better understanding of the floristic composition and vegetation of inselbergs under the influence of a strictly seasonal climate.

## Material and methods

The vegetation characteristics of 18 inselbergs ranging from 100 $m^2$ to 75,000 $m^2$ in size were studied. Figure 1 shows the location of the individual rock outcrops, 13 of which are found within the Comoé National Park. The remaining five are situated just outside the southern boundary of the National Park. All vascular plant species were recorded and life-form spectra were compiled in accordance with the RAUNKIAER (1934) classification. Although the vegetation of the inselbergs was studied in previous years in order to become familiar with the special characteristics, the data presented here are based on detailed fieldwork carried out during 1991, when all inselbergs were repeatedly examined throughout the rainy season. In this manner, a complete picture of the vegetation for one season covering all 18 inselbergs was obtained.

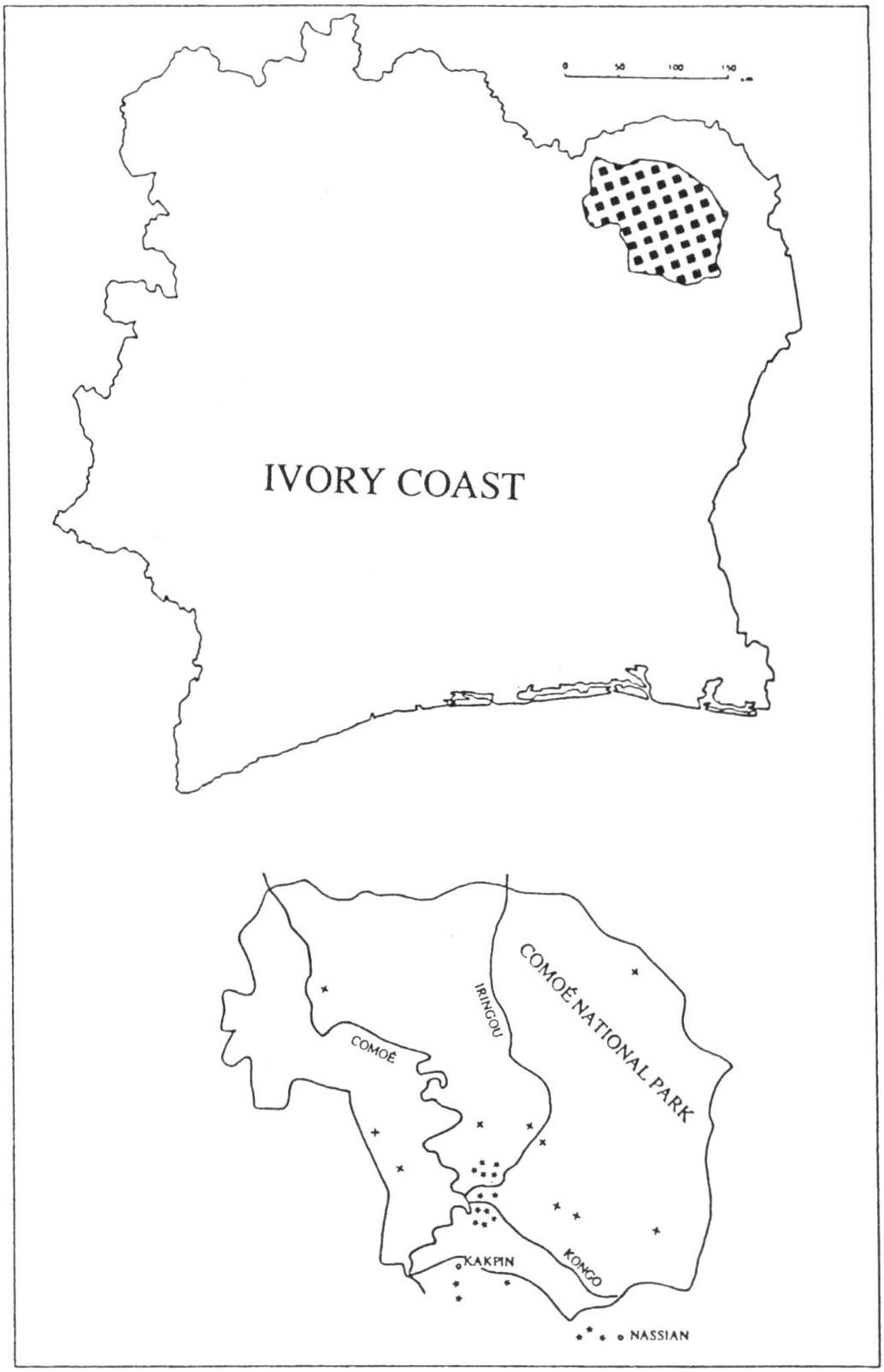



Fig. 1. — Map of the Ivory Coast (Comoé National Park dotted) and the study area. Rock outcrops examined are indicated by asterisks. Otherwise occurring rock outcrops are shown by crosses.

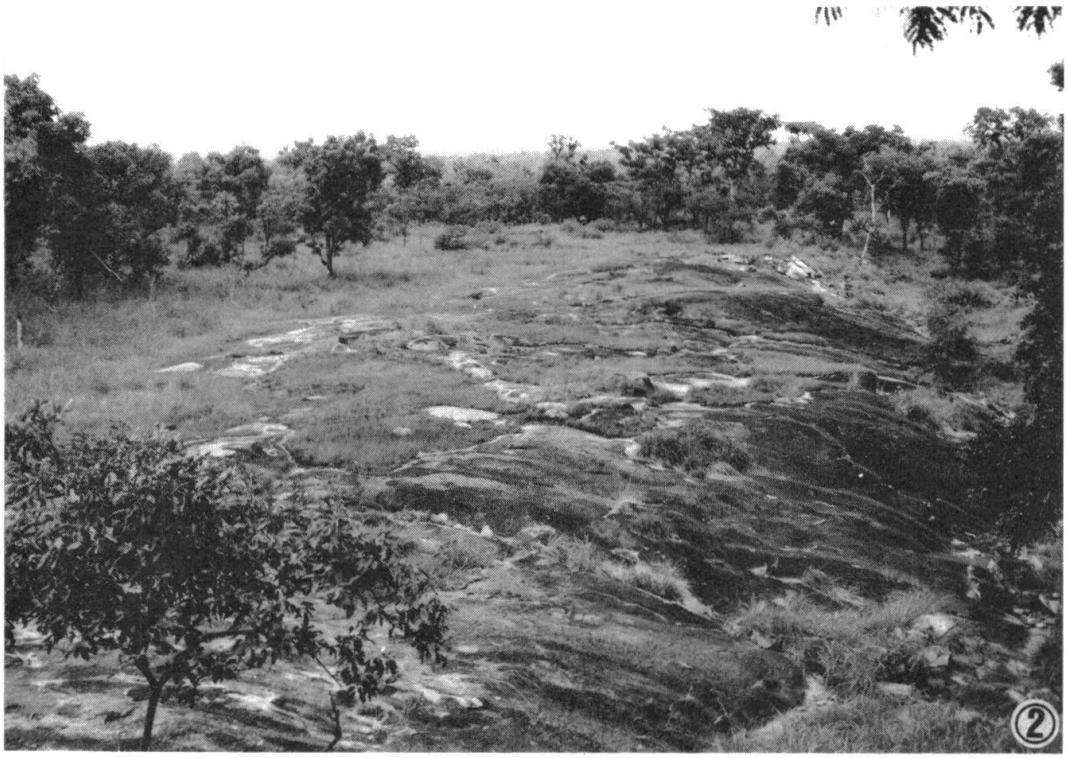


Fig. 2. — Granite shield-inselberg in the Comoé National Park. Open rock faces covered by lichens. The *Cyperaceae Afrotrilepis pilosa* forms large mats.

Fig. 3. — Flat granite outcrop south of Kakpin. Characteristic are vegetation islands dominated by the *Commelinaceae Cyanotis lanata.*

Fig. 4. — Rock outcrop in the Comoé National Park surrounded by dense savanna woodland. Although tiny in extension, characteristic species such as *Aeollanthus pubescens* are present.

Fig. 5. — Seasonally water-filled rock pool on inselberg. *Cyperus submicrolepis* is a typical element of this habitat type (photograph by Nadja Biedinger).



Fig. 6. — The geophytic *Isoetes nigritiana* is widespread on inselbergs in the Comoé area where it occurs on wet, shallow soils (photograph by Nadja Biedinger).

Fig. 7. — The deciduous tree *Hymenodictyon floribundum* (in fruit) is a typical element of the vegetation of inselbergs throughout tropical Africa (photograph by Nadja Biedinger).

Table 1. — List of vascular plant species found on 18 inselbergs in the Comoé area.

| | *Author* | *Family* |
|---|---|---|
| *Abrus precatorius* | L. | Fabaceae |
| *Acroceras amplectens* | Stapf | Poaceae |
| *Acroceras zizanioides* | (Kunth) Dandy | Poaceae |
| *Adansonia digitata* | L. | Bombacaceae |
| *Aeollanthus pubescens* | Benth. | Lamiaceae |
| *Afraegle paniculata* | (Schum. & Thonn.) Engl. | Rutaceae |
| *Aframomum latifolium* | (Afzel.) K. Schum. | Zingiberaceae |
| *Afrotrilepis pilosa* | (Boeck.) J. Raynal | Cyperaceae |
| *Afzelia africana* | Sm. | Caesalpiniaceae |
| *Albuca nigritana* | (Bak.) Troupin | Hyacinthaceae |
| *Aloe buettneri* | A. Berger | Aloaceae |
| *Alysicarpus ovalifolius* | (Schum. & Thonn.) J. Léonard | Fabaceae |
| *Ammania auriculata* | Willd. | Lythraceae |
| *Amorphophallus johnsonii* | N. E. Br. | Araceae |
| *Anadelphia liebigiana* | Scholz | Poaceae |
| *Anchomanes welwitschii* | Rendle | Araceae |
| *Andropogon curvifolius* | W. D. Clayton | Poaceae |
| *Andropogon fastigiatus* | Sw. | Poaceae |
| *Andropogon gayanus* | Kunth | Poaceae |
| *Aneilema setiferum* | A. Chev. | Commelinaceae |
| *Aristida adscensionis* | L. | Poaceae |
| *Ascolepis capensis* | (Kunth) Ridley | Cyperaceae |
| *Ascolepis protea* | Welw. | Cyperaceae |
| *Ascolepis pusilla* | Ridley | Cyperaceae |
| *Asparagus africanus* | Lam. | Asphodelaceae |
| *Aspilia bussei* | O. Hoffm. & Muschl. | Asteraceae |
| *Asplenium stuhlmannii* | Hieron. | Aspleniaceae |
| *Bacopa floribunda* | (R. Br). Wettst. | Scrophulariaceae |
| *Bombax costatum* | Pellegr. & Vuillet | Bombacaceae |
| *Borreria paludosa* | Hepper | Rubiaceae |
| *Borreria scabra* | (Schum. & Thonn.) K. Schum. | Rubiaceae |
| *Brachiaria stigmatisata* | (Mez) Stapf | Poaceae |
| *Brachiaria villosa* | (Lam.) A. Camus | Poaceae |
| *Brachystelma mortonii* | Walker | Asclepiadaceae |
| *Brachystelma simplex* | Schltr. | Asclepiadaceae |
| *Bulbostylis coleotricha* | (A. Rich.) C. B. Cl. | Cyperaceae |
| *Bulbostylis congolensis* | De Wildeman | Cyperaceae |
| *Burkea africana* | Hook. | Caesalpiniaceae |
| *Burmannia madagascariensis* | Martius | Burmanniaceae |
| *Ceiba pentandra* | (L.) Gaertn. | Bombacaceae |
| *Ceratophyllum demersum* | L. | Ceratophyllaceae |
| *Ceropegia deightonii* | Hutch. & Dalz. | Asclepiadaceae |
| *Chamaecrista absus* | (L.) Irwin & Barneby | Caesalpiniaceae |
| *Chamaecrista mimosoides* | (L.) Greene | Caesalpiniaceae |
| *Chasmopodium caudatum* | (Hack) Stapf | Poaceae |
| *Chlorophytum blepharophyllum* | Schweinf. ex Bak. | Anthericaceae |
| *Cissus corylifolia* | (Bak.) Planch. | Vitaceae |
| *Cissus populnea* | Guill. & Perr. | Vitaceae |
| *Cochlospermum planchoni* | Hook. f. | Cochlospermaceae |
| *Combretum nigricans* | Lepr. ex Guill. & Perr. | Combretaceae |
| *Corchorus fascicularis* | Lam. | Tiliaceae |
| *Crinum humile* | A. Chev. | Amaryllidaceae |
| *Crotalaria goreensis* | Guill. & Perr. | Fabaceae |
| *Crotalaria leprieurii* | Guill. & Perr. | Fabaceae |
| *Curculigo pilosa* | (Schum. & Thonn.) Engl. | Hypoxidaceae |
| *Cussonia barteri* | Seemann | Araliaceae |
| *Cyanotis lanata* | Benth. | Commelinaceae |
| *Cyanotis longifolia* | Benth. | Commelinaceae |
| *Cyperus compressus* | L. | Cyperaceae |
| *Cyperus cuspidatus* | Kunth | Cyperaceae |
| *Cyperus difformis* | L. | Cyperaceae |
| *Cyperus haspan* | L. | Cyperaceae |
| *Cyperus podocarpus* | Boeck. | Cyperaceae |
| *Cyperus pustulatus* | Vahl | Cyperaceae |
| *Cyperus reduncus* | Hochst. ex Boeck. | Cyperaceae |

Table 1. — List of vascular plant species found on 18 inselbergs in the Comoé area (cont.).

| | *Author* | *Family* |
|---|---|---|
| *Cyperus submicrolepis* | Kük. | Cyperaceae |
| *Desmodium hirtum* | Guill. & Perr. | Fabaceae |
| *Desmodium linearifolium* | G. Don | Fabaceae |
| *Detarium senegalense* | J. F. Gmel. | Caesalpiniaceae |
| *Digitaria delicatula* | Stapf | Poaceae |
| *Digitaria leptorhachis* | (Pilger) Stapf | Poaceae |
| *Dipcadi taccazeanum* | (Hochst. ex A. Rich.) Bak. | Hyacinthaceae |
| *Djaloniella ypsilostyla* | P. Tayl. | Gentianaceae |
| *Drosera indica* | L. | Droseraceae |
| *Echinochloa colona* | (L.) Link | Poaceae |
| *Eichhornia natans* | (P. Beauv.) Solms-Laub. | Pontederiaceae |
| *Eleocharis acutangula* | (Roxb.) Schult. | Cyperaceae |
| *Elephantopus senegalensis* | (Klatt) Oliv. & Hiern | Asteraceae |
| *Elionurus euchaetus* | Adjanohoun & W. D. Clayton | Poaceae |
| *Entada mannii* | (Oliv.) Tisserand | Mimosaceae |
| *Eragrostis gangetica* | (Roxb.) Steud. | Poaceae |
| *Eragrostis scotelliana* | Rendle | Poaceae |
| *Eriocaulon afzelianum* | Wikstr. ex Koern. | Eriocaulaceae |
| *Eriocaulon plumale* | N.E. Br. | Eriocaulaceae |
| *Euphorbia convolvuloides* | Hochst. ex Benth. | Euphorbiaceae |
| *Euphorbia kouandenensis* | Beille | Euphorbiaceae |
| *Evolvulus alsinoides* | (L.) L. | Convolvulaceae |
| *Ficus abutilifolia* | (Miq.) Miq. | Moraceae |
| *Ficus umbellata* | Vahl | Moraceae |
| *Fimbristylis alboviridis* | C. B. Cl. | Cyperaceae |
| *Fimbristylis dichotoma* | Vahl | Cyperaceae |
| *Fimbristylis ferruginea* | (L.) Vahl | Cyperaceae |
| *Fimbristylis hispidula* | (Vahl) Kunth | Cyperaceae |
| *Fuirena umbellata* | Rottb. | Cyperaceae |
| *Gynandropsis gynandra* | (L.) Briq. | Capparidaceae |
| *Heliotropium strigosum* | Willd. | Boraginaceae |
| *Hibiscus asper* | Hook. f | Malvaceae |
| *Hibiscus scotellii* | Bak. f | Malvaceae |
| *Hydrolea floribunda* | Kotschy & Peyr. | Hydrophyllaceae |
| *Hygrophila senegalensis* | (Nees) T. Anders. | Acanthaceae |
| *Hymenodictyon floribundum* | (Steud. & Hochst.) B. L. Robinson | Rubiaceae |
| *Indigofera astragalina* | DC. | Fabaceae |
| *Indigofera deightonii* | Gillett | Fabaceae |
| *Indigofera dendroides* | Jacq. | Fabaceae |
| *Indigofera hirsuta* | L. | Fabaceae |
| *Indigofera nigritana* | Hook. f | Fabaceae |
| *Indigofera omissa* | Gillett | Fabaceae |
| *Indigofera paniculata* | Vahl & Pers. | Fabaceae |
| *Isoetes nigritiana* | A. Br. ex Kuhn | Isoetaceae |
| *Kaempferia aethiopica* | (Schweinf.) Solms-Laub. | Zingiberaceae |
| *Khaya senegalensis* | (Desr.) A. Juss. | Meliaceae |
| *Kyllinga bulbosa* | P. Beauv. | Cyperaceae |
| *Kyllinga nigritana* | C. B. Cl. | Cyperaceae |
| *Kyllinga pumila* | Michx. | Cyperaceae |
| *Lemna paucicostata* | Hegelm. ex Engelm. | Lemnaceae |
| *Lepidagathis anobrya* | Nees | Acanthaceae |
| *Lepidagathis collina* | (Endl.) Milne-Redhead | Acanthaceae |
| *Leptochloa caerulescens* | Steud. | Poaceae |
| *Lindernia debilis* | Skan | Scrophulariaceae |
| *Lindernia exilis* | (Skan) Philcox | Scrophulariaceae |
| *Lindernia schweinfurthii* | (Engl.) Dandy | Scrophulariaceae |
| *Lipocarpha chinensis* | (Osb.) Kern | Cyperaceae |
| *Lipocarpha filiformis* | (Vahl) Kunth | Cyperaceae |
| *Lobelia djurensis* | Engl. & Diels | Lobeliaceae |
| *Loudetia arundinacea* | (Hochst. ex A. Rich) Steud. | Poaceae |
| *Loudetia simplex* | (Nees) C. E. Hubbard | Poaceae |
| *Loudetia togoensis* | (Pilger) C. E. Hubbard | Poaceae |
| *Loudetiopsis kerstingii* | (Pilger) Conert | Poaceae |
| *Ludwigia abyssinica* | A. Rich. | Onagraceae |
| *Ludwigia erecta* | (L.) Hara | Onagraceae |

Table 1. — List of vascular plant species found on 18 inselbergs in the Comoé area (cont.).

| | *Author* | *Family* |
|---|---|---|
| *Manilkara multinervis* | (Bak.) Dubard | Sapotaceae |
| *Mariscus dubius* | (Rott.) C. E. C. Fischer | Cyperaceae |
| *Mariscus squarosus* | (L.) C. B. Cl. | Cyperaceae |
| *Marsilea* spec. | | Marsileaceae |
| *Maytenus senegalensis* | (Lam.) Exell | Celastraceae |
| *Melliniella micrantha* | Harms | Fabaceae |
| *Melochia corchorifolia* | L. | Sterculiaceae |
| *Merremia pinnata* | (Hochst. ex Choisy) Hallier f. | Convolvulaceae |
| *Microchloa indica* | (L. f.) P. Beauv. | Poaceae |
| *Mimusops kummel* | Bruce ex A. DC. | Sapotaceae |
| *Mollugo nudicaulis* | Lam. | Molluginaceae |
| *Monechma ciliatum* | (Jacq.) Milne-Redhead | Acanthaceae |
| *Murdannia simplex* | (Vahl) Brennan | Commelinaceae |
| *Nauclea latifolia* | Sm. | Rubiaceae |
| *Nemum spadiceum* | (Lam.) Dev. ex Hamilton | Cyperaceae |
| *Oldenlandia herbacea* | (L.) Roxb. | Rubiaceae |
| *Oldenlandia goreensis* | (DC.) Summerh. | Rubiaceae |
| *Oldenlandia lancifolia* | (Schumach.) DC. | Rubiaceae |
| *Ophioglossum costatum* | R. Br. | Ophioglossaceae |
| *Ophioglossum gomezianum* | Welw. ex A. Br. | Ophioglossaceae |
| *Pancratium trianthum* | Herb. | Amaryllidaceae |
| *Pandiaka heudelotii* | (Moq.) Hook. f. | Amaranthaceae |
| *Panicum lindleyanum* | Nees ex Steud. | Poaceae |
| *Panicum maximum* | Jacq. | Poaceae |
| *Panicum pilgeri* | Mez | Poaceae |
| *Parkia biglobosa* | (Jacq.) Benth. | Mimosaceae |
| *Paspalum orbiculare* | Forst. | Poaceae |
| *Paspalum scrobiculatum* | L. | Poaceae |
| *Pellaea doniana* | Hook. | Pteridaceae |
| *Pennisetum pedicellatum* | Trin. | Poaceae |
| *Pennisetum polystachion* | (L.) Schult. | Poaceae |
| *Phyllanthus maderaspatensis* | L. | Euphorbiaceae |
| *Phyllanthus urinaria* | L. | Euphorbiaceae |
| *Polycarpaea eriantha* | Hochst. ex A. Rich. | Caryophyllaceae |
| *Polycarpaea linearifolia* | (DC.) DC. | Caryophyllaceae |
| *Polygala arenaria* | Willd. | Polygalaceae |
| *Polygala lecardii* | Chodat | Polygalaceae |
| *Polygala multiflora* | Poir. | Polygalaceae |
| *Portulaca foliosa* | Ker.-Gawl. | Portulacaceae |
| *Pterocarpus erinaceus* | Poir. | Fabaceae |
| *Raphionacme brownii* | Sc. Elliott | Periplocaceae |
| *Rhamphicarpa fistulosa* | (Hochst.) Benth. | Scrophulariaceae |
| *Rotala tenella* | (Guill. & Perr.) Hiern | Lythraceae |
| *Saba senegalensis* | (A. DC.) Pichon | Apocynaceae |
| *Sansevieria liberica* | Gér. Labr. | Dracaenaceae |
| *Schoenoplectus senegalensis* | (Steud.) Palla ex J. Raynal | Cyperaceae |
| *Scleria melanotricha* | Hochst. ex A. Rich | Cyperaceae |
| *Selaginella* spec. | | Selaginellaceae |
| *Setaria barbata* | (Lam.) Kunth | Poaceae |
| *Sida linifolia* | Juss. ex Cav. | Malvaceae |
| *Sida* spec. | | Malvaceae |
| *Solenostemon graniticola* | A. Chev. | Lamiaceae |
| *Sopubia simplex* | (Hochst.) Hochst. | Scrophulariaceae |
| *Spermacoce filifolia* | (Schum. & Thonn.) Lebrun & Stork | Rubiaceae |
| *Sphenoclea zeylanica* | Gaertn. | Sphenocleaceae |
| *Sporobolus festivus* | Hochst. ex A. Rich. | Poaceae |
| *Sporobolus infirmus* | Mez | Poaceae |
| *Sporobolus pectinellus* | Mez | Poaceae |
| *Striga asiatica* | (L.) O. Ktze. | Scrophulariaceae |
| *Striga gesnerioides* | (Willd.) Vatke | Scrophulariaceae |
| *Stylochiton lancifolius* | Kotschy & Peyr. | Araceae |
| *Tacca leontopetaloides* | (L.) O. Ktze. | Taccaceae |
| *Tephrosia bracteolata* | Guill. & Perr. | Fabaceae |
| *Tephrosia elegans* | Schum. | Fabaceae |
| *Tephrosia pedicellata* | Bak. | Fabaceae |

Table 1. — List of vascular plant species found on 18 inselbergs in the Comoé area (cont.).

| | *Author* | *Family* |
|---|---|---|
| *Tephrosia platycarpa* | Guill. & Perr. | Fabaceae |
| *Terminalia glaucescens* | Planch. & Benth. | Combretaceae |
| *Themeda triandra* | Forsk. | Poaceae |
| *Tragia senegalensis* | Müll. Arg. | Euphorbiaceae |
| *Tripogon minimus* | (A. Rich.) Hochst. ex Steud. | Poaceae |
| *Uraria picta* | (Jacq.) DC. | Fabaceae |
| *Urena lobata* | L. | Malvaceae |
| *Urginea altissima* | (L. f.) Bak. | Hyacinthaceae |
| *Utricularia arenaria* | A. DC. | Lentibulariaceae |
| *Utricularia prehensilis* | E. Meyer | Lentibulariaceae |
| *Utricularia pubescens* | Sm. | Lentibulariaceae |
| *Utricularia stellaris* | L. f. | Lentibulariaceae |
| *Utricularia subulata* | L. | Lentibulariaceae |
| *Utricularia tortilis* | Welw. ex Oliv. | Lentibulariaceae |
| *Vigna filicaulis* | Hepper | Fabaceae |
| *Virectaria multiflora* | Sm. | Rubiaceae |
| *Vitex doniana* | Sweet | Verbenaceae |
| *Wormskioldia pilosa* | (Willd.) Schweinf. ex Urb. | Turneraceae |
| *Xyris straminea* | Nilss. | Xyridaceae |
| *Zornia glochidiata* | Reichb. ex DC. | Fabaceae |

## Results

### *Habitat types*

In accordance with BARTHLOTT & al. (in press) the following habitat types were encountered on the rocky outcrops (Fig. 2, 3, 4): 1. exposed rock surfaces; 2. drainage channels; 3. rock crevices; 4. seasonally-filled rock pools; 5. flat depressions; 6. monocotyledonous mats and 7. ephemeral flush vegetation. In the following, the most important features of these habitats are briefly discussed.

Exposed rock surfaces are usually devoid of phanerogams, but squamulose lichens such as *Peltula congregata* and *P. umbilicata* flourish. Such inselbergs on which lichens are a predominant feature belong to the "lichen-type" (POREMBSKI & BARTHLOTT, 1992). Lichens of the genus *Peltula* are fairly widespread on rock surfaces of inselbergs in many parts of tropical Africa. Less frequently, small patches of mosses are encountered, most notably *Bryum arachnoideum* and *Brachymenium exile.*

Drainage channels are formed by runoff water. Such channels usually serve to divert water off the outcrop, but some run towards the centre where ephemeral flush communities may also benefit from the surplus of water. *Peltula lingulata* is a characteristic lichen of this habitat.

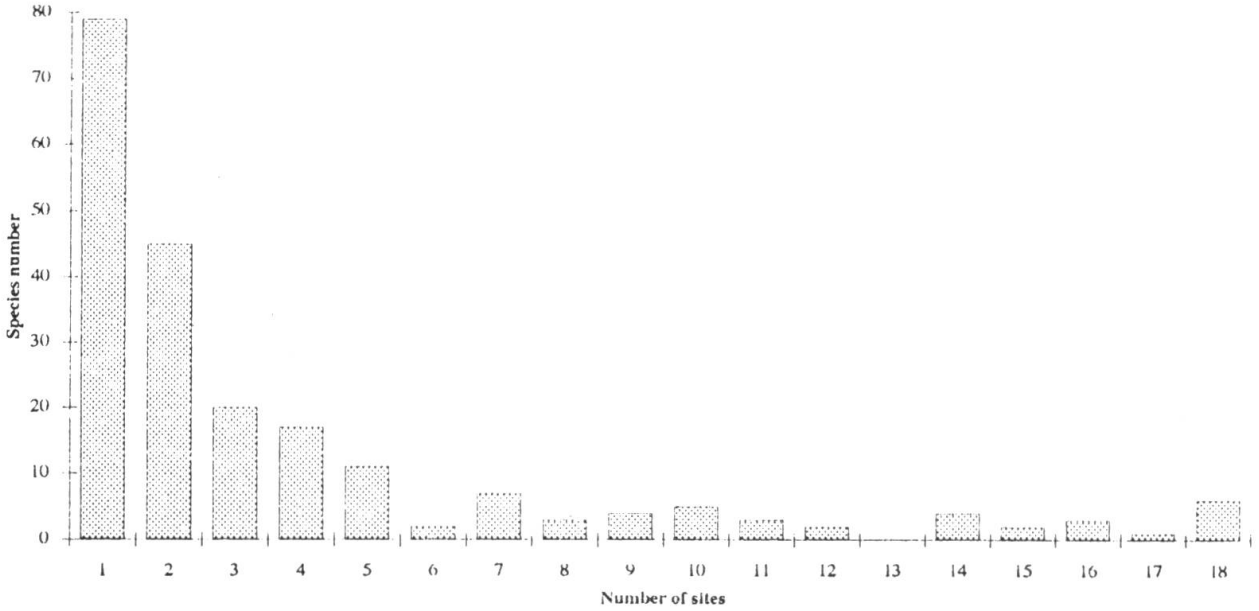
Rock crevices are often colonized by a number of short-lived herbs, most notably *Bulbostylis coleotricha, Cyanotis lanata* and several species of *Indigofera.*

Seasonally-filled rock pools (Fig. 5): man made grinding holes and irregularly shaped pools occur in large numbers, reaching a maximum depth of 30 cm. The bottom of such pools is usually covered by sandy substrate. Frequent species found here include *Cyperus* spp., *Rotala tenella* and *Cyanotis lanata.*

Flat depressions are colonized by therophytes such as *Cyanotis lanata, Aeollanthus pubescens* and *Lindernia exilis* where the substrate is less than 3 cm in depth. Hemicryptophytes such as *Tripogon minimus* and cryptophytes like *Pancratium trianthum, Ophioglossum costatum* and *Isoetes nigritiana* (Fig. 6) are found on deeper soils. A characteristic feature is the occurrence of liverworts of the genus *Riccia,* particularly *R. lanceolata,* as well as cushion-forming cyanobacteria (*Schizothrix* sp.).

The vegetation of *monocotyledonous mats* is primarily composed of the poikilohydrous Cyperaceae *Afrotrilepis pilosa,* as well as a limited number of other species (particularly *Cyanotis*

Fig. 8. — Number of records for the 216 species of vascular plants found on 18 inselbergs in the Comoé area. Only six species occurred on every inselberg.



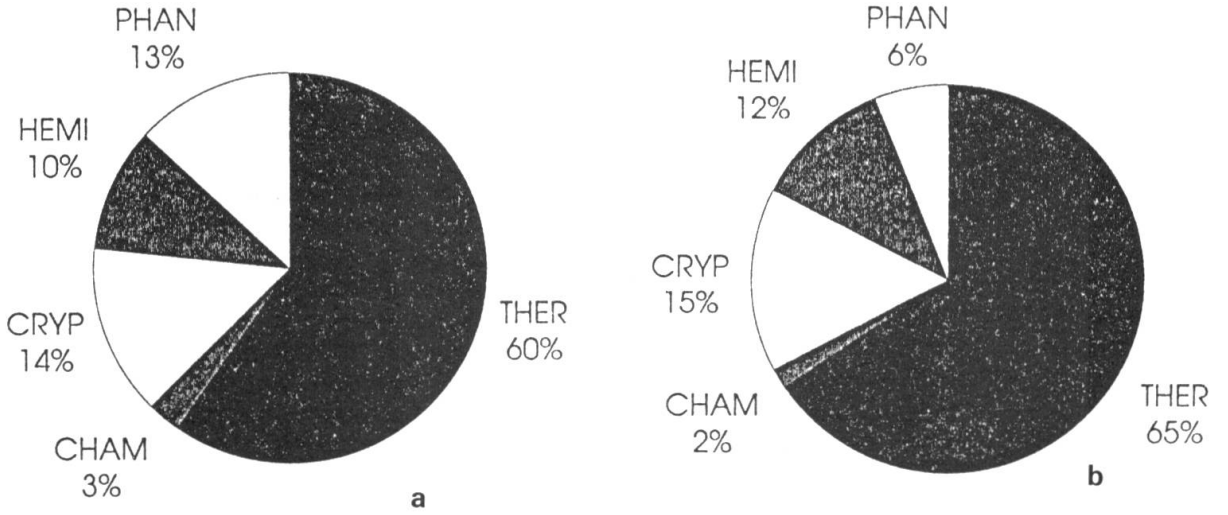




Fig. 9. — Average life-form spectrum of rock outcrop flora.
**a,** average life-form spectrum of rock outcrop flora; **b,** as 9a, but data corrected to reflect relative frequency.
Abbreviations: CHAM = Chamaephytes; CRYP = Cryptophytes; HEMI = Hemicryptophytes; PHAN = Phanerophytes; THER = Therophytes.

*lanata, Lindernia exilis* and *Hymenodictyon floribundum,* Fig. 7). Such mats with *Afrotrilepis* only occur on rocky outcrops with areas exceeding ca. 20.000 $m^2$.

Ephemeral flush vegetation is typical of larger rock outcrops, where water continuously seeps during the rainy season. A number of highly characteristic species inhabit these areas, and include in particular several carnivorous species such as *Drosera indica, Utricularia pubescens* and *U. subulata.* Several grasses (e.g. *Panicum lindleyanum*) and sedges (e.g. *Scleria melanotricha*) form an upper stratum which provides shelter for smaller hydrophilic herbs such as *Rotala tenella, Burmannia madagascariensis* and *Lindernia schweinfurthii.*

### *Floristic composition, species richness and phytogeographic aspects*

Two hundred sixteen species representing a total of 66 families were found on the inselbergs (Table 1). The most important family regarding the number of species is the *Poaceae* (35), followed by *Cyperaceae* (32), *Fabaceae* (21), *Rubiaceae* (9), *Scrophulariaceae* (8) and *Lentibulariaceae* (6). Dicots (54%) outnumber the monocots (43%), with ferns accounting for only 3% of the total number of species recorded. *Cyperus* is the genus with the highest number of species (9), followed by *Indigofera* (7), *Utricularia* (6), *Fimbristylis* (4) and *Thephrosia* (4).

The highest number of species recorded on the outcrops was 115, the lowest 22. If species number is plotted against the total area, the relationship is definable in terms of a rectangular hyperbola, increasing rapidly initially, but gradually tapering off and assuming a near-constant value (not shown). Only six species, *Chamaecrista mimosoides, Cyanotis lanata, Fimbristylis dichotoma, Hibiscus scotellii, Lindernia exilis* and *Sporobolus festivus* were present on all rock outcrops. *Hibiscus scotellii* and *Lindernia exilis* are confined to rocky habitats throughout their distribution area (the latter species also occurs on ferricretes). *Cyanotis lanata* and *Sporobolus festivus* are usually encountered on rock outcrops but can also be found in other open places. *Chamaecrista mimosoides* and *Fimbristylis dichotoma* are widespread ruderals. More than 75% of all species recorded occurred on fewer than five outcrops, with 37% of species restricted to a single inselberg (Fig. 8). Species which can be classified as "generalists" (i.e. occurring in a broad range of habitats) make up the bulk of the latter category. "Specialists" (i.e. found predominantly on rock outcrops) make up the largest proportion of species which were present on 90% of the rock outcrops examined.

Most species can be regarded as Sudano-Zambezian elements (23.5%) or belong to an ill-defined group found throughout Tropical Africa (also 23.5%). Within the Ivory Coast several of the widespread Sudano-Zambezian elements (e.g. *Brachystelma simplex*) are restricted to the savanna zone and do not occur on rock outcrops in the rainforest region. The proportion of pantropics (14.5%) such as *Andropogon fastigiatus* and *Cyperus compressus* and paleotropics (13%) like *Bacopa floribunda* and *Burmannia madagascariensis* is remarkably high. Species restricted to Upper Guinea, for example *Andropogon curvifolius* and *Djaloniella ypsilostyla,* make up 7% of the total number of taxa occurring on the rock outcrops. One species *(Ceratophyllum demersum)* has a cosmopolitan distribution. No endemic species were recorded.

### *Ecological aspects of the rock outcrop vegetation*

Figure 9a shows the average life-form spectrum of the rock outcrop flora as the proportion of species in each of the five categories. In Fig. 9b, the data have been corrected as a percentage of the total number of observations of all species to better reflect the vegetation structure. In both cases therophytes predominate, accounting on average for 60% of all phanerogams (Fig. 9a) and even 65% if relative frequency is taken into account (Fig. 9b). This is in marked contrast with the vegetation of the surrounding areas, where phanerophytes and hemicryptophytes are the most common life-forms. On the rock outcrops, chamaephytes are consistently the most poorly represented category (2%/3%). The remaining life-forms are divided into roughly equal proportions, with cryptophytes in general more common (15%/14%), followed by hemicryptophytes (10%/12%), and finally phanerophytes (13%/6%). It is interesting to note that with respect to the individual

outcrops, the proportions of the various life-form categories remain relatively constant, independent of the total number of species recorded (not shown).

Species endowed with special properties enabling them to endure prolonged periods of drought (such as poikilohydry or succulence) are relatively few in number. The most striking example of a poikilohydric species is *Afrotrilepis pilosa*. Succulents are primarily represented by *Aloe buettneri*. The succulent *Euphorbia poissoni* has a patchy distribution on rock outcrops in the study area, but was not recorded during the present investigation.

## Discussion

The vegetation of the rock outcrops in the Comoé National Park comprises a host of floristically and ecologically unique plant communities. Most species found within the framework of this study, however, are not restricted to the granite outcrops, but also occur in a broad variety of other habitats, most notably savannas, marshes or waste ground. Floristic links also exist with the vegetation of ferricretes, where certain species (e.g. *Cyperus submicrolepis*) are encountered in seasonally water-filled depressions. Only relatively few species such as *Afrotrilepis pilosa* and *Brachystelma simplex* appear to be confined to inselbergs in the study area. Many of the plant species inhabiting the rock outcrops display a distinct preference for unshaded habitat types and are considerably rarer in surrounding areas where they are less competitive. Inselbergs can thus be regarded as providing a refuge for a number of species.

Overall, the pattern of life-form spectra displays a strong resemblance to that found on granite outcrops in the Piedmont region, USA (see PHILLIPS, 1982), except that here the proportion of phanerophytes (almost 30%) is much higher than in the Comoé study area. In both areas, the life-form spectra are reminiscent of a desert environment. According to RAUNKAIER (1934), tropical environments are characterized by a preponderance of phanerophytes, with therophytes accounting for a relatively small percentage of species. The fact that the reverse situation exists on the outcrops of the Comoé study area and is in marked contrast with the surrounding vegetation, suggests that certain environmental conditions on the outcrops are extreme. This is particularly true for temperatures, which can be as high as 50°C (measured at a height of 10 cm above the surface) and also for short-term variation of water-availability. Precipitation in the study area tends to vary greatly from year to year. Particularly dry years are characterized by about 700 mm rainfall, whereas in wetter years, over 1000 mm are registered (data kindly provided by the research station of Würzburg University). Even in wet years, precipitation is not evenly distributed throughout the rainy season, but is patchy with occasional heavy downpours. It is not uncommon for no rain to fall for up to 10 days. Plants such as *Cyanotis lanata* react to extremes of temperature and lack of moisture by rolling in their leaves. Others are completely parched and die back, particularly on exposed sites with shallow soils.

Amongst the species present on the examined rock outcrops, only a small number occur at all study sites. Many more species were found only once or twice, and their presence could not be predicted. The high degree of randomness which is a marked feature of the occurrence of many species on rock outcrops may be associated with the pronounced temporal variability of the environmental conditions on rock outcrops. Most species which were only rarely present appear particularly well-adapted to be able to colonize sites characterized by an enhanced frequency of catastrophes (mostly climatic). Weeds in particular depend on temporally variable habitats, and it can be concluded that inselbergs play an important role as natural growing sites of some of today's widespread ruderals.

With regard to its phytogeographical affinities, the flora of Comoé rock outcrop communities is similar to that found in the adjacent areas. It is interesting to note that not a single local endemic species has been found on the inselbergs of the region to date. This is in sharp contrast with the situation in other tropical and temperate regions, where inselbergs can support a considerable number of endemic species (see ALVES & KOLBECK, 1994; BASKIN & BASKIN, 1988; GRÖGER, 1994; ORNDUFF, 1987; REITSMA & al., 1992). The reasons for the lack of endemics on the rock

outcrops in the Comoé study area are not yet fully understood. One explanation could be the general absence of endemics from the whole study area which belongs to the vast, but floristically relatively monotonous sudanian region. The large number of rock outcrops and other ecologically comparable habitats in the savanna zone of the Ivory Coast means that effective barriers between populations do not exist, or have not yet had time to have any impact. The probability of differentiation processes taking place within geographically separated populations resulting in the formation of local endemic species is therefore not particularly high. Certain species (e.g. *Cyanotis lanata, Brachstelma simplex*), however, do display a considerable degree of morphological variation between populations on different inselbergs, which might indicate that differentiation processes are in progress.

The conservation aspect of the vegetation of the rock outcrops in the north-east of the Ivory Coast merits special attention. Such habitats represent terrestrial islands scattered in a matrix of savanna and woodland, and frequently support a number of species which have become highly endangered in the surrounding landscape due to ever increasing human pressure. According to AKÉ ASSI (1988), *Burmannia madagascariensis* and *Drosera indica* are on the brink of extinction in the Ivory Coast. These species occur on disjunct "habitat islands" and display a characteristic patchy distribution pattern. *Burmannia madagascariensis, Drosera indica* and *Hymenodictyon floribundum* are examples of widely distributed species but which only rarely form large populations. This characteristic renders them particularly susceptible to becoming extinct locally. The only compensation for such species is their widespread distribution which allows reinvasion of former sites by existing populations elsewhere.

Since the rock outcrops of the study area have not attracted any significant human attention to date, their relictual character might be preserved, thus preventing the extinction of a number of rare and vulnerable species. Rock outcrops situated near villages, however, are sometimes used for agricultural purposes. In this context, the ephemeral flush communities have been the most seriously affected due to the ready availability of water. As a consequence, they have occasionally been converted into rice or manioc plantations resulting in the loss of most of the characteristic species.

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