PHYTOGEOGRAPHY AND VEGETATION OF TROPICAL INSELBERGS

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Résumé : Un bref aperçu de la végétation des inselbergs néo- et paléotropicaux est présenté. Les données proviennent d'études effectuées sur le terrain en Afrique de l'Ouest (Côte-d'Ivoire, Guinée, Cameroun), en Afrique de l'Est (Malawi), à Madagascar, au Brésil, au Venezuela et en Guyane française. Les habitats rocheux isolés sont occupés par une flore adaptée à ce milieu particulier qui diffère presque complètement de la végétation environnante. Ils constituent ainsi des modèles pour l'étude de l'écologie insulaire.

Les surfaces de roche apparemment nues sont ordinairement couvertes de cyanobactéries (ex. Guyane française) ou de lichens (ex. Côte-d'Ivoire). La végétation discontinue d'Angiospermes est constituée d'une mosaïque de différentes formations. Les plus remarquables sont caractérisées par des tapis de Monocotylédones (Broméliacées dans la région néotropicale et Cypéracées dans la région paléotropicale), des végétations marécageuses sur dalle granitique humide (plusieurs espèces d'*Utricularia*, de *Genlisea*, de *Burmannia* ainsi que d'Eriocaulacées) et des groupements saisonniers de plantes dans les cuvettes rocheuses (ex. Scrophulariacées). On trouve des types biologiques convergents dans les régions paléo- et néotropicales (ex. rosettes caulescentes chez les Cypéracées et Velloziacées).

Mots-clés : Biodiversité, géobotanique, inselbergs, écologie insulaire, phytogéographie, rochers découverts. Broméliacées,Cactacées, Velloziacées.

Abstract: A short survey of the vegetation of neo- and paleo-tropical rock outcrops (inselbergs) is provided. The data are based on field studies in West Africa (Ivory Coast, Guinea, Cameroon), East Africa (Malawi), Madagascar, Brazil, Venezuela and French Guyana. The insular rock habitats are covered by a highly adapted flora differing almost totally from the surrounding vegetation and thus provide models for studying questions of island ecology.

Apparently nude rock surfaces are usually covered almost completely by cyanobacteria (e.g. French Guyana) or lichens (e.g. Ivory Coast). The fragmented angiosperm vegetation consists of a mosaic of different vegetation types. Characteristic are monocotyledonous mats (Bromeliaceae in the neotropics and Cyperaceae in the paleotropics), flush vegetation (many *Utricularia* spp., *Genlisea* spp., *Burmannia* spp., Eriocaulaceae) and seasonal plant communities in rock pools (e.g. Scropholariaceae). Phenotypic similar life forms occur convergently in the paleo- and neotropics (e.g. caulescent rosette-trees in Cyperaceae, Velloziaceae).

Keywords: Biodiversity, geobotany, inselbergs, island ecology, phytogeography, rock outcrops. Bromeliaceae, Cactaceae, Velloziaceae.

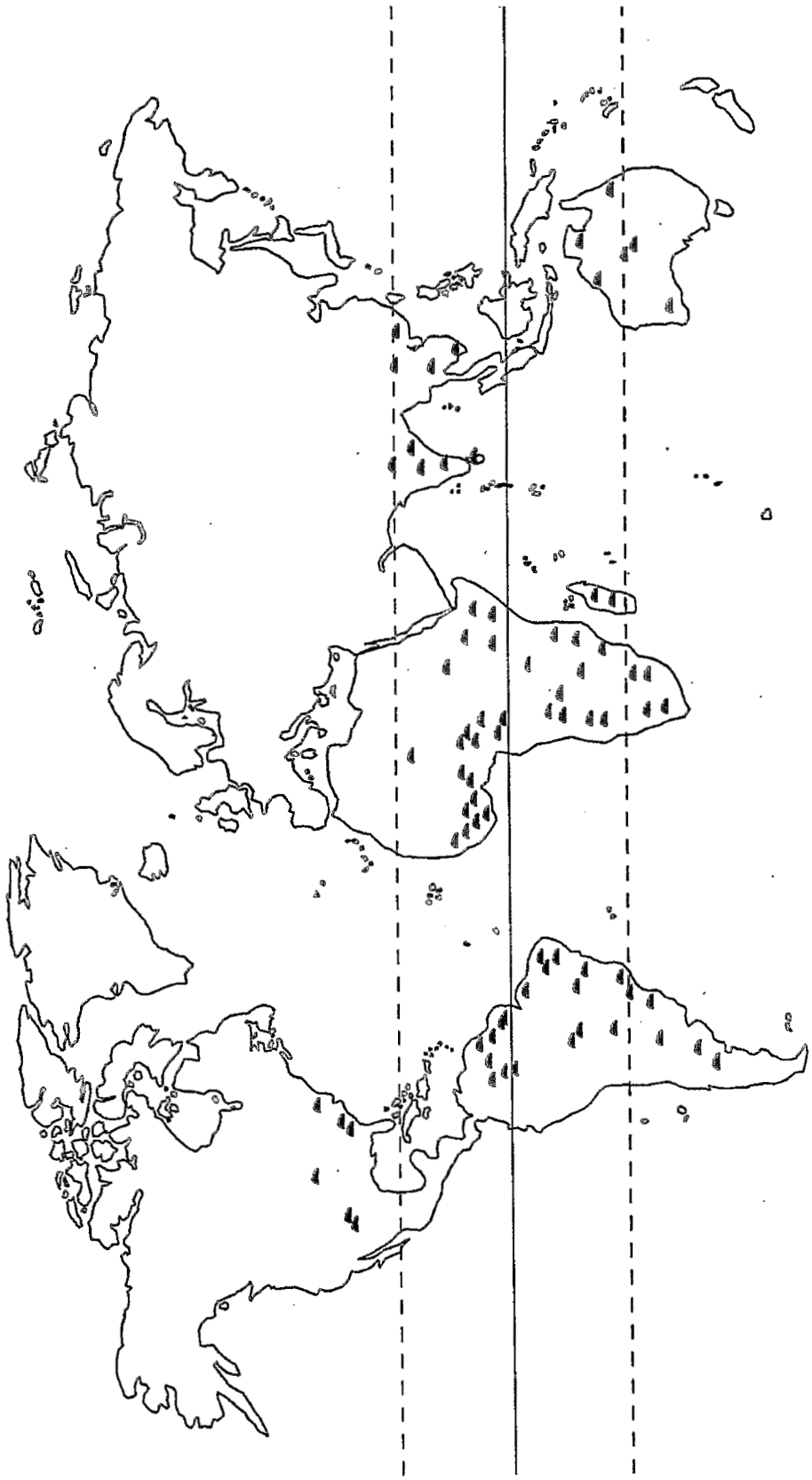


Figure 1
Global distribution of inselbergs. The symbols indicate clusters of inselbergs concentrations.

Introduction

Inselbergs are isolated tropical (rarely extratropical) rock outcrops, mostly of precambrian granitic or gneissic origin (figs 1, 2). They are geomorphologically very old structures up to 70 million years old.

The geographer W. BORNHARDT (1900) introduced the term "insel-berg" to describe the dome-shaped monoliths in East Africa. The geomorphology and geology of inselbergs has been studied worldwide; a monographic survey is provided by BREMER & JENNINGS (1978).

However, little is known about the biotic cover of inselbergs. This is most surprising, because they bear an extremely adapted vegetation differing almost completely from the surrounding forests or savannas. This was pointed out already by Alexander von HUMBOLDT in 1819 based on his observations of rock outcrops along the Orinoco in 1799.

The botanical exploration of "inselbergs" was initiated in Ceylon by WILLIS (1906). Floristically best known is the vegetation of West African inselbergs (e.g. MILDBRAED, 1922; MIEGE, 1955; RICHARDS, 1957; HAMBLER, 1964; ADJANOHOUN, 1964; BONARDI, 1966; SCHNELL, 1952; GUILLAUMET, 1967; LETOUZEY, 1968; VILLIERS, 1981; REITSMAR *et al.*, 1992; POREMBSKI & BARTHLOTT, 1992).

Inselbergs are usually isolated "insular" structures under edaphic, floristic, and microclimatic (POREMBSKI *et al.*, 1994) aspects. As "terrestrial islands" (in the sense of Mc ARTHUR & WILSON, 1967), they are suitable models for studying questions of island ecology. For studying processes of ecogeographical differentiation, speciation and mechanisms of regulation of biodiversity (deterministic and stochastic influences) they may provide better models than true marine islands (BARTHLOTT, GROEGER & POREMBSKI, 1993).

They vary in size from mountains (fig. 2) to miniature islands of a few square meters in minimum size, which still show their typical biotic cover (fig. 3). In contrast to oceanic islands they may occur as continental systems over short distances in steep climatic gradients (compare map fig. 1). Contrary to marine islands they represent often the last intact ecosystems in landscapes disturbed by man.

Geographical occurrence of inselbergs

Inselbergs occur throughout the perhumid and semihumid tropics; occasionally in arid, subtropical (Australia) or even temperate regions (e.g. USA). In the neotropics inselbergs are mostly distributed in atlantic Eastern Brazil and the western orinocan (Venezuela) and eastern border (Guianas) of

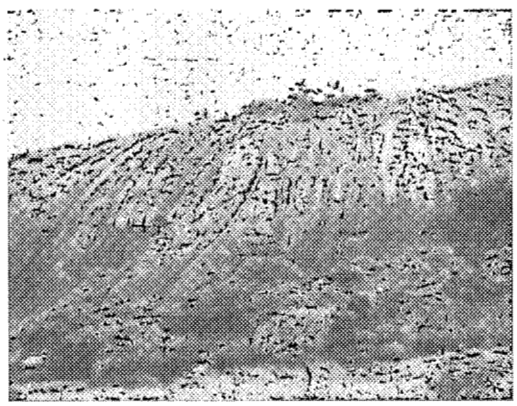


Figure 2

Mont Niangbo, southern summit of the largest inselberg in Ivory Coast, West Africa. Different habitats and vegetation types are visible: belt forest, exposed rock surface with numerous drainage channels, *Afrotrilepis*-mats and small woody patch on top.

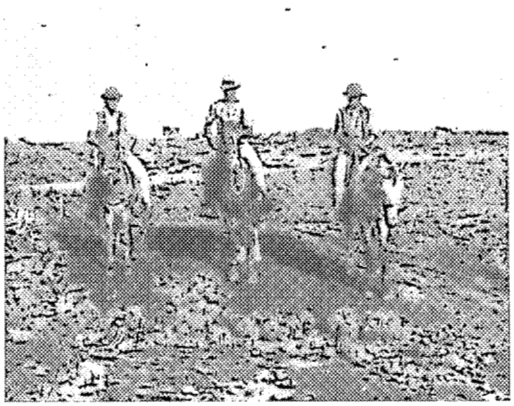


Figure 3

Small rock outcrop: a miniature "shield"-inselberg with its typical representative *Melanocactus ferreophilus* Buining and Brederoo (Bahia Brazil).

the Guyana Shield. The paleotropic occurrence is concentrated in Africa (Upper Guinea, Cameroon and Central Africa to Angola; semiarid East Africa); they are also present in Central and South Madagascar. Inselbergs also occur in India and Ceylon, between South China and Malaysia, and in Australia. Table-Mountains like the Tepuis are not considered as "inselbergs" in our context.

The concentration of inselbergs coincides to a high degree with the regional centers of biodiversity. This emphasizes the importance of studies in these very little known biota.

Habitats and vegetation types on inselbergs

Edaphic conditions and thus habitat types and subsequently vegetation communities on inselbergs are drastically different from the surrounding.

(1) Exposed rock surfaces are usually covered by crustose lichens or cyanobacteria; (2) drainage channels (fig. 2) bear a slightly differing cryptogamic flora. (3) Rock crevices and boulder-falls may be colonized by perennials or even woody plants. (4) Rock pools are seasonally water filled and colonized by aquatic or semiaquatic ephemerals and occasionally geophytes, similar are (5) Flat depressions which harbour seasonally inundated communities. (6) Monocotyledonous mats are a most characteristic uniform plant community inhabiting rock slopes; in the paleotropics they are usually dominated by Cyperaceae, in the neotropics by Bromeliaceae and Velloziaceae. (7) Ephemeral flush vegetation often develops adjacent to monocot mats or larger rock pools on thin layers of peaty soil: the most diverse habitat type concerning species numbers on inselbergs (e.g. *Genlisea*). (8) Wet flush vegetation, a less diverse community of few highly adapted species (e.g. *Utricularia),* may occur during the rainy season in water films on bare rocks. Two additional vegetation types are often associated with larger inselbergs. (9) Wood patches occurring in depressions (e.g. *Clusia* on the Guyana shield inselbergs) or even as summit forest; (10) belt forests often surround larger inselbergs like gallery forests even in xeric vegetation types (e.g. savannas) caused by the local water runoff.

Figure 4

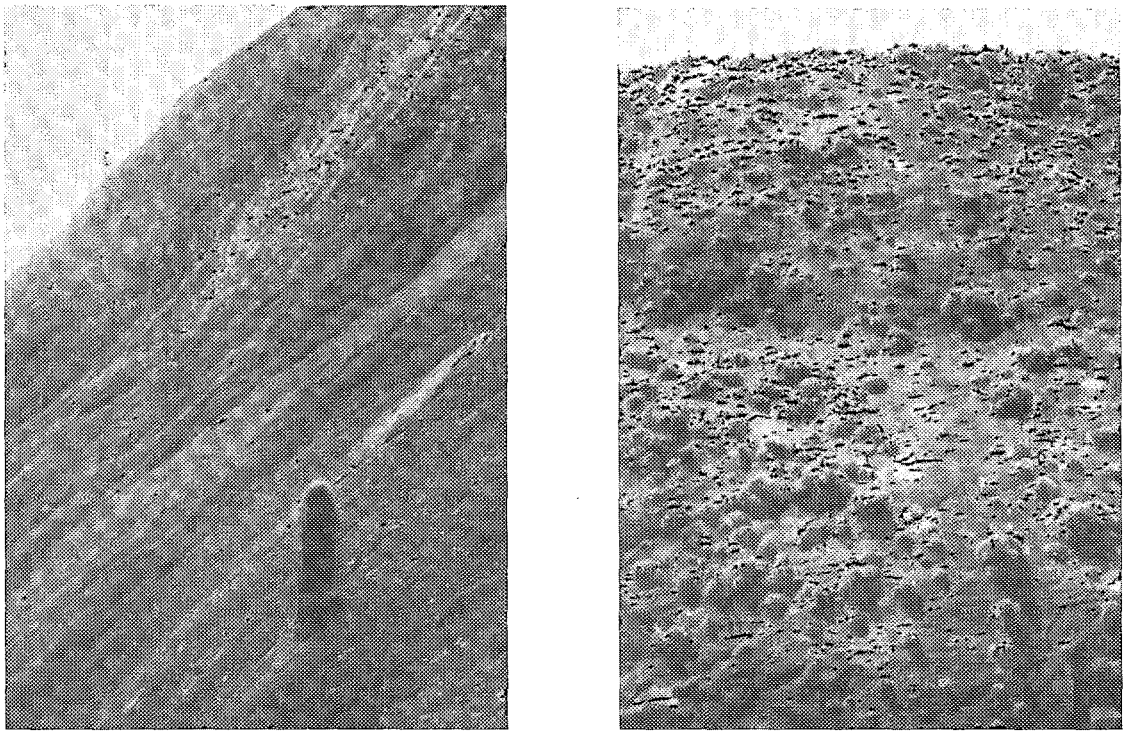
Floristic elements of an inselberg in Central Madagascar: *Pachypodium densiflorum* Baker, *Xerophyta dasyliroides* Baker, and *Coleochloa setifera* (Ridley) Gilly.

Figure 5

Coleocephalocereus fluminensis (Miquel) Backeberg inhabiting a tropical atlantic rain forest inselberg (Espiritu Santu, Brazil).

The vegetation of neotropical inselbergs

Inselbergs are restricted to the Guyana and Brazilian shield (up to East Bolivia); they are absent in Central America and the Caribbean (the Cuban karst mountains of the "mogotes-type" are not considered here). The classical whale back and sugar loaf forms (Rio de Janeiro!) dominate. They are locally known as "morros" or "lajas". Vegetation studies are published from French Guyana (de GRANDVILLE, 1978, 1982; SARTHOU, 1992; LARPIN, 1993) and Surinam (THEUNISSEN & WILDSCHUT, 1979); only few notes are published on Venezuela (HUBER 1980), and Brazil (e.g. EGGLI, 1992).



Figures 6 and 7

Two neighbouring inselbergs in Northern Espiritu Santu, Brazil, showing a totally different vegetation: uniform cover of mats of *Echolirium horridum* L. B. Smith (left) in contrast to white tufts of *Tillandsia kurt-horstii* Rauh & Grob with a single short column of *Coleocephalocereus brevicylindricus* (Buining) Riter (right).

The almost blackish colour of the Guyana shield inselbergs, which HUMBOLDT (1819) expected to be efflorescing mangan and iron, is mainly caused by cyanobacteria (e.g. *Scytonema, Stigonema*).

The monocotyledon mats are usually formed by Bromeliaceae like *Pitcairnia* spp. on the Guyana shield and by *Dyckia, Encholirium, Tillandsia* and *Vriesea* on the Brazilian shield. In NE Brazil Velloziaceae (*Vellozia, Barbacenia)* in association with Bromeliaceae may dominate these mats, in South Brazil Apiaceae are associated like the Bromeliad-like *Eryngium pristis.* Restricted to Velloziaceae as host plants are particular epiphytic orchids (*Pseudolaelia*: fig. 9 and *Constantia*). Wood patches seem to be characteristic of the Guyana shield inselbergs. They are often composed by *Clusia* spp. and semideciduous tree species obviously derived from deciduous sister taxa inhabiting the surrounding forests.

The Brazilian inselbergs are particularly rich in endemic species often restricted to very small areas. The beta-diversity between almost neighbouring inselbergs may vary dramatically as illustrated in figs. 6 and 7: two inselbergs in sight distance in northern Espiritu Santo, one almost exclusively colonized by *Encholirium horridum* (fig. 7), the other one by the white tufts of *Tillandsia kurt-horstii* in combination with few specimens of *Coleocephalocereus brevicylindricus* (fig. 6). Cactaceae is ultimately the family which characterizes the inselbergs of the Brazilian shield. They are derived from three different systematic groups (BARTHLOTT & HUNT, 1993). The inselbergs in Rio Grande do Sul bear small globular Notocacteae (*Parodia* incl. *Notocactus, Brasili-cactus*) with relatives in the semiarid regions of the La Plata States. Inselbergs in the tropical atlantic rainforest and adjacent caatinga and campo cerrado regions show a particular characteristic cactus flora of genera belonging to the Cereeae: derived from large arborescent forms (e.g. many *Cereus* and *Pilosocereus* spp.) they are reduced to solitary columns in the genus *Coleocephalocereus* (fig. 5) which may become procumbent or even very short and stout (fig. 6) and thus show almost a complete transi-

tion to the globular *Melocactus* spp. (fig. 3). A last group of Cacti is derived from a completely differing systematic and ecological group: a few members of the epiphytic tribe Rhipsalideae are specialized on rock outcrops (e.g. *Rhipsalis epiphyllanthoides*, R. *russellii*).

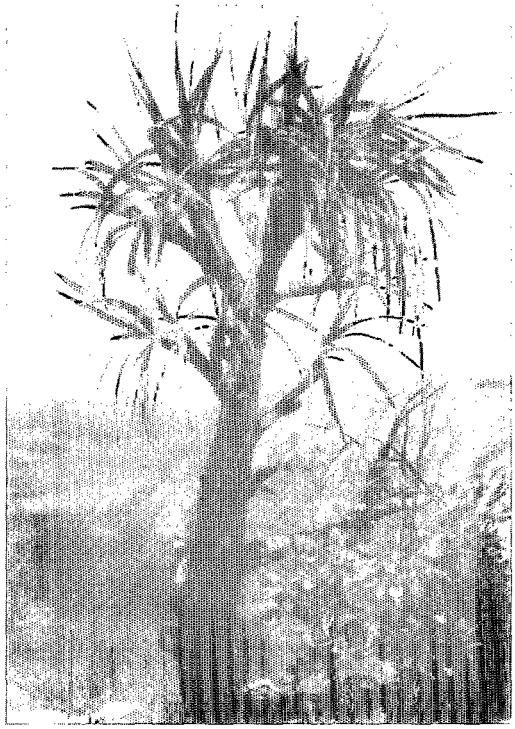


Figure 8
Xerophyta splendens (Rendle) N. Menezes, Velloziaceae (Malawi).

Figure 9
Vellozia candida Mican, Velloziaceae with its specific epiphyte *Pseudolaelia vellozicola* (Hoehne) C. Porto & Brade (Bahia, Brazil).

The epiphytic *Rhipsalis baccifera* is the only cactus occurring naturally in the paleotropics: interestingly enough in Madagascar this species found a secondary evolutionary center with neotenic polyploid forms (BARTHLOTT, 1983) colonizing inselbergs (fig. 13). The species richness of neotropical inselbergs is high and many more families could be listed. Amongst these the Orchidaceae are to be mentioned (with e.g. many xeromorphic or even succulent *Pleurothallis* spp., *Laelia* spp.), *Utricularia* spp. and Eriocaulaceae of the ephemeral flush vegetation. The "geophyte" (MARTINELLI, 1984) *Worsleya rayneri* produces giant bulbs on bare rock surfaces in Eastern Brazil.

The vegetation of inselbergs in Africa and Madagascar

Inselbergs occur throughout perhumid to semiarid Africa (geomorphologically in Southern and Eastern Africa often "kopje"-types) and in Central and Southern Madagascar.

In Africa the inselbergs of Ivory Coast are best studied. Only some 400-600 species of vascular plants are known from these inselbergs, usually the vegetation of one particular inselberg is composed of about 70-100 species. Most characteristic are the Guineo-Congolian *Afrotrilepis pilosa* and the Sudano-Zambezian *Cyanotis lanata*. The West African inselbergs are rather uniform (higher diversity gradients betweeen neighbouring inselbergs in the Cameroons: FISCHER & BARTHLOTT, 1994); a center of endemism is Guinea (e.g. *Microdracoides squamosus* also in Nigeria and Cameroon, fig. 10; the bromeliad *Pitcairnia feliciana*, fig. 12). The occurrence of particular species may be connected to a minimum size of rock surface (e.g. *Afrotrilepis* requires more than 50 000 m^2). The biodiversity of particular subhabitats is differently influenced by deterministic (e.g. *Afrotrilepis*- mats) or stochastic (e.g. vegetation of rock-pools) factors.

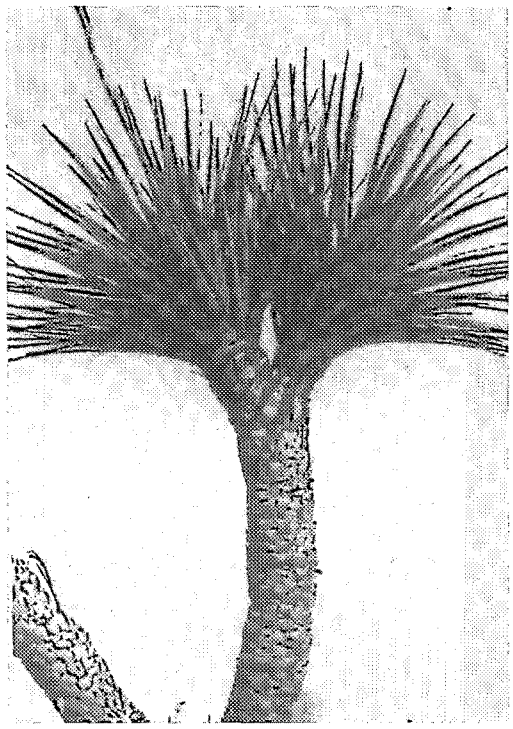


Figure 10
Microdracoides squamosus Hua, Cyperaceae (Guinea).

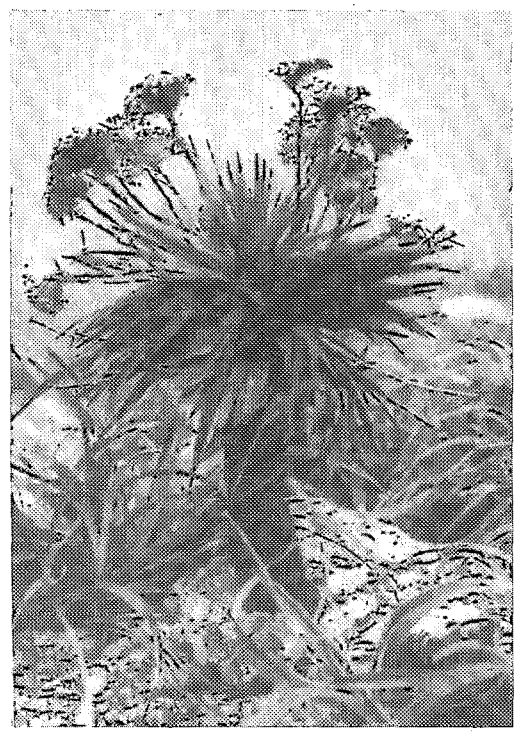


Figure 11
Paepalanthus robustus Silveira, Eriocaulaceae (Minas Gerais, Brazil).

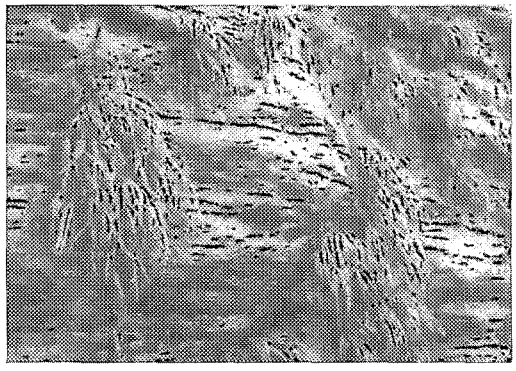


Figure 12
Pitcairnia feliciana (A. Chev.) Harms & Mildb., Bromeliaceae (Guinea).

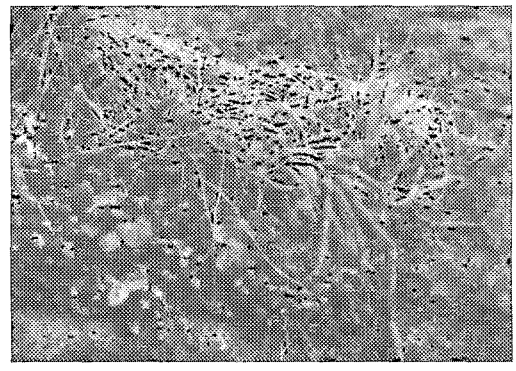


Figure 13
Rhipsalis baccifera ssp. *horrida* (Baker) Barthlott, Cactaceae, with *Xerophyta dasyliroides* Bak. and *Stapelianthus decaryii* Choux. (South Madagascar).

The ephemeral flush vegetation harbours the highest number of species on paleotropical inselbergs and is dominated by Lentibulariaceae, Cyperaceae and Eriocaulaceae. In particular *Utricularia* is well represented, and *Genlisea* seems to be almost exclusively restricted to this type of vegetation in Africa (e.g. *G. africana)* and Madagascar (*G. margaretae).* Only a small number of species in vascular plants is common to neo- and paleotropical inselbergs, and most of them belong to the flush vegetation: e.g. *Utricularia pubescens, U. subulata, Neurotheca loeselioides.* Floristically the vegetation of African inselbergs seems to be related to the vegetation of ironstone outcrops ("Bowals", see

e.g. SCHNELL, 1952) and thus savannas in general. Even on inselbergs located within the rain forest belt (e.g. the Mt. Niénokoué in the Taï-forest) Sudano-Zambezian elements occur in high numbers.

In contrast to the neotropics epilithic orchids and other plants derived from epiphytic communities are relatively rare. However, convergently to the situation in Brazil we find orchids specifically bound to caulescent rosette-trees as host plants: e.g. *Polystachya microbambusa* on *Afrotrilepis pilosa* and *Polystachya johnstonii* on *Xerophyta splendens* (Malawi).

The West African *Afrotrilepis* is replaced by *Coleochloa setifera* in East Africa and Madagascar. A high number of other genera inhabits the *Coleochloa*-mats: e.g. succulent Aloe - and *Euphorbia* spp. In particular the inselbergs of Madagascar are characterized by a high number of dwarf succulents (*Aloe, Euphorbia, Kalanchoe, Pachypodium, Stapelianthus, Rhipsalis*: figs. 4-13); they share with Eastern and Southern Africa the poikilohydric genera *Myrothammnus* and *Xerophyta.*

Vegetation of Asian and Australian inselbergs

Apart from a few monolithic rocks, inselbergs are less dominating landscape elements on the Indian subcontinent, South East Asia and Australia. In India and Ceylon (WILLIS, 1906, 1911) dominate Cyperaceae, Orchidaceae (e.g. *Bulbophyllum* spp., *Eria* spp.), Lamiaceae, Scrophulariaceae; *Utricularia* spp. and succulent *Euphorbia* spp. Apart from a few studies (e.g. ORNDUFF, 1987) little is published about Australian inselbergs. Their vegetation differs significantly from the rock vegetation in other regions: dominating are Asteraceae, Stylidiaceae and Liliaceae s.l. (e.g. the poikilohydric *Borya sphaerocephala*) which represent about 40% of the species.

Inselbergs in temperate regions

Inselbergs in temperate regions are rare and considered as relicts of tertiary tropical climatic conditions (survey *in* KESEL, 1973). In particular in North America they occur between North Carolina and East Alabama and there are several floristic (McVAUGH 1943) and ecological studies (HOULE & PHILLIPS, 1988, 1989a, 1989b). The subhabitats are somewhat similar to tropical inselbergs. Generally, the vegetation is poorer than within the tropical counterparts and relatively uniform (KEEVER *et al.*, 1951). After McVAUGH (1943) the number of taxa on rock outcrops up the 100 000 m^2 size does not exceed 20 spp., whereas comparable inselbergs in West Africa harbour up to 100 species. On the other hand, MURDY (1968) has pointed out that granite outcrops are centers of diversity in Georgia and particular adapted species have evolved. The best example seems to be *Amphianthus pusillus* (Scrophulariaceae) in seasonal rock pools and thus being an ecological counterpart of its tropical relative *Chamaegigas intrepidus* from similar habitats on inselbergs of Namibia.

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LITERATURE CITED

ADJANOHOUN, E., 1964 - Végétation des savanes et des rochers découverts en Côte-d'Ivoire centrale. Mém. ORSTOM. 7, Paris, 178 p.

AKE ASSI, L., 1984 - Flore de la Côte-d'Ivoire : étude descriptive et biogéographique, avec quelques notes ethnobotaniques, 3 parts in 6 vols., thèse université Abidjan, 1206 p.

BARTHLOTT, W., 1983 - Biogeography and evolution in neo- and paleotropical Rhipsalinae (Cactaceae). - *Sonderbd. naturwiss. Ver. Hamburg,* 7: 241-248.

BARTHLOTT, W., A. GREGER et S. POREMBSKI, 1993 - Some remarks on the vegetation of tropical inselbergs: Diversity and ecological differentiation. *Biogéographica* , 69: 105-124.

BARTHLOTT, W. et D. HUNT, 1993 - Cactaceae. KUBITZKI, K. et *al.* (eds.), The families and genera of vascular plants 2: 161-197. Springer, Berlin, Heidelberg, New York.

BONARDI, D., 1966 - Contribution à l'étude botanique des inselbergs de Côte-d'Ivoire forestière. Dipl. Et. Sup., Abidjan, 81 p.

BORNHARDT, W., 1900 - Zur Oberflechengestaltung und Geologie Deutsch-Ostafrikas. Reimer, Berlin 495 p.

BREMER, H. et J. JENNINGS (eds.), 1978 - Inselbergs, Inselberge. Z. Geomorph. N.F., Suppl. 31.

EGGLI, U., 1992 - Brasiliens « Zuckerhote ». *Gartenpraxis* , 3: 54-57.

FISCHER, E. et W. BARTHLOTT, 1994 - Zur Vegetation der Inselberge bei Yaounde/Kamerun. Phytocoenologica (in prep.).

GRANVILLE, de J.-J., 1978 - Recherches sur la flore et la végétation guyanaises. Thèse de doctorat d'Etat, USTL, Montpellier, 272 p.

GRANVILLE, de J.-J., 1982 - Rain forest and xeric flora refuges in French Guiana. *In* G.T. PRANCE (ed.), Biological Diversification in the tropics. Columbia Univ. Press, New York: 159-181.

GUILLAUMET, J.-L., 1967 - Recherches sur la végétation et la flore de la région du Bas-Cavally (Côte-d'Ivoire). Mém. ORSTOM 20, Paris.

HAMBLER, D. J., 1964 - The vegetation of granitic outcrops in Western Nigeria. *J. Ecol.* 52: 573-594.

HOULE, G. & D. L. PHILLIPS, 1988 - The soil seed bank of granite outcrop plant communities. *Oikos,* 52: 87-93.

HOULE, G. & D. L. PHILLIPS, 1989a - Seasonal variation and annual fluctuation in granite outcrop plant communities. *Vegetatio* , 80: 25-35.

HOULE, G. & D. L. PHILLIPS, 1989b - Seed availability and biotic interactions in granite outcrop plant communities. *Ecology* , 70: 1307-1316.

HUBER, O., 1980 - Die Felsvegetation am oberen Orinoko in Süd-Venezuela. In H. REISIGL (ed.), Blumenparadiese und botanische Gärten der Erde. Pinguin Verlag, Innsbruck und Umschau-Verlag, Frankfurt/Main: 200-203.

HUMBOLDT, A. V., 1819 - Relation historique du voyage aux régions équinoxiales du Nouveau Continent fait en 1799-1804, par A. de HUMBOLDT et A. BONPLAND Vol. 2, Paris 1819.

KEEVER,C., H. J. OOSTING & L. E. ANDERSON, 1951 - Plant succession on exposed granite of Rocky Face Mountain, Alexander County, *North Carolina. Bull. Torrey Bot. Club* , 78: 401-421.

KESEL, R. H., 1973 - Inselberg landforms elements: definition and synthesis. *Revue de géomorphologie dynamique* , 22: 97-108.

LETOUZEY, R., 1968 - Etude phytogéographique du Cameroun. Ed. Paul Lechevalier, Paris.

Mc ARTHUR, R. H. & E. O. WILSON, 1967 - The theory of island biogeography. Princeton University Press, Princeton.

Mc VAUGH, R., 1943 - The vegetation of the granite flatrocks of the southeastern United States. *Ecol. Monog.*, 13: 119-165.

MARTINELLI, G., 1984 - Nota sobre *Worsleya rayneri* (H. D. Hooker) Traub & Moldenke, espécie ameçeada de extinçáo. *Rodriguesia* , 36: 65-71.

MIEGE, J., 1955 - Savanes et forêts claires de la Côte-d'Ivoire. *Etudes Eburnéennes, IFAN* , 4: 62-83.

MILDBRAED, J., 1922 - Wissenschaftliche Ergebnisse der Zweiten Deutschen Zentral-Afrika-Expedition 1910-1911. Band II: Botanik. Klinkhardt & Biermann, Leipzig.

MURDY, W. H., 1968 - Plant speciation associated with granite outcrop communities of the southeastern Piedmont. *Rhodora,* 70: 394-407.

ORNDUFF, R., 1987 - Islands on islands: plant life on the granite outcrops of Western Australia. Harold Lyon Arboretum, lecture no. 15, University of Hawaii Press, Honolulu.

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

POREMBSKI, S. & W. BARTHLOTT, 1993 - Ökogeographische Differenzierung und Diversität der Vegetation von Inselbergen in der Elfenbeinkuste. In: Barthlott, W., Naumann, C.M. et al. (eds.) Res. of the annual GTO-Meeting 1992. "Animal-Plant-Interactions in Tropical Environments", Bonn: 149-158.

POREMBSKI, S., J.-P. MUND, J. SZARZYNSKI et W. BARTHLOTT, 1994 - Ecological conditions and floristic diversity of an inselberg in the savanna zone of Ivory Coast: Mt. Niangbo, ORSTOM, Paris (in press).

REITSMA, J. M., A. M. LOUIS et J. J. FLORET, 1992 - Flore et végétation des inselbergs et dalles rocheuses : première étude au Gabon. *Adansonia* , 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.

SARTHOU, C., 1992 - Dynamique de la végétation pionnière sur un inselberg en Guyane française. Thèse de doctorat d'Etat, université Paris 6, 253 p.

SCHNELL, R., 1952 - Contribution à une étude phytogéographique de l'Afrique occidentale : les groupements et les unités géobotaniques de la Région Guinéenne. *Mém. IFAN*, 18 : 45-234.

SCHNELL, R., 1952 - Végétation et flore de la région montagneuse du Nimba. Mém. Inst. Francais d'Afrique noire, n° 22.

THEUNISSEN, P. A. et J. T. WILDSCHUT, 1970 - Vegetation and flora of the savannas in the Brickheuvel Nature Reserve, Northern Suriname. *Verh. kon. ned. Akad. Wet.* 59, n° 2, 58 p.

VILLIERS, J.F., 1981 - Formations climaciques et relictuelles d'un inselberg inclus dans la forêt dense camerounaise, thèse de doctorat d'État, université Paris 6, 501 p.

WILLIS, J. C., 1906 - The flora of Ritigala, an isolated mountain in the North-Central province of Ceylon; a study in endemism. *Annals of the Royal Botanic Gardens, Peradeniya*, 8: 271-302.

WILLIS, J. C., 1911 - The Flora of Naminakulikanda, a somewhat isolated Mountain in the province of Uva. *Annals of the Royal Botanic Gardens, Peradeniya,* 11: 217-222.