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The palm flora of West Africa: Côte d'Ivoire, Ghana, Togo and Bénin

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Abstract

We present the first comprehensive floristic treatment of the native palms from Côte d'Ivoire, Ghana, Togo and Bénin. The morphology of vegetative and reproductive organs and the ecology of the 21 different palm species in 11 genera are described and the geographical distribution as well as informative figures are presented for all taxa reported in the area. Identification keys to all genera and species are proposed to facilitate identification of living individuals and herbarium material. Our survey includes almost 60 % of all palm species currently reported for West Africa. We also present analyses on the taxonomic, floristic, growth habit and morphologic diversity, the ecology and the economic importance. The main threats faced by the species present in the studied area are preliminary discussed.

Keywords: Floristics, taxonomy, ecology, palms, Arecaceae, West Africa

Résumé

Nous proposons le premier traitement floristique complet des palmiers autochtones de la Côte d'Ivoire, du Ghana, du Togo et du Bénin. La morphologie des organes végétatifs et reproductifs, ainsi que l'écologie des quelques 21 espèces et 11 genres sont présentés, avec la distribution géographique et des images détaillées de tous les taxons cités pour les pays concernés. Des clés d'identification pour tous les genres et espèces sont fournies pour faciliter l'identification du matériel tant vivant qu'herborisé. Notre étude inclut presque 60% de l'ensemble des espèces actuellement répertoriées en Afrique de l'Ouest. Nous présentons également des analyses sur leur richesse taxonomique et floristique, leur diversité en formes de croissances et morphologie, leur écologie et leur importance économique. Des commentaires préliminaires sont proposés sur l'état de conservation des espèces.

Mots-clés: Floristique, taxonomie, écologie, palmiers, Arecaceae, Afrique de l'Ouest

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Introduction

Continental African palms, in particular the ones native of West African countries, have been subject of floristic and taxonomic research in the Conservatory and Botanic Gardens of Geneva (CJBG) since 2010. With 38 species in 13 genera (9% of palm taxa being endemics) the palm floristic diversity reported for this region is only second after the one identified in Central Africa (Stauffer et al. 2014, 2017; Mbandu Luzolawo et al. 2020). The high ecologic and economic importance of most palms of the region has been highlighted by several authors (i. e. Burkill, 1997; Kahn & Luxereau, 2008; Sambou et al. 2002; Ouattara et al. 2015, 2017; Michon et al. 2018) and their accurate inventory at country level has been regarded as critical for the proposal of local conservation and sustainable use strategies. Despite their recognized importance many West African palm taxa remain incompletely known and only represented by fragmentary specimens stored in local or international herbaria.

The first historical palm collector visiting the region was the French explorer and botanist Ambroise M. Palisot de Beauvois (1752-1820), who collected several benchmark palms in southern Nigeria and probably also eastern Bénin between 1786 and 1787. The Danish botanist Peter Thonning (1775-1848) was appointed by the Danish crown to supervise the plantations of its colonies in Gold Coast, now Ghana, and from 1799 to 1803 collected some benchmark palms. Unfortunately, all specimens associated to Thonning's period in Ghana were destroyed during the bombardment of Copenhagen by the English army in 1807. More than fifty years later the German botanists Gustav Mann was appointed as gardener by the Royal Botanic Gardens Kew and recruited by the director of this institution, William Hooker (1785-1865), as responsible of plant collecting on the Niger Expedition, then exploring this major river in West Africa under the leadership of Captain William Balfour Baikie (1825-1864). The main results of Mann's palm studies appeared in the first comprehensive account on West African palms (Mann and Wendland 1864), in which many benchmark palm genera and species of the region were first described. The French botanist and explorer August Chevalier (1873-1956) should be cited as a remarkable palm collector during the early decades of the XX century. This prolific collector, appointed by the *Laboratoire d'agronomie coloniale du Muséum national d'histoire naturelle de Paris* carried out extensive palm research in West Africa and made important efforts towards the scientific comprehension of economically important taxa (Chevalier 1932; Chevalier & Dubois 1938). Although often incomplete and lacking precise information on the geographical origin,

the palms gathered by historical botanists were described by the most renowned palm experts at that time (i. e. O. Beccari, O. Drude, N. von Jacquin, C. von Martius and H. Wendland). The taxonomic interpretation of type specimens of West African palms can represent, nonetheless, a very frustrating task as they may no longer be extant or when present only represented by small fragments of leaflets, inflorescences, or fruits. Moreover, extremely important historical material is frequently stored in neglected or inaccessible carpological collections.

Modern standards of palm collecting leading to considerably more informative specimens were applied by botanists from the mid XX century. Indeed, good examples of palm collecting in West Africa can be identified when studying the specimens gathered by Laurent Aké Assi (Côte d'Ivoire, Bénin), P. B. Tomlinson, Harold Moore and J. B. Hall (Ghana), J. P. Profizi (Bénin), and T. Sunderland and J. van Valkenburg (several countries of West Africa). More recently, a complete team from the CJBG generously funded by the A. Lombard of the SPHN has been carrying out a multidisciplinary study (floristics, ecology, ethnobotany conservation) of the palms of Côte d'Ivoire, Ghana, Togo and Bénin. Several researchers of CJBG and master students of the University of Geneva have been able to gather more than 130 informative palm specimens from these countries. The material is now deposited in the herbarium of Geneva (G), making of this the richest collection with respect West African palms to date, and duplicates being systematically stored in at least one institutional herbarium in the countries where the palms have been collected.

The evolution of West African palms is far to be understood and most fossil records are restricted to pollen from drill cores dating back to the Late Cretaceous-Early Miocene (Pan et al. 2006). The calibration of modern molecular phylogenies including West African palms lack important properly dated fossils and it is clear that further efforts should be undertaken on this subject in order to better define the origin and diversification of this interesting palm flora. The plant inventories undertaken in several West African countries have largely contributed to our current knowledge of the native palm flora. Preliminary palm checklists were included in the general plant inventories of Côte d'Ivoire (Aké Assi 2002; Chatelain et al. 2011), Ghana (Irvine 1961), Togo (Brunel et al. 1984), Bénin (Aké Assi et al. 2006) or in the comprehensive and well-illustrated plant treatments of the region published by Hawthorne and Jongkind (2006). These contributions represent an important starting point for the present study, but the lack of well-collected specimens still hindered our understanding of the palms in the region. The present study aims to provide a detailed and updated

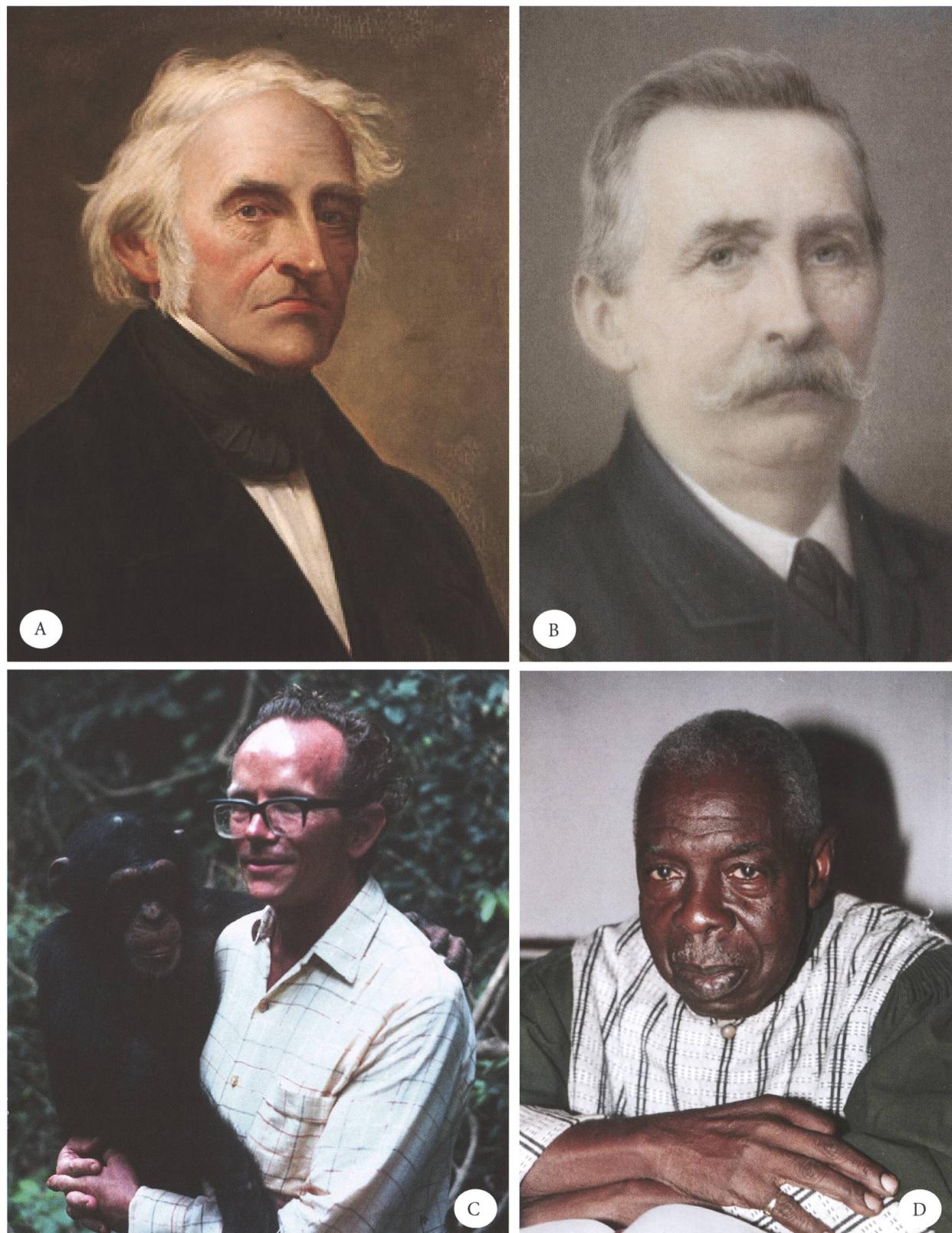


Fig. 1. Main botanists collecting and describing palm diversity in Côte d'Ivoire, Ghana, Togo and Benin. **A.** Carl von Martius; **B.** Hermann Wendland (photo courtesy of the Gottfried Wilhelm Leibniz Library, Hannover); **C.** John Hall (photo courtesy Herbarium GC); **D.** Laurent Aké-Assi (Photo courtesy of Emma Aké-Assi, Abidjan).

picture on the palm flora of these countries, focusing on intensive field efforts undertaken between 2010 and 2019. We describe the morphology, distribution, and ecology of the 21 different palm species in 11 genera native from Côte d'Ivoire, Ghana, Togo and Bénin, which represents almost 60 % of all the palm species reported for West Africa.

Although probably lacking more field data for some imperfectly known and under collected taxa, we believe that the present flora not only contributes to a better floristic knowledge of the palm family in the region, but may also become an important support tool for disciplines such as economic botany, ethnobotany, ecology and conservation. The present work represents the first of a series of contributions describing the palm flora of West African countries.

Geological and geographical context

The countries included in our study are all part of the West African Craton (WAC), one of the five cratons of the Precambrian basement rock of Africa that make up the African Plate, the others being the Kalahari craton, Congo craton, Saharan Metacraton and Tanzania Craton (Jessell and Liégeois 2015). The West African craton consists of an Archean or Paleoproterozoic basement covered by Neoproterozoic to Holocene sedimentary deposits (Villeneuve and Cornée, 1994). It is composed by two centers juxtaposed against multiple Paleoproterozoic domains made of greenstone belts, sedimentary basins, regional granitoid-tonalite-trondhjemite-granodiorite (TTG) plutons, and large shear zones. The craton is overlain by Neoproterozoic and younger sedimentary basins. The boundaries of the WAC are predominantly defined by a combination of geophysics and surface geology, with additional constraints by the geochemistry of the region (Jessell and Liégeois 2015).

Côte d'Ivoire, Ghana, Togo, and Bénin are in West Africa (4°-28°N, 15°E and 16°W.), one of the classical sub-regions characterizing the large African continent. The southern boundary of West Africa is defined by the Gulf of Guinea, and that to the north reaches the septentrional regions of Mauritania, Mali, and Niger. The Mount Cameroon-Adamawa Highlands, with its highest elevation at 4040 m, delimit the sub-region to the West whereas the Atlantic Ocean represents the eastern boundary. The region covers about 6 million km² and is characterized by topographical, hydrological, and climatic conditions that largely shape the palm biological diversity observed in the area. Here below we provide a brief description of the main geographical features characterizing the countries included in our palm inventories.

Côte d'Ivoire (322.463 km²) is located between 4°-11° N and 2°-9° W. The highest altitude is reached at Mount Nimba with 1742 m, located in the western part of the country and bordering Liberia. Côte d'Ivoire is 400 km far from the equator on its southern borders and 1400 km away from the Tropic of Cancer on its northern limits. Côte d'Ivoire borders Burkina Faso and Mali in the North, Ghana in the East and Liberia and Guinea in the West, this border delineated by the Cavally river.

Ghana (239 460 Km²) is located between 4 ° and 11 ° N, and 0° and 3° W. Half the territory of the country is located above 150 m and its highest altitude is reached at Mont Afadjato with 885 m, located in the Volta Region, near the Togo border (Donkor & Vlosky, 2003). The lake Volta is the largest artificial reservoir in the world and with 8502 km² it occupies almost 3.5% of all the surface of the country. Ghana is bordered by Togo to the East, Côte d'Ivoire to the Ouest and Burkina Faso to the north.

Togo (56 785 km²) is located between 6°-11° N and 1° E. The highest altitude is reached at the mount Agou near to the Ghana border with 1742 m. This mountain represents the highest elevation of the Atacora chain, the latter extending south-west/north east from Ghana to western Niger and separating Togo in two main flat regions. To the south the sandy coasts extend into a narrow band of only 50 km and replaced by a lagoon depression where the Lake Togo (E of Lomé) is present. The country is bordered by Bénin to the East, Ghana to the West and Burkina Faso to the north.

Bénin (114 763 km²) is located between 6°15'-12°25' N and between 0°40'- 3°45' E. The country is relatively flat, and its highest altitude reached at Mont Sokbaro (658 m), also part of the Atacora chain and right in the border with Togo. From North to South the country is approximately 700 km long; it is bordered by the Niger River to the North, Burkina Faso to the Northwest, Nigeria to the East and Togo to the West (Neuenschwander et al. 2011).

Climatic features

Most West Africa is characterized by a wet and a dry season resulting from the interaction of two important migrating air masses. The first corresponds to the hot, dry tropical continental air mass of the northern high-pressure system giving rise to the dry and dusty north-easter winds widely known as Harmattan. The latter generally blow from November to February from the Sahara over most of West African countries and producing extraordinary differences in day (30°C) and night (8-9°C) temperatures. The

second air mass is the wet and tropical maritime or equatorial air mass which produces southwest winds. During July, this wet air mass reaches latitudes as far north as of 18°- 21°. The two air masses meet in a belt called the Intertropical Convergence Zone (ITCZ) that depending on the region is of variable width and stability (Nicholson 2005). The north and south migration of this ITCZ, is by far the major phenomenon controlling seasonal precipitation patterns across the sub-region. Regarding temperatures in the countries included in our study, they are relatively high throughout the year, with annual means frequently above 18°C, whereas in the Sahelian portions towards the northern regions of those countries the maximum temperatures can reach above 40°C. What might be extremely concerning is that in general terms temperatures over West Africa have increased over the last 50 years, in line with an increase in global temperatures (Niang et al. 2014), and this will certainly have important consequences on the land uses and their impact on the palm populations. Based on the information presented by Combres & Eldin (1979), Donkor and Vlosky (2003), and Neuenschwander et al. (2011) here below we provide specific climatic features of the four countries included in our palm inventories.

Côte d'Ivoire presents tropical conditions largely associated to the African monsoon. The dry season extends from December to February and the rainy season extends from April to October, although the latter may be also present in March and November-December on the southwestern part of the country. Rainfall is particularly abundant on the coast (1500-2500 mm/year), with the highest values reported towards the border with Liberia, west of the cities of San Pedro and Tabou. This includes also the southernmost areas of the Tai National Park where the best-preserved high forests of the country are still present. The inland regions are characterized by lower rainfalls (less than 1500 mm/year), but they can reach up to 2000 mm/year in the small western mountain area including the Monts du Toura and the Mont Sanghe National Parc, north and north-east of the city of Man, and heading west in direction to the Mount Nimba region shared with neighbouring Liberia and Guinea.

In Ghana, the south-eastern region is characterized by warm and dry conditions, whereas the south-west area is influenced by warm and wet conditions. The northern regions are subject to extremely warm and dry climatic conditions. Rainfall ranges from 700 mm in the Sudanian savanna to 2800 mm supporting the evergreen wet forests of the south-west region. A strong bimodal pattern of rainfall, as observed in Côte d'Ivoire, is observed in the coastal region whereas it is rather unimodal in the savanna region.

The climatic conditions observed in Togo and Bénin are also largely influenced by the orientation of the coast with respect to the monsoon and the confrontation between coastal and maritime winds attributed to the ITCZ. The climatic conditions dominant in these countries, also observed in eastern Ghana, are responsible of the « Dahomey gap », a 200 km wide forest savanna mosaic separating the West African and Central African rain forest blocks. The Upper Guinean Forest that characterizes the West African coast is in this way interrupted by large savannas reaching the coastal regions.

Material and methods

Field missions and palm collections

The current floristic inventory is based on extensive field missions in Côte d'Ivoire and Ghana undertaken by the authors between 2010 and 2019. Our study has also benefited of the results obtained in the frame of three master projects undertaken in the Conservatory and Botanic Gardens of Geneva and the University of Geneva (Doudjo Ouattara: palms of Ghana, 2010-2012), Simona da Giau (palms of Côte d'Ivoire, 2012-2013) and Loïc Michon (palms of Togo and Bénin, 2014-2015). In all cases our missions have always tried to include the dry and the rainy seasons in order to cover as much as possible all phenological stages for every palm studied. In the frame of our missions 185 out of the 221 palm specimens ever gathered in these countries were collected and they are now stored in the G herbarium, with most duplicates stored in local herbaria of Côte d'Ivoire, Ghana, Togo and Bénin. Some of the specimens gathered in the frame of our field trips have been used in recent molecular phylogenetic analyses, such as the one on the genus *Raphia* (Helmstetter et al. 2020), the genus *Borassus* (Couvreur et al. in progress), and the genus *Hyphaene* (Stauffer et al. in progress).

Study of herbarium specimens

The general floristic and taxonomic analysis on West African palms has made extensive use of our own collections; however, critical data have also been obtained from historical or modern collections stored in international herbaria. We have studied in particular the specimens deposited in seven European herbaria (BM, BR, BRLU, FI, G, K, P and WAG) and in West Africa material stored in the national or local herbaria of Côte d'Ivoire (CSRS), Ghana (GC, CCG, KUM), Togo (TOGO) and Bénin (BÉNIN). A visit in 2018 to the herbarium OUA (University of Ouaga I Pr Joseph Ki-Zerbo, Burkina Faso) was important to better define some incompletely known taxa.

Bibliography and databases

The general taxonomy and distribution of the palms is largely based on the work of Stauffer et al. (2014). The taxonomic identification of specific palm groups was based on the publications of Chevalier and Dubois (1938), Furtado (1967) and van Valkenburg and Dransfield (2004) for the genus *Hyphaene*, Barrow (1998), for the genus *Phoenix*, Bayton (2007) and Bayton et al. (2006) for the genus *Borassus*, Otedoh (1982) and Mogue et al. (2019) for the genus *Raphia*, Sunderland (2012) for rattan genera, Van Valkenburg and Sunderland (2008) for the genus *Podococcus* and van Valkenburg et al. (2008) for the genus, *Sclerosperma*. For other palm groups we based our identifications on the general publication of Tuley (1995). We have largely benefited of the well-curated African database hosted by the Conservatory and Botanical Garden of Geneva (<https://www.ville-ge.ch/musinfo/bd/cjb/africa/index.php?langue=fr>).

Distribution maps

The distribution maps for all the species are based on data included in the African Plants Database (2020), to which we have added the new samples gathered in the frame of our palm inventory. Occurrence data have been plotted on maps adapted from the vegetation maps proposed by White (1983).

Results

Palms (Arecaceae) of Côte d'Ivoire, Ghana, Togo, and Bénin

Perennial, solitary or clustered palms; stem aerial and clearly developed or inconspicuous and then subterranean, sometimes climbing lianas; pleonanthic or hapaxanthic; dioecious, or monoecious; rarely branched (*Hyphaene thebaica*); leaves pinnate, costapalmate, or entire-bifid; leaflets reduplicate or induplicate; inflorescences interfoliar, divided in one or rarely two order branches, rarely spicate; flowers hermaphrodite or unisexual, with perianth well differentiated in calyx and corolla or with more or less similar pieces of the perianth (perigone); fruits monosperms or very rarely polysperms, smooth or covered with imbricate scales.

Our inventory identified 11 genera and 21 species naturally distributed in the studied area and at least 10 non-native palms, in genera such as *Adonidia*, *Bismarkia*, *Dypsis*, *Phoenix* and *Washingtonia*, were observed cultivated as ornamentals in private and public gardens in the main cities visited.

The keys proposed here are based on vegetative and reproductive characters and they aim to be useful when identifying to genus level living plants collected in the field or dry material stored in herbaria. For proper taxonomic identification, we recommend field botanists trying palm identification primarily on individuals bearing vegetative and reproductive structures and prioritizing mature developmental stages (i. e. flowers at anthesis, ripe fruits). The 11 native palm genera are presented following the taxonomic arrangement proposed by Dransfield et al. (2008) for the differentiated subfamilies reported in the studied area (Calamoideae, Coryphoideae, Arecoideae).

Identification key based on vegetative characters

- 1a. Palms with a conspicuous aerial stem or acaulescent, never climbing on a support **2**
- 1b. Liana palm, often climbing over other plants in the forest **8**
- 2a. Leaves costapalmate; leaf-sheath with a conspicuous longitudinal division **3**
- 2b. Leaves pinnate or entire-bifid; leaf-sheath entire **4**
- 3a. Stem frequently swollen (ventricose) below the leaf crown; never branched **Borassus**
- 3b. Stem not swollen (ventricose) below the leaf crown, aerially branched or not **Hyphaene**
- 4a. Leaves entire-bifid **Sclerosperma**
- 4b. Leaves regularly pinnate **5**
- 5a. Leaflets induplicate (V-shaped); stem covered with small woody projections of remnant leaf-sheaths; basalmost leaflets transformed into long spines **Phoenix**
- 5b. Leaflets reduplicate (inverted V shape); stem covered or not with remaining leaf sheaths; basalmost leaflets transformed or not into long spines **6**
- 6a. Leaflets margins and main veins armed with minute spines; stem conspicuous and well-developed or acaulescent palms, often covered with curly or stiff leaf sheath fibers; **Raphia**
- 6b. Leaflets margins and main veins unarmed; stems always conspicuous and well-developed **7**
- 7a. Stem more or less smooth and with clear sinuous scars (rings) after the fall of the leaves; petioles unarmed; leaflets usually arranged on a single axis **Cocos**
- 7b. Stem frequently covered with remaining woody leaf-sheaths, rarely with sinuous scars; petioles basally armed with short spines; leaflets frequently arranged on at least two different axis **Elaeis**
- 8a. Solitary or clustering palm, climbing through a flagellum emerging from the leaf-sheath; the latter always armed **Calamus**
- 8b. Clustering palm, climbing through a cirrus (apical extension of the leaf rachis) armed with hooks; leaf-sheath armed or not **9**

9a. Leaf sheath unared **Eremospatha**
 9b. Leaf sheath armed with spines 10
 10a. Ocrea triangular, drying; spines on the leaf sheath long **Laccosperma**
 10b. Ocrea neat, horizontal, not dryng; spines on the leaf sheath short **Oncocalamus**

9a. Inflorescence lacking conspicuous bracts **Eremospatha**
 9b. Inflorescence with conspicuous bracts 10
 10a Apaxanthic palms; flowers arranged in groups of dyads or rarely triads **Laccosperma**
 10b. Pleonanthic palms; flower arranged in clusters of 7-11 **Oncocalamus**

Identification key based on reproductive characters

1a. Palms dioecious (unisexual flowers on different individuals) 2
 1b. Palms monœcious (unisexual flowers on the same individual) or hermaphrodite (androœcium and gynoœcium developing on the same flower) 5
 2a. Fruit diameter larger than 15 cm in length when ripe; epicarp smooth **Borassus**
 2b. Fruit diameter less than 10 cm in length when ripe; epicarp smooth or scaly 3
 3a. Fruits pear-shaped or oblong, more than 6 cm in length when ripe, epicarp always smooth **Hypaene**
 3b. Fruits oblong, ellipsoid or globose, never pear-shaped, less than 4 cm in length when ripe; epicarp scaly or smooth 4
 4a. Peduncle longer than the rachis of the inflorescence; rachillæ often whorled along the rachis; fruits oblong and smooth, orange when ripe **Phoenix**
 4b. Peduncle shorter than the rachis of the inflorescence; rachillæ clearly not whorled along the rachis; fruit oblong-ellipsoidal and always scaly, light brown when ripe **Calamus**
 5a. Monoecious 6
 5b. Hermaphroditic palms 9
 6a. Inflorescences staminate and pistillate separated but present on the same individual, sometimes the palm producing only one type of inflorescence **Elaeis**
 6b. Inflorescence bearing staminate and pistillate flowers simultaneously 7
 7a. Inflorescences and infructescences spicate always covered by a fibrous peduncular bract throughout their development **Sclerosperma**
 7b. Inflorescences and infructescences always branched, always exposed when fully developed 8
 8a. Inflorescences branched to one order; flowers arranged in a triads of one central pistillate flower flanked by two staminate flowers at the base of the rachilla and staminate flowers tightly concentrating in the mid-apical portion; fruit round, more than 20 cm in length when ripe; epicarp smooth **Cocos**
 8b. Inflorescences branched to two orders; basal rachillæ bearing pistillate flowers in the proximal area and staminate flowers at the top, apical rachillæ bearing only staminate flowers throughout their length; fruits oblong, less than 8 cm in length when ripe, epicarp scaly **Raphia**

Description of genera and species native to Côte d'Ivoire, Ghana, Togo and Bénin

Calamus L., Sp. Pl. 325 (1753).

Pleonanthic, dioecious palms, most often with clustered, high-climbing stems and pinnate leaves; inflorescences bearing unisexual flowers; fruits covered by imbricate scales.

Calamus is the largest palm genus. It is composed of 520 species (Baker 2015). These palms are present in wet zones of tropical Africa (absent in Madagascar), India, Burma, the South of China, Queensland, Fiji, and the Malay Archipelagos (Dransfield et al. 2008). Borneo and New Guinea rank as the most important centers of diversity for this genus. *Calamus* displays a variable ecology according to the species. Certain taxa are adapted to seasonally dry zones, whereas others are adapted to swamp conditions. Other species have narrow ecological requirement such as the calcareous or ultrabasic soils. Only one species (*Calamus deerratus*) was observed in the studied region.

1. *Calamus deerratus* G. Mann & H. Wendl., Trans. Linn. Soc. London 24: 429 (1864).

Syn: *Calamus akimensis* Becc., *Calamus barteri* Drude, *Calamus falabensis* Becc., *Calamus heudelotii* Becc., *Calamus laurentii* De Wild., *Calamus leprieurii* Becc., *Calamus perrottetii* Becc., *Calamus schweinfurthii* Becc.

Palms growing in clumps of several individuals. *Stems* 15-20 m long and 3-4 cm in diameter, circular in cross-section, enclosed by leaf-sheaths. *Leaves* pinnate; sheath 15-20 cm long, tubular, armed with clusters of flattened and triangular spines, 1-3 cm long and 1-3 mm wide, ocrea 5-10 cm long; petiole 17-20 cm long and 1-1.3 cm wide, flattened adaxially, convex abaxially, armed with black spines 0.5-1.5 cm long; rachis 120-180 cm long and 0.2-1 cm wide, triangular in cross-section, loosely covered by 0.5-1.5 cm long spines, the latter sharp, greyish at the base and black towards the apex; leaflets 35-80 pairs, shape and size variable (depending on the environment), often lanceolate with an acuminate apex, light green, with 1-2 mm long spines on the margins, the midrib



Fig. 2. Morphological diversity in *Calamus deerratus*. **A.** Growth habit of the palm in a seasonally flooded area; note the regularly pinnate leaves and the long armed flagellum. In-land savanna in the Yamoussoukro region, Côte d'Ivoire (photo Didier Roguet); **B.** Spiny leaf sheath; note the flat spines. Central Côte d'Ivoire (photo Didier Roguet); **C.** Female inflorescence bearing fully anthetic flowers. Central Côte d'Ivoire (photo Didier Roguet).



Fig. 3. Morphological diversity in *Calamus deerratus*. **A.** Inflorescence bearing unripe fruits. In-land savanna in the Yamoussoukro region, Côte d'Ivoire (photo Didier Roguet); **B.** Detail of fruits; note the acuminate apex Central Côte d'Ivoire (photo Didier Roguet).

and on the secondary veins; basal leaflets 37-39 cm long and 1.2-2 cm wide, inserted every 2-3 cm, with one or two prominent veins on the adaxial surface, median leaflets 40-57 cm long and 1.7-2.2 cm wide, each inserted 3-3.5 cm, apical leaflets 21-34 cm long and 1.5-2 cm wide, inserted every 1-2 cm. *Flagellum* 2-4 m long, emerging from the leaf-sheath and opposite to the petiole, hooks 4-5, 1-2 mm long, inserted each 1.4-2.4 cm and concentrated on one side of the flagellum, spines 1.5-2 cm long, black. *Staminate inflorescence* 1-order branched, prophyll not observed; peduncular bracts only one observed, 6-12 cm long; peduncle 10-25 cm long and 1-1.5 cm in diameter, green; inflorescence rachis 30-40 cm long; first order branches 30-40 cm long, rachillae 30-40, 6-8 cm long. *Staminate flowers* very small, subtended by bracteoles. *Pistillate inflorescence* 2-order branched, prophyll 18-20 cm long and 0.7-1 cm wide, smooth and unarmed; peduncular bracts only 1 observed, 57 cm long and 0.7 cm wide, longitudinal opened, smooth and unarmed; peduncle 30-53 cm long 0.5-0.7 cm wide, elliptical in cross section; inflorescence rachis 23-40 cm long and 0.6 cm wide, covered by bracteoles 0.8-0.9 cm long and bearing spines 2-3 mm long at the base; first order branches 10-20 cm long, rachillae 10-15, 6-8 cm long and 0.3 cm wide, densely covered by bracts enclosing the flowers. *Pistillate flowers* with undifferentiated perianth, anthers yellow. *Fruits* 2-4 cm long, oblong-ellipsoidal, some forming the top of the rachilla, pericarp densely scaly, olive-green in development, brown-orange when ripe, stigmatic remains persistent.

Distribution and ecology

This is the most widely distributed African rattan (Sunderland 2012). In western Africa, its presence has been reported for Bénin, Côte d'Ivoire, Gambia, Ghana, Guinea, Liberia, Nigeria, Senegal and Sierra Leone (Stauffer et al. 2014). This species grows in seasonally inundated open areas but has been also found in forest margins or open areas of dense primary forest. The presence of this palm in disturbed areas is not uncommon, as long as the soil is partially flooded at least during some months. It is certainly the most sun-resistant species among all African rattan palms.

Specimens examined

CÔTE D'IVOIRE: Lacs Region (District of Yamoussoukro): Yamoussoukro- N'Zéré, 06° 93' 75.6" N - 05° 17' 33.0" W, 209 m, 25 July 2012, Da Giau & Ouattara SD004 (G); Yamoussoukro- N'Gblékro, 06°53 37.0 N - 05° 09' 21.2" W, 215 m, 26 July 2012, Da Giau & Ouattara SD006 (G). **Lagunes Region (Agnéby-Tiassa Region):** Lamto, forêt galerie, Marigot salé, 05° 1' N - 06°13' W, 8 July 1992, Kouamé & Téré 238 (CSRS); Sous-préf. Tiassalé, Lamto, Marigot Salé, 06° 13' N -05° 01' W, 8 January 1996, Gautier et al., LG2850 (G); Natural Reserve of Lamto, V-Baoulé Region, savanna with patches of forest, 06° 13' 00.7" N- 05° 01' 32.1" W, 45 m, 02 December 2017, Stauffer et al. 898 (CSRS, G). **Haut-Sassandra Region:**

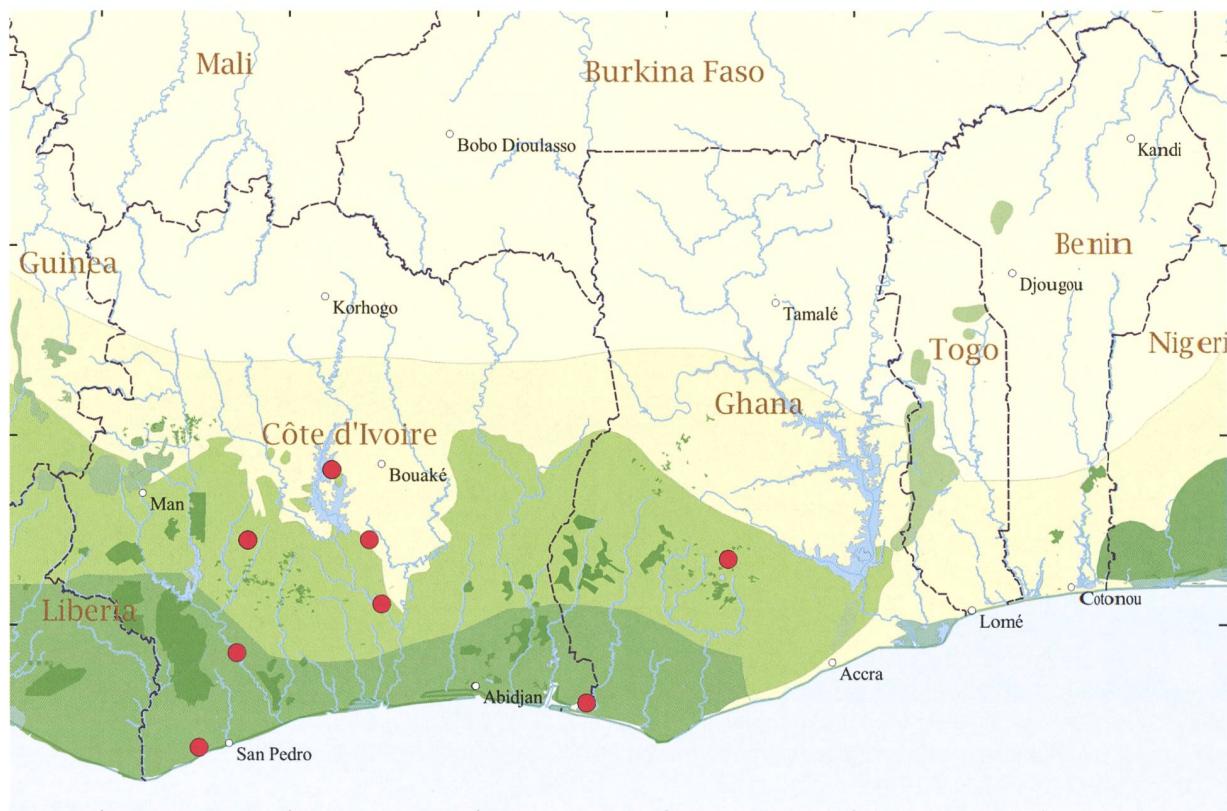


Fig. 4. Distribution of *Calamus deerratus* in Côte d'Ivoire, Ghana, Togo and Bénin.

Daloa-Guedeguhe, 06° 53' 22.2" N – 06° 26' 56.9" W, 205 m, 2 August 2012, Da Giau & Ouattara SD009 (G); 2 August 2012, Da Giau & Ouattara SD010 (G); 2 August 2012, Da Giau & Ouattara SD011 (G); 2 August 2012, Da Giau & Ouattara SD012 (G); 2 August 2012, Da Giau & Ouattara SD013 (G); Daloa, F. C. du Haut-Sassandra, centre, 07° 00' N-07° 07' W, 8 February 1994, Kouamé & Chatelain 989 (CSRS). **Bas-Sassandra Region (Nawa Region):** Soubré- encampment Akoumiakro, 05°42' 08.0" N – 06° 33' 53.8" W, 104 m, 9 August 2012, Da Giau & Ouattara SD018 (CSRS, G, K); San Pedro, SOGB forest, 04° 42' 10.7" N – 06° 58' 03.2" W, 37 m, 15 August 2012, Da Giau & Ouattara SD024 (CSRS, G, K, WAG); entre Sassandra et Lakota, 27 August 1958, Aké Assi s. n. (G); Soubré (bord de la Sassandra), 18 June 1907, Chevalier 19103 (P). **Sud-Comoé Region:** Nouamou, forêt des marais Tanoé-Ehy (FMTE), 05° 10' 20.8" N -02° 50' 51.2" W, 16 m, 9 September 2012, Da Giau & Ouattara SD030 (CSRS, G). **18 Montagnes region (Cavally Region):** Guiglo, Keibli, 05° 28" N-07°59' W, 22 February 1994, Chatelain CC1269 (CSRS). **N'zi-Comoé Region (N'zi Region):** Abogui, 8 May 1971, Audru 4076 (P). **Sud-Bandama Region (Lôh-Djiboua Region):** Zikidiès, 05° 47' 50.77" N-05° 28' 29.17" W, 182 m, 28 December 2013, Gaille & Ouattara EG18 (G, LILLE).

GHANA: Ashanti Region: Ashanti Region, 1895, Cummins 128 (K); Nyinahin, 8 March 1912, Chipp

127 (KUM); Nyinahin, Ashanti, s. d., Chipp 127 (KUM); Bobiri Forest Reserve, 06° 41' 20.1" N-01° 20' 30.6" W, 234 m, 20 May 2011, Ouattara, Aman, Adoma & Bridget OD3 (G); Bobiri Forest Reserve, 06° 41' 22.9" N-01° 20' 40".9" W, 245 m, 26 Mai 2011, Ouattara, Aman, Adoma & Bridget OD 9 ; Bobiri F. R., 20 December1957, Tomlinson (K); S. Fomangsu Forest Reserve, s. d. Vigne 3951 (KUM) ; Amentia, E. Région, 30 March 1930, Vigne 1868 (K, KUM) ; Amentia, Ashanti, s. d., Vigne 1868 (KUM). Brong-Ahafo Region: Sampa (near Tarkwa), 13 February 1934, Kinloch 3238 (KUM) ; Sampa (near Tarkwa) , 13 February 1934, Kinloch 3236 (KUM). **Central Region:** Ankaful near Cape Coast, 20 January 1965, Hall 2846 (CCG, K) ; Ankaful, 20 Januaryy 1965, Hall 2846 (GC) ; Cape Coast F. R., 15 December1957, Tomlinson s. n. (GC). **Eastern Region:** Bunu, 22 November 1995, Tsiforkor s. n (K) ; Kade Agricultural Station, 17 March 1972, Enti 643 (GC) ; Kade Agricultural Station, 30 May 1970, Enti & Hall 40268 (GC) ; A. R. S. Kade, 30 May 1970, Enti & Hall 40268 (GC) ; Kade Agriculture Research Station, 17 March 1972, Spartan Entreprises Sp 643 (GC). **Western Region:** alluvial plain, 2 km E of Bibiani, at edge of secondary bush, 23 December 1953, Adams 2025 (GC) ; Awisa (Akim Swedru), December 1933, Irvine 2075 (GC) ; Bia National Park, 06° 22' 11" N-03° 01' 31" W, 02 March 1993, Merello et al. 1365 (GC); Draw River Forest Reserve, 26 May 1999, Sunderland 2262 (K, KUM).

TOGO: locality of Mafacasse, cultivated, June 1982, Brunel 7696 (TOGO); Region IV, 1922, Panderyst 12343 (BRU).

BÉNIN: Lokoli, swampy forest border, 07° 01' 48" N – 02° 08' 59.99" E, 2010, Dan 922 (BRU); Forest on sandy hill, Ouémé, Avagbodji, 06° 29' 18.25" N – 02° 33' 25.28" E, January 1973, De Souza & Paradis 1930a (BÉNIN); in water, Azili lake, Zou, Zangnanado, 07° 15' 47.66" N – 02° 27' 4.56" E, 1974, De Souza & Paradis 1930b (BÉNIN); swampy forest, Ouémé, 25 March 1985, Profizi 1930c; swamps near Adjarra, 06° 31' 23.044" N – 02° 39' 46.73" E, 6 December 1988, n. c. 4755 (BÉNIN).

Eremospatha (G. Mann & H. Wendl.) H. Wendl., Les Palmiers 244 (1878).

Pleonanthic, hermaphroditic, spiny palms; most often with high-climbing, solitary or clustered stems, entire-bifid leaves when juvenile and regularly or irregularly pinnate leaves at maturity, the latter with a cirrus emerging from the rachis apex. The combination of leaf sheaths without spines and stem sometimes presenting a conspicuous knee below leaf junction is quite characteristic for this genus.

The genus *Eremospatha* contains 10 species and is restricted to the rainforests of Western Africa, the Congo basin, and East Africa (Tanzania) (Sunderland 2012; Stauffer et al. 2014). The species of this genus are much appreciated for the quality of their canes in the manufacturing of handcrafts and therefore the wild populations severely threatened due to over-exploitation. The observation of flowering or fruiting individuals in the field is difficult and this explains that at least five species in this genus have been only described based on vegetative organs (Stauffer et al. 2017). Four species (*Eremospatha dransfieldii*, *E. hookeri*, *E. laurentii* and *E. macrocarpa*) were identified in the studied region.

Identification key

- 1a.** Knee absent ***E. macrocarpa***
- 1b.** Knee present **2**
- 2a.** Mature leaflets less than 20 on each side of the rachis, the lowermost reduced but with more or less the same morphology as the ones towards the apex of the leaf; cirrus armed ***E. hookeri***
- 2b.** Mature leaflets more than 20 on each side of the rachis, lowermost reduced (linear, strap-like), clearly different to the ones towards the apex of the leaf; cirrus unarmed **3**
- 3a.** Leaf sheath more or less triangular in cross section; lowermost leaflets linear; mid-length and apical leaflets linear-lanceolate, with a finely acuminate apex ***E. laurentii***

3b. Leaf sheath more or less circular in cross section; lowermost leaflets linear to ovate; mid-length and apical leaflets obovate-elliptic, oblanceolate or rhomboid, with a praemorse apex ***E. dransfieldii***

2. *Eremospatha dransfieldii* Sunderl., Kew Bull. 58: 987-990 (2003).

Palms growing in clumps of 3-5 individuals. *Stems* 15-20 m long and 2.9-3.5 cm in diameter, circular in cross-section, covered by sheaths. *Leaves* pinnate, reduplicate; sheath 15-38 cm long, unarmed; ocrea tubular, 2.2- 4 cm from the insertion of the petiole, unarmed with longitudinal striations, with a prominent knee below the insertion of the petiole; petiole almost absent (presence of leaflets directly in the axils of the leaf); rachis 0.9-1.90 m long and 2-2.2 cm wide at the base, 1 cm wide in the median and 0.5 cm wide near the apex, slightly convex abaxially, flat adaxially with two rows of spines at the base and a single row at the mid-apical part, spines 0.3-0.5 cm long inserted at varying distances 1-5 cm; cirrus 1-1.99 m long and 2-4 mm wide, flattened adaxially and abaxially convex, margin armed with 2-3 mm long spines inserted every 1-2.5 cm sometimes leaving unarmed portions; hooks 5-9 pairs, 3-4.2 cm long and 0.3 cm wide, alternate or opposite, 10-27 cm spaced apart, leaflets 29-35 pairs, variable forms, usually lanceolate to rhomboid, praemorse apex, inserted at varying distances (6-20 cm) on the rachis, margin armed, the praemorse part reminiscent the action of an animal, however, we realize the natural character of this morphology by the presence of small spines that would have disappeared with the action of an animal, midribs 6, unarmed, prominent on the adaxial surface; basal leaflets 10-20 cm long and 4-5 cm wide, margins densely armed with spines 3-6 mm long, basal leaflets greatly reduced and highly armed wrapping around the stem, median leaflets 30-35 cm long and 5-5.3 cm wide, apical leaflets 25-30 cm long 5-8 cm wide, elongated. Inflorescences not recorded.

In the frame of his study on the taxonomy, ecology, and the uses of the African rattans Sunderland (2001) discovered a species that could easily be confused with *E. hookeri*. The species will be finally described in 2003 and was dedicated to John Dransfield, one of the most eminent palm specialists in the world, working on Royal Botanic Gardens, Kew. To date, no reproductive organs of this species have been observed. One of the challenges with this species is to find it in the reproductive stage (flowers or fruits). Indeed, it has been described only based on vegetative characters. In the original publication (Sunderland, 2003), it is clearly mentioned that the inflorescences are unknown. Our efforts to observe



Fig. 5. Morphological diversity in *Eremospatha dransfieldii* **A.** Growth habit of adult individuals. South-West Ghana (photo Doudjo Ouattara); **B.** Detail of stem and mature leaves. Note the highly transformed basal pinnae almost embracing the stem and the strongly armed pinnae margins. South-West Ghana (photo Fred Stauffer); **C.** Detail of stem and mature leaves. Note the irregular-lacerate apex of the pinnae. South-West Ghana (photo Doudjo Ouattara); **D.** Growth habit of a young individual. South-West Ghana (photo Fred Stauffer).

and collect these inflorescences or infructescences during our work were unsuccessful. Kouassi (2007) had collected a specimen of this taxon with fructification in Côte d'Ivoire, but according to this researcher that sample unfortunately disappeared in 2011 during a civil war in the country, which caused the destruction of many samples stored in the herbarium of the National Centre for Floristics (CNF) in Abidjan.

Distribution and ecology

This species has very restricted a distribution in all the countries where it was observed (Sierra Leone, Liberia, Côte d'Ivoire, and Ghana) (Sunderland 2003). Indeed, its distribution is closely linked to the wet zones of high pluviometry corresponding to the evergreen rain forests (Sunderland 2012). In Ghana, its distribution center is the evergreen forest of the Southwest, in particular in the Subri Forest Reserve. Dense but much localized populations were observed in the Ankasa Forest Reserve. It is a light and humidity demanding species that grows particularly on the borders of forests, in the opened areas of forests. The red ants were observed on many visited individuals. They fold leaflets to make their nest.

Specimens examined

GHANA: Western Region: Draw River Forest Reserve, 10 November 2001, Balinga 71 (K, KUM); Ankasa River Forest Reserve, 3 March 1971, Moore & Enti 9888 (GC); Draw River Forest Reserve, 26 May 1999, Sunderland 2261 (K, KUM); Ankasa Forest Reserve, 05° 17' 13.2" N-02° 38' 08.4" W, 141 m, 19 October 2011, Ouattara & Stauffer OD 27 (G); Ankasa Forest Reserve, 05° 15' 04.5" N-02° 38' 32.1" W, 119 m, 20 October 2011, Ouattara & Stauffer OD 30 (G).

3. *Eremospatha hookeri* (G. Mann & H. Wendl.) H. Wendl., Les Palmiers: 244 (1878).

Syn.: *Calamus hookeri* G. Mann & H. Wendl.

Palms growing in clumps of 3-6 individuals. *Stems* 8-20 m long and 7-9 mm in diameter, circular in cross-section, densely covered by leaf sheaths. *Leaves* pinnate, with reduplicate segments; leaf sheath tubular, 10-16 cm long, with a pronounced knee, unarmed; ocrea 2.7-3 cm long, olive green, completely covering the stem; petiole 4-8 cm long and 4-5 mm wide, flattened adaxially, convex abax-

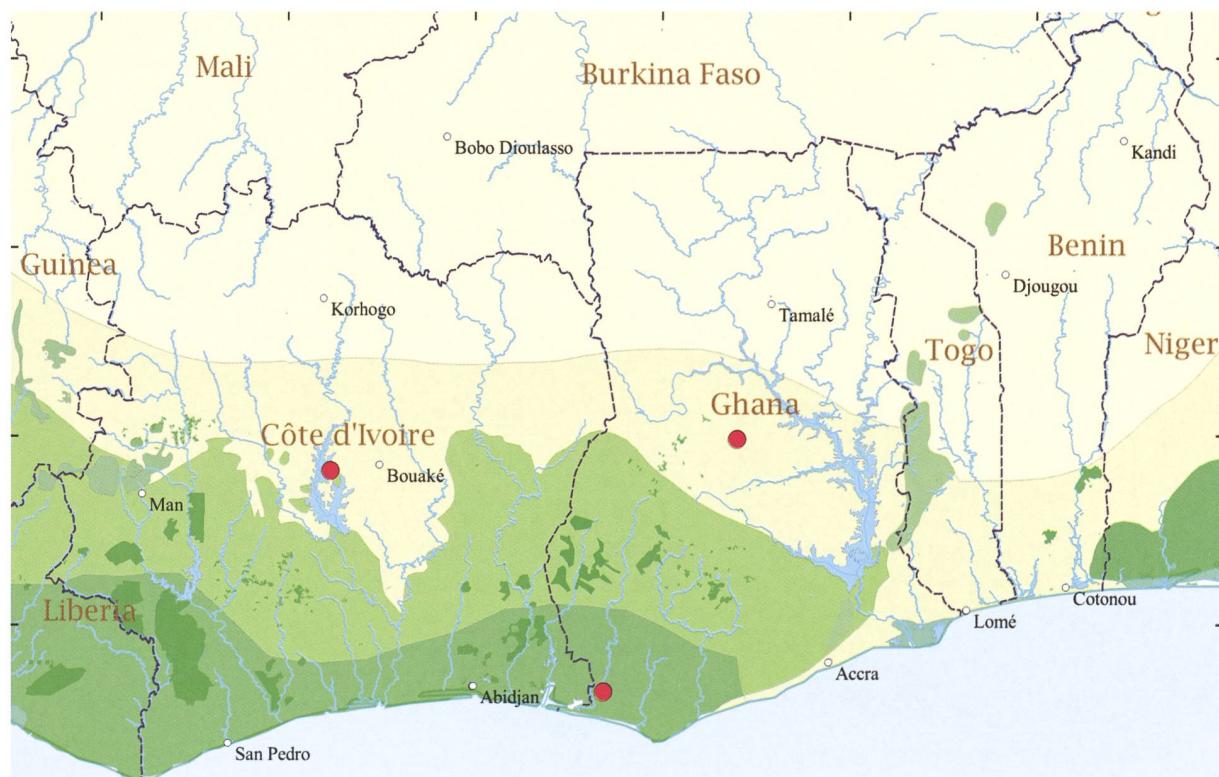


Fig. 6. Distribution of *Eremospatha dransfieldii* in Côte d'Ivoire, Ghana, Togo and Bénin.



Fig. 7. Morphological diversity in *Eremospatha hookeri*. Growth habit of a juvenile individual. Note the irregular-lacerate apex of the pinnae. South-West Ghana (photo Fred Stauffer).

ially, armed at the margin with 4-5 mm long spines, the latter inserted every 1.5-2 cm; rachis 32-75 cm long and 2-7 mm wide, convex adaxially, flattened abaxially, slightly elliptical in cross-section, bearing spines similar to those on the petiole, inserted every 9-20 mm; cirrus 27-95 cm long and 1-3 mm wide, bearing 4-8 pairs of hooks, the latter 1-3.5 cm long at inserted at variable distance; leaflets 5-10 pairs, dark green, opposite or alternate, more or less rhomboidal with the apical portion lacerated (praemorse),

the margins armed by spines 1-2 mm long and inserted each 8-9 mm, midribs 5-7, unarmed, prominent on the adaxial surface; basal leaflets 10-20 cm long and 2-5 cm wide, median leaflets 15-30 cm long and 5-8 cm wide, apical leaflets 10-21 cm long and 5-8.5 cm wide. Inflorescences lateral, one order branched; prophyll and peduncular bracts not observed; peduncle 10-20 cm long and 2-3 cm in diameter, circular in cross-section; rachis 30-40 cm long, bracts not observed; rachillae 30-45, basal rachillae 12-15 cm long, median rachillae 10-12 cm long, apical rachillae 6-8 cm long. Flower with well-differentiated perianth, calix 2-3 mm long, coup-shaped, petals 3, 0.5-1 cm long. Fruit ovoid, 2.5-3 cm long, covered by several rows of brown-black, rhomboidal scales.

This species was first described under the genus *Calamus*. It has been also treated in some publications dealing with African palm floristics and ethnobotany (Dalziel 1937; Irvine 1961; Burkhill 1997 and Sunderland 2001, 2007). Some specimens of *Eremospatha dransfieldii* were stored in international herbaria under the name *E. hookeri*.

Distribution and ecology

Eremospatha hookeri presents a guineo-congolesian distribution. It has been reported in Sierra Leone,

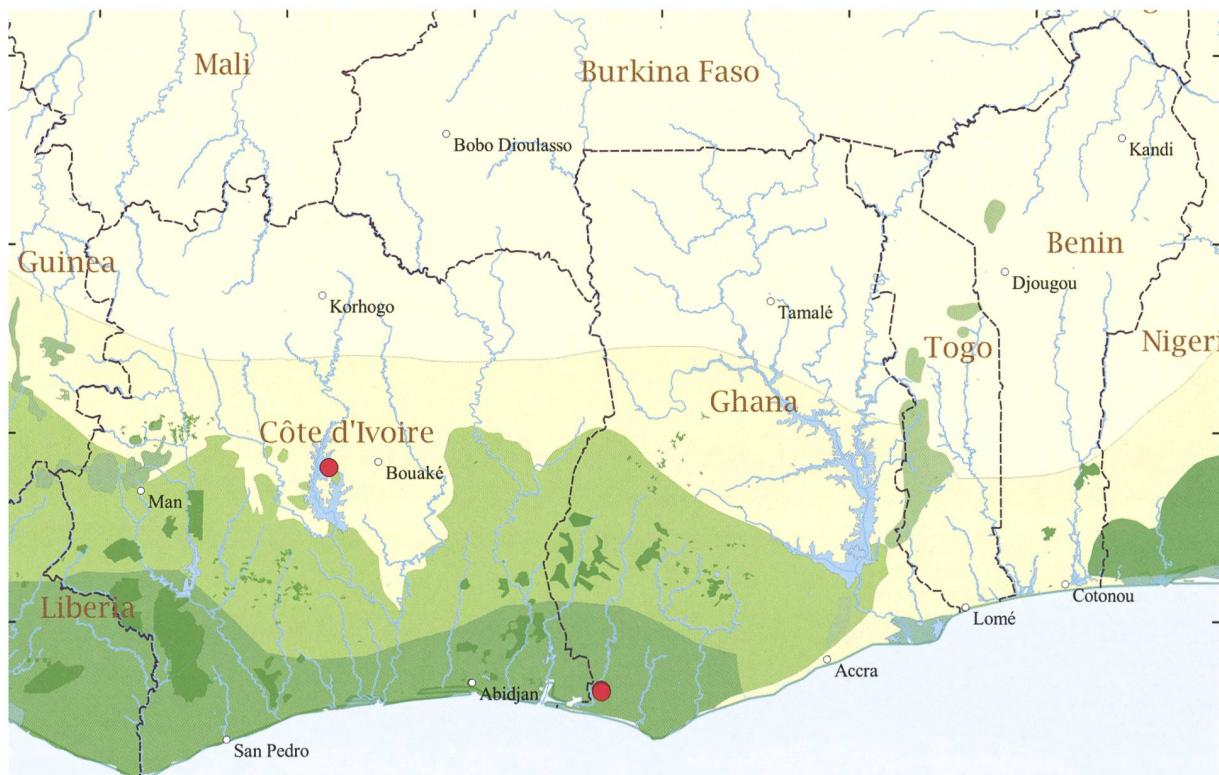


Fig. 8. Distribution of *Eremospatha hookeri* in Côte d'Ivoire, Ghana, Togo and Bénin.

Côte d'Ivoire, Nigeria, Gabon, Cameroon, Congo, Democratic Republic of Congo and Central African Republic (Kouassi et al. 2005, Sunderland 2007, 2012; Stauffer et al. 2014; Mbandu Luzolawo et al. 2020. This species grows in the openings of wet evergreen forests but easily tolerates understory conditions.

Specimens examined

GHANA: Western Region: Dabouase to Subri Forest Reserve, 2 January 1975, Hall & Abbiw 45124 (GC); Ankasa Forest Reserve, 05° 16' 21.2" N-02° 38' 47.7" W, 83 m, 19 October 2011, Ouattara & Stauffer OD 26 (G); Ankasa Forest Reserve, 05° 15' 17.6" N-02° 38' 35.6" W, 69 m, 20 October 2011, Ouattara & Stauffer OD 31 (G).

4. *Eremospatha laurentii* De Wild. Bull. Jard. Bot. État 5: 147 (1916).

Syn.: none reported in literature

Palms growing in clumps of several individuals. Stems up to 30 m long, 1.8-2.5 x 2.4-3 cm in diameter, slightly triangular in cross-section; internodes

10-16 cm. Leaves sessile, up to 3 m long; leaf sheath slightly striate, moderately to profusely covered or not by a caduceus, grey-black indumentum; ocrea entire, obliquely truncate, extending 1-2 cm; knee conspicuous, narrow, linear, 5-8 cm long, abrupt at base; rachis 1.2-1.5 m long, abaxially rounded, adaxially convex to concave, becoming trapezoid and then triangular in cross-section towards the apex, sparsely covered or not by a grey indumentum in the lower surface, armed in the margins with robust, reflexed, bulbous-based, black-tipped spines, the latter becoming sparsely armed distally; cirrus 1.2-1.5 m long, unarmed; leaflets up to 30 on each side of the rachis, inequidistant, opposite to sub-opposite, linear-lanceolate to ovate, bluntly contracted at the base, very finely acuminate at apex, with the latter often breaking off giving a slightly blunt appearance, basal 13-16 cm long x 0.7-1 cm wide, medial 18-20 cm long x 2.5-3 cm wide, apical 10-12 cm long x 2.5 cm wide, concolorous, armed along the margins with slender to robust black-tipped yellow spines, with ca. 6 moderately conspicuous, 1-2 mm apart, transverse secondary veins; basalmost leaflets smaller than the rest, linear, strap-like, armed along the margins with robust, bulbous-based, black-tipped yellow to orange spines; acanthophylls 3-4 cm long. Inflorescence branching to 2 orders, glabrous, 24-32 cm



Fig. 9. Morphological diversity in *Eremospatha laurentii*. **A.** Growth habit of a juvenile individual. Note strongly modified basal pinnae (photo Doudjo Ouattara). **B.** Well developed knee at the base of the petiole. South-West Côte d'Ivoire (photo Fred Stauffer).

long; peduncle 10–15 cm long, slightly flattened in cross-section; rachis 12–17 cm long, erect in development, arching towards anthesis; rachillae 8–10, distichous, 5–16 cm long, decreasing in size towards the apex; rachis bracts acuminate, up to 4 mm long, decreasing in size towards the apex; flower cluster subtended by minute and incomplete bracts. Flowers hermaphrodite, borne in close pairs; calyx 4 mm long × 5 mm wide, with 3, rounded, striate, 1.5–mm long lobes; corolla 7–9 mm × 3–4 mm, fused up to 3/4 of its length; stamens united into a 4 mm-long, epipetalous ring; filaments free up to 0.1 mm long, anthers up to 0.5 mm long; ovary 1 mm long × 1.5 mm wide, topped by 1 mm long style. Fruit 1-seeded, globose or cylindrical, 1.6–2.2 cm long × 1.7–2 cm wide, covered by 18–22 vertical rows of scales. Seed ± compressed, 1–1.2 cm long × 0.8–1 cm wide, rounded on one side.

Distribution and ecology

According to Sunderland (2012) and Stauffer et al. (2014) this species occurs predominantly in the lowland forests of the northern Congo Basin; however, there are surprising outliers of this palm in the forests of Upper Guinea, with a pronounced disjunction from Côte d'Ivoire to Bénin. Chatelain et al. (2011)

did not include this species in the checklist of Côte d'Ivoire although its presence in the Bas-Sassandra region, precisely in the Haute Dodo classified forest (Forêt Classée) had been pointed out by Kouassi (2007). The report of this palm in Côte d'Ivoire was recently confirmed during our visit to the forest of the Taï National Park, in the South-Western part of the country. In this area, where it can be locally abundant, the palm grows in forest gaps but easily reaches the canopy in forest conditions. Our observations agree with those of Sunderland (2011) who found this species growing in both open areas as well as in closed-canopy forest.

Herbarium samples studied

CÔTE D'IVOIRE: Bas-Sassandra Region (Cavally Region): South-western region of the Taï National Park, adjacent area to the village of Guirotou, trail departing from the Ecotel Touraco (OIPR), 05° 23' 43.22" N-07° 14' 55.32" W, 100-120 m, 12 June 2013, Stauffer et al., 854 (CSRS, G); South-western region of the Taï National Park, adjacent area to the village of Guirotou, trail departing from the Ecotel Touraco (OIPR), 05° 23' 46.5" N-07° 14' 45.52" W, 100-120 m, 12 June 2013, Stauffer et al., 855 (CSRS, G); South-western region of the Taï National Park,



Fig. 10. Distribution of *Eremospatha laurentii* in Côte d'Ivoire, Ghana, Togo and Bénin.

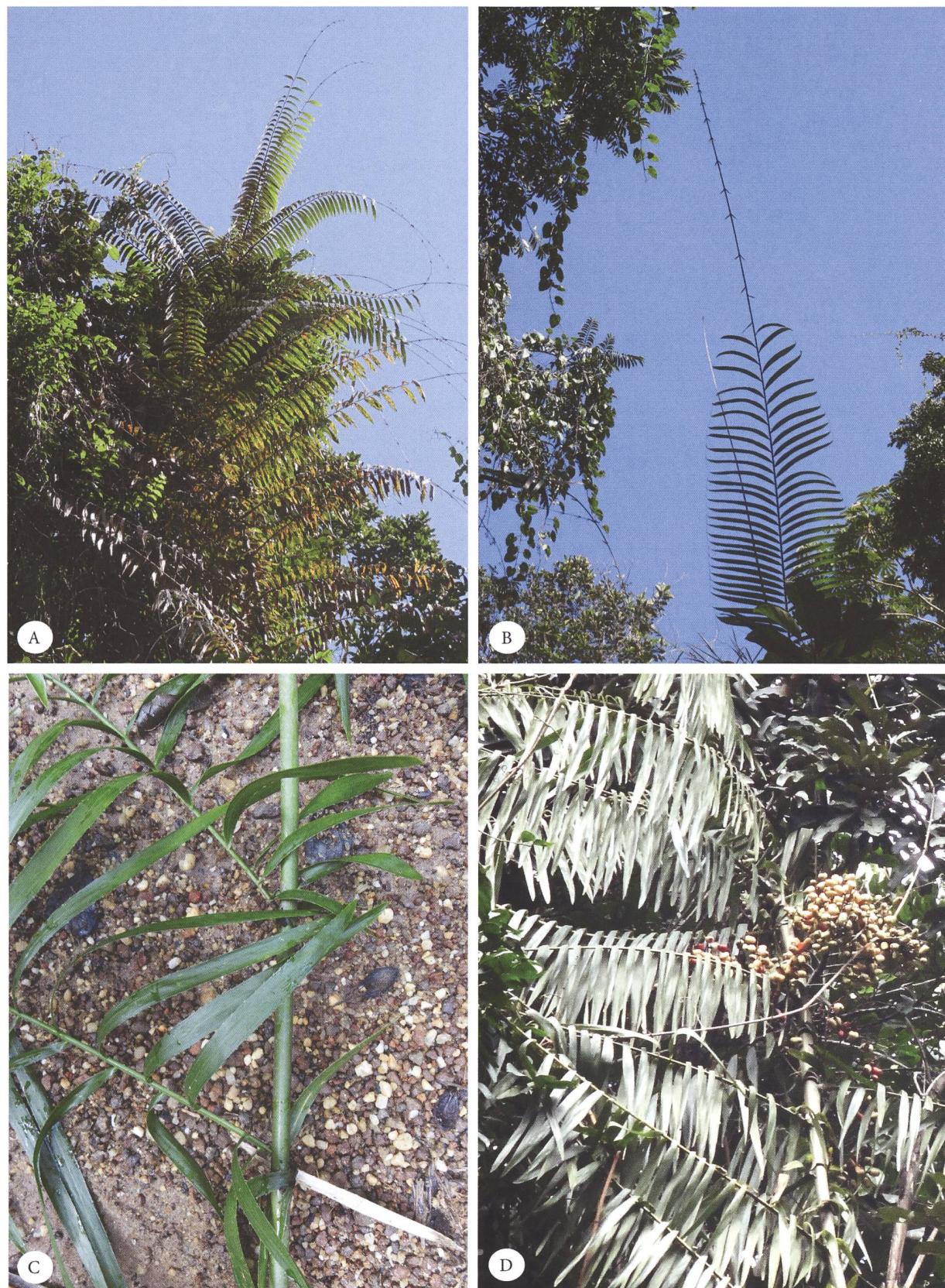


Fig. 11. Morphological diversity in *Eremospatha macrocarpa*. **A.** Growth habit of an adult individual. South-West Ghana (photo Doudjo Ouattara); **B.** Detail of regularly pinnate leaf. Note the well-developed flagellum as a prolongation of the leaf rachis. South-West Ghana (photo Doudjo Ouattara); **C.** Detail of stem and pinnae in a young leaf. Note the clearly unarmed leaf sheath. South-West Ghana (photo Fred Stauffer); **D.** Growth habit of an adult individual. Note Infruktescence with fruits at different stages of development. South-West Ghana (photo Doudjo Ouattara).

adjacent area to the village of Guirotou, trail departing from the Ecotel Touraco (OIPR), 05° 24' 4.60" N-07° 14' 11.94" W, 100-120 m, 13 June 2013, Stauffer et al., 859 (CSRS, G).

5. *Eremospatha macrocarpa* G. Mann & H. Wendl., Les palmiers 244 (1878).

Syn.: *Calamus macrocarpus* G. Mann & H. Wendl., *Eremospatha sapini* De Wild.

Palms growing in clumps of 5-10 individuals. Stems of 8-35 m long and 1.4-4 cm in diameter, cylindrical. *Leaves* 3-4 m long, pinnate; leaf-sheath 20-25 cm long, tubular, unarmed, green; ocrea tubular 2.2-2.5 cm long; petiole usually absent or inconspicuous in adults, or present in juveniles, when present of 0.5-1 cm long and 0.9 cm wide, adaxially flattened, abaxially convex, margins armed with 1-2 mm long spines, knee absent; rachis 68-80 cm long and 0.3-0.7 cm wide, abaxially convex, adaxially flattened, covered with spines similar to those observed in the petiole; spines inserted 1-4 cm, oriented in different directions; cirrus 80-150 cm long and 2-4 mm wide, slightly convex abaxially and flattened adaxially, with 6-12 pairs of hooks, 3.5-4.5 cm long and 2 mm wide, inserted every 5 cm at the apex and every 11-14 cm at the base; leaflets 18-30 pairs, lanceolate, dark green, regularly inserted every 3-4 cm at the basal and median portion of the rachis and rather irregularly between 6-8 cm towards the apex; midrib prominent; secondary veins 2-3, prominent on the abaxial surface, unarmed, basal leaflets 13-16 cm long and 1-2 cm wide, lowermost leaflets very reduced and displaying abnormal morphology, median leaflets 23-42 cm long and 1.5-2 cm wide, apical leaflets 16-28 cm long and 1.5-2.3 cm wide. *Inflorescence* axillary, outward arched, 1-order branched, sprouting in the axils of the leaf; prophyll and peduncular bracts not observed; peduncle 7-12 cm long and 1.3-2 cm in diameter, slightly convex abaxially, flattened adaxially; rachis 27-28 cm long and 0.5-1.2 cm wide, similar to the peduncle; rachillae 16-35, inserted every 2.5-3 cm; basal rachillae 16-17 cm long and 0.3-0.4 cm wide, median rachillae 13-14 cm long and 0.2-0.3 cm wide, apical rachillae 9-11 cm long and 0.2-0.3 cm wide. *Flowers* borne in dyads, the latter subtended by incomplete bracts less than 1 mm long, triangular; calyx 3 mm long and 6 mm wide, with distinct, rounded lobes; corolla 10 mm long and 4 mm wide, fused up to 2.5 mm and free towards the apex, stamens fused into a 5 mm long epipetalous ring. *Fruit* 1.5-2 cm long and 1-2 cm in diameter, ovoid, slightly elongated, pericarp scaly, red to red-orange at maturity.

This palm ranks the most appreciated rattans because of the high quality of its cane, in particu-

lar useful for the manufacture of a wide range of handcrafts (Dalziel 1937; Irvine 1961; Abbiw 1990; Tuley 1995; Burkhill 1997; Sunderland 2001, 2007, 2012; Hawthorne and Jongkind 2008).

Distribution and ecology

This species is widely distributed in Africa. It has been reported in Sierra Leone, Liberia, Côte d'Ivoire, Bénin, Nigeria, Cameroon, Gabon, and Equatorial Guinea (Sunderland 2012; Stauffer et al. 2014) (Fig. 12). *Eremospatha macrocarpa* grows in openings of the wet evergreen forests but has also been reported in wet semi-deciduous forests. In the countries visited not yet reported in Togo.

Specimens examined

CÔTE D'IVOIRE: Bas-Sassandra Region (Nawa Region): Soubre-encampment Akoumiakro, 05° 42' 13.9" N, 06° 33' 53.9" W, 90 m, 09 July 2012, Da Giau & Ouattara SD017 (G); Soubre-encampment Akoumiakro, 05° 41' 56.3" N-06° 33' 53.2" W, 83 m, 9 July 2012, Da Giau & Ouattara SD019 (CSRS, G, K, WAG); San-Pédro, SOGB forest, 04° 39' 54.0" N-07° 05' 45.9" W, 55 m, Da Giau & Ouattara SD023 (G); **Cavally Region:** South-western region of the Taï National Park. Adjacent area to the village of Guirotou. One hour walk on trail departing from the Ecotel Touraco (OIPR), 05° 23' 34.22" N-07° 14' 48.98" W, 100-120 m, 11 June 2013, Stauffer et al., 852 (CSRS, G, K); South-western region of the Taï National Park, adjacent area to the village of Guirotou, trail departing from the Ecotel Touraco (OIPR) in direction to the Mont Ninokoué (2 hours walk), 05° 47' 39.47" N-07° 06' 26.64" W, 100-120 m, 14 June 2013, Stauffer et al., 861 (CSRS, G); Sassandra, Monogaga, Kounouko, 6° 26' N- 4° 48' W, 30 April 2001, Adou Yao AY56 (CSRS); Côte d'Ivoire, Grabo, Djiroutou, 05° 22' N- 07° 17' W, 15 May 1986, Poilecot 2516 CI (G); Sud-Comoé Region: Nouamou Forêt des marais Tanoé-Ehy (FMTE), 05° 10' 20.8" N-02° 50' 51.6" W, 23 m, 9 September 2012, Da Giau & Ouattara SD032 (CSRS, G, K, WAG). **Agnéby Region (Agnéby-Tiassa Region):** Forêt classée de Yapo, 25 July 1991, Téré HTG1919b (CSRS); Adzopé, FC de Mabi au sud, 5° 53' N- 3° 31' W, 10 July 1996, Chatelain & Téré CC1443 (CSRS). **Sud-Bandama Region (Lôh-Djiboua Region):** Tiégbé, 05° 36' 13.92" N-05° 07' 48.67" W, 71 m, 02 December 2013, Gaille & Ouattara EG10 (G, LILLE, CSRS); Zikidiès, 05° 36' 16.39" N- 05° 07' 50.27" W, 184 m, 20 January 2013, Gaille & Irié EG86 (G, LILLE).

GHANA: Ashanti Region: Bobiri F. R., 20 December 1957, Tomlinson s. n (GC); Kumasi District, 30

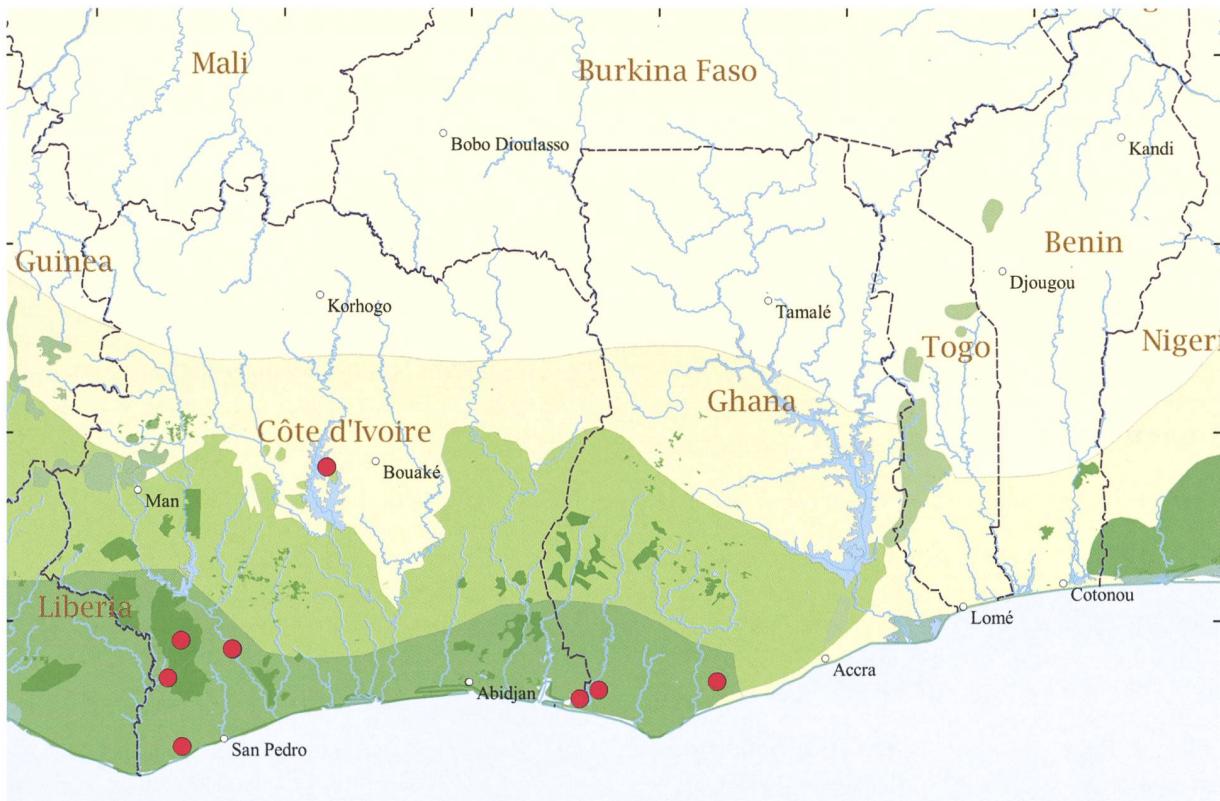


Fig. 12. Distribution of *Eremospatha macrocarpa* in Côte d'Ivoire, Ghana, Togo and Bénin.

May 1945, Vigne 4858 (K, KUM); Juasso, 28 February 1938, Vigne 1829 (K, KUM); Juasso, 1957, West-Skinn 11 (K). **Central Region:** Kakum National Park, 05° 21' 14.5" N- 01° 22' 59".4" W, 157 m, 17 June 2011, Ouattara & Amponsah OD 16 (G). **Eastern Region:** Kade Agricultural Research Station, June 1961, Irvine 4861 (K); Kade Agricultural Research Station, June 1961, Irvine 4873(K); Kade Agricultural Research Station June 1961, Irvine 4886 (K); Aburi, 25 February 1901, Johnson s. n. (K). **Western Region:** Enchi, between Kamokrom and Boinso about 61/2 miles from Enchi in bamboo swamp, 30 December 1953, C. D. Adams 2214 (GC); Enchi, Near Ajaka, on road to Boinso, 7 miles from Enchi, in low-lying forest, 30 December 1953 C. D. Adams 2195 (GC); Ankasa River F. R. 12 February 1971, Hall 42605 (GC); Tarkwa s. d., Douglas 183 (KUM); Ankasa F. R. 30 January 1979, Enti 1914 (WAG); Ankasa River F. R., 4 March 1971, Moore & Enti 9887 (GC); Ankasa River F. R., 4 March 1971, Moore & Enti 9891 (GC); Ankasa River, 4 March 1971, Moore & Enti 9893 (GC); Draw River Forest Reserve, 26 May 1999, Sunderland 2260 (K, KUM); Draw River Forest Reserve, 26 May 26 1999, Sunderland 2264 (K, KUM); Ankasa Forest Reserve, 05° 15' 53.1" N-02° 38' 44.0" W, 63 m, 19 October 2011, Ouattara & Stauffer OD 28 (G).

BÉNIN: Ouémé valley, Sèdjé (Zinvié), 06° 42' 3.88" N- 02° 22' 57.784" E, February 1988, n. c., 3612

(BÉNIN); Swamp near Adjara, 06° 31' 23.044" N-02° 39' 46.734" E, 06 December 1988, n. c., 4756 (BÉNIN); on ferrallitic soil, Adjara, Tchakou (Ouémé), 06° 16' 48" N-02° 25' 11.99" E, 11 August 1999, Adjakidjé, V., 3068 (BÉNIN); swampy degraded forest on clay soil, Djassin (Ouémé), 06° 17' 26.52" N-02° 21' 14.4" E, 27 m., 01 December 2000, Adjakidjé, V., 3949, 3950 (BÉNIN); Lokoli, Koussoukpa tosonou, swampy forest, 07° 01' 49.11" N- 02° 09' 42.33" E, 19 December 2002, Dan, 681 (BRU); flooded area under other palms, on the Kraké road (Ouémé), 06° 23' 13.58" N-02° 40' 32.76" E, January 1971, De Souza & Paradis, 1421a (BÉNIN); swampy forest, Mondo tokpa (Ouémé), 08 April 1985, De Souza & Paradis, 1421f (BÉNIN); Swampy forest, Mondo tokpa (Ouémé), 26 February 1981, De Souza 1421d, (BÉNIN); swampy forest, Mondo tokpa (Ouémé), 12 July 1971, Paradis, G., 1421b (BÉNIN); swampy forest with temporarily flooded, Tohoué (Ouémé), 06° 22' 53.54" N-02° 35' 2.38" E, 19 November 1984, Profizi 1421e (BÉNIN); fresh water swamps, Tohoué (Ouémé), 06° 12' 26.13" N-01° 28' 0.56" E, 04 June 1985, Profizi 1421 g (BÉNIN); no locality, 1974, De Souza & Paradis, 1421c (BÉNIN).

Laccosperma (G. Mann & H. Wendl.) Drude, Bot. Zeitung 35:635 (1877).

Pleonanthic, hermaphroditic, spiny palms; most often with high-climbing, clustered stems and pin-

nate leaves, the latter with a cirrus emerging from the rachis apex. The combination of hermaphroditic flowers and armed leaf sheaths observed in *Laccosperma* is unique among African rattans.

The genus is composed of 5 species, all of them endemic of the rainforests of Western Africa and of the Congolese basin (Dransfield *et al.* 2008; Sunderland 2012; Stauffer *et al.* 2014). Four species observed in the studied region (*L. acutiflorum*, *L. laeve*, *L. opacum* and *L. secundiflorum*).

Identification key

1a. Canes of small diameter (2-3 cm); leaflets less than 20 pairs **2**
1b. Canes of large diameter (3-8 cm); leaflets more than 20 pairs **3**
2a. Leaflets margin clearly spiny; fruits globose **L. opacum**
2b. Leaflets spineless, fruits ovoid **L. laeve**
3a. Leaflets lanceolate, horizontally oriented, ocrea not truncate; fruits ovoid to obovoid **L. acutiflorum**
3b. Leaflets sigmoid and elongated, hanging (pendulous), ocrea truncate; fruits oblong **L. secundiflorum**

6. *Laccosperma acutiflorum* (Becc.) J. Dransfield, Kew Bull. 37 (3): 456 (1982).
 Syn.: *Ancistrophyllum acutiflorum* Becc.

Palms growing in clumps of 3-7 individuals. Stems of 20-45 m long and 3-5 cm in diameter, covered with densely spiny leaf-sheaths. Leaves pinnate, apically extending in a cirrus; leaf-sheath tubular, 20-30 cm long and 4-8 cm in diameter, yellow-orange, indumentum present or not, if present brown, armed with spines 0.5-1 cm long, greyish, easily removable; ocrea 8-15 cm long, truncated; petiole very flattened and short at the base, 5-10 cm long; rachis 1-2.5 m long, armed with spines on the adaxial surface; leaflets linear-lanceolate, sub-opposite to alternate, dark green, 12-50 cm long and 1.5-3 cm wide, horizontally oriented, armed with 1-2 cm long spines, the latter regularly distributed at 0.8-1 cm on the margins, midrib present, bearing the same spines, secondary veins inconspicuous; cirrus 1-2.5 m long, bearing with opposite or alternate hooks of 2-5 cm long. Inflorescence two order branched, prophyll 20-25 cm long, tubular; peduncular bracts 4-8, similar to the prophyll; peduncle 1-2 m long, with the same diameter as the stem; rachis 0.5-1 m long; partial inflorescence 30-45 cm long, robust; rachillae 20-25 cm long, thin, cylindrical, elongated, curved, with a pointed apex. Flowers hermaphroditic, inserted in pairs, sepals 3, welded on over half of their length, petals 3, apex acuminate. Fruit globose, 3-4 cm in diameter with a very sharp and long apex, with a remnant calix.



A



B

Fig. 13. Morphological diversity in *Laccosperma acutiflorum*. **A.** mature individual at vegetative stage growing in understorey conditions. South-west Côte d'Ivoire (photo Fred Stauffer); **B.** Well-developed inflorescens at pre-anthesis stage. South-west Côte d'Ivoire (photo Doudjo Ouattara).



Fig. 14. Distribution of *Laccosperma acutiflorum* in Côte d'Ivoire, Ghana, Togo and Bénin.

Distribution and ecology

The species is distributed from Sierra Leone to Cameroon and south to the Congolese basin (Sunderland 2012; Stauffer et al. 2014). In spite of its wide distribution, this species is particularly poorly represented in herbaria. In the studied region, the species was rarely collected. *Laccosperma acutiflorum* is a light-demanding species, generally found in openings of dense and wet forests, although it was also observed in semi-deciduous forests.

Specimens examined

CÔTE D'IVOIRE: Cavally Region: South-western region of the Taï National Park, adjacent area to the village of Guiroutou, trail departing from the Ecotel Touraco (OIPR), high, wet, dense evergreen forest, 5° 24' 4.60" N-7° 14' 11.94" W, 100-120 m., 13 June 2013, Stauffer 858 (CSRS, G.)

GHANA: Ashanti Region: Konongo, 4 February 1914, Chipp 643 (K). **Greater Accra Region:** Aiyaola F. R., June 1972, Enti 758 (KUM). **Western Region:** Draw River Forest Reserve, 26 May 1999, Sunderland 2263 (K, KUM).

Note: This species can easily be confused with *L. secundiflorum*. Sunderland (2007) noted that it can

be distinguished from the latter by the yellow-green leaf-sheaths, the robust size of its cane and horizontal insertion of the leaflets.

7. *Laccosperma laeve* (G. Mann & H. Wendl.) H. Wendl., Revis. Gen. Pl. 2: 729 (1891).

Syn.: *Ancistrophyllum laeve* (G. Mann & H. Wendl.) Drude, *Calamus* (subgen. *Laccosperma*) *laevis* G. Mann & H. Wendl.

Palms growing in clumps of several individuals. Stem 15-20 m long and 0.7-1 cm in diameter. Leaves pinnate, with a terminal cirrus; leaf-sheath 12-20 cm long, blackish indumentum, densely armed with black and erected spines, the latter 2-7 mm long and 1.5 mm wide; ocrea 10-26 cm long; petiole 8-41 cm long and 4-7 mm wide, covered with the same indumentum of the leaf-sheath, margins armed with spines 2-7 mm long and inserted every 5-28 mm, adaxially flattened, abaxially convex; rachis 13-60 cm long and 2-7 mm wide at the base, 3 mm at the middle and 2 mm towards the apex, spines and indumentum similar to that of the petiole, spines inserted every 1-2 cm; cirrus 13-31 cm long and 1-4 mm wide, with hooks and spines, hooks 4-5 pairs, rarely solitary, inserted each 1-7 cm, spines 2-3 mm long, inserted each 7-10 mm; leaflets 10-12 pairs, sigmoidal, apical leaflets deltoids-sigmoidal, unarmed, inserted each 4-6 cm, sometimes con-

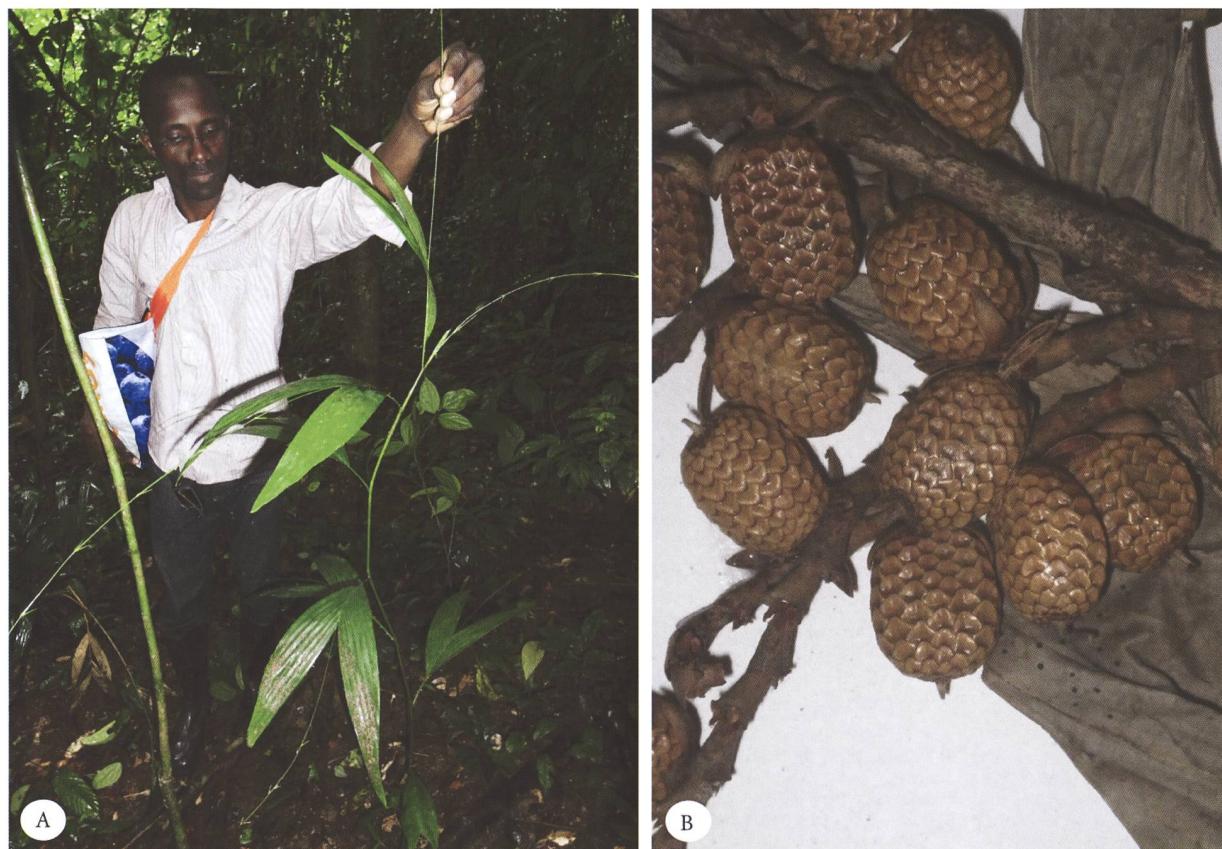


Fig. 15. Morphological diversity in *Laccosperma laeve*. **A.** Growth habit of a juvenile individual. Note entire-bifid leaves. Ghana (photo Fred Stauffer); **B.** Ripe fruits. Ghana (photo Doudjo Ouattara).

sisting of 2-3 at the base and at mid-length and regularly inserted in the apical portion, dark-green, with a base of 1.5-2 cm wide, apex acuminate, mid-ribs 2-4, prominent on the abaxial surface, basal leaflets 12-26 cm long and 3.4-5 cm wide, median leaflets 17-20 cm long and 5 cm wide, apical leaflets 11-21 cm long and 2.6-5 cm wide, very large at the base. Inflorescence terminal, 2-order branched; prophyll not observed; peduncular bracts at least 3 present, 1.5-7 cm long; peduncle 3. 2- 8.2 cm long and 3-6 mm wide; rachis 8-22 cm long, covered with the same bracts observed in the peduncle; partial inflorescences 4-5, 10-15 cm long, covered with conical bracts; rachillae 8-10 cm long and 2-4 mm wide, densely protected by bracteoles. Flowers hermaphroditic, subtended by slightly conical bracteoles, petals longer than sepals. Fruit oblong, rarely obovoid, 11-15 mm long and 8-9 mm in diameter, bright red when ripe, persistent sepals, with a sharp, 3 mm long stigmatic remain.

Distribution and ecology

Laccosperma laeve is present in the rainforests of the Upper Guinean Forest (Sierra Leone, Liberia, Côte d'Ivoire, and Ghana) as well as in Cameroon

(Sunderland 2007; Stauffer et al. 2014). The species grows in the understory of dense high forests but also tolerates heliophilous conditions

Specimens examined

CÔTE D'IVOIRE: Bas-Sassandra Region (San-Pédro Region): San-Pedro, SOGB forest, 04° 39' 53.9" N-07° 05' 46.3" W, 38 m, 15 August 2012, Da Giau & Ouattara SD021 (CSRS, G, K, WAG); South-western region of the Taï National Park, adjacent area to the village of Guirotou. Trail departing from the Eco-tel Touraco (OIPR), 05° 23' 46.5" N-07° 14' 45.52" W, 100-120 m, 12 June 2013, Stauffer et al. 856 (CSRS, G). **Sud-Comoé Region:** Nouamou, Forêt des marais Tanoé-Ehy (FMTE), 05° 10' 31.2" N-02° 50' 59.3" W, 16 m, 9 September 2012, Da Giau et al. SD026 (CSRS, G); **Lagunes Region (District of Abidjan):** Forêt de l'Anguédédou, July 1960, Aké Assi s. n. (G); Banco, December 1971, Fredoux 358 (G). **Sud-Bandama Region (Lôh-Djiboua Region):** Tiegbé, 05° 36' 13.92" N-05° 07' 48.67" W, 71 m, 02 December 2013, Gaille & Ouattara EG9 (G, LILLE).

GHANA: Western Region: Enchi near Adjaka road to Boinso, 7 miles from Enchi in low-lying forest, 30



Fig. 16. Distribution of *Laccosperma laeve* in Côte d'Ivoire, Ghana, Togo and Bénin.

December 1953, C. D. Adams 2190 (GC); Neung F. R., Tarkwa, 30 November 1988, Enti 2344 (GC); Tarkwa, Ndumfri F. R., 3 February 1934, Kinlock 3237 (KUM); Ankasa River F. R., 4 March 1971, Moore & Enti 9882 (GC); Ankasa Forest Reserve, 05° 16' 54.0" N-02° 38' 28.7" W, 101 m, 20 October 2011, Ouattara & Stauffer OD 32 (G); Draw River Forest Reserve 05° 07' 12" N-02° 12' 0" W, 26 May 1999, Sunderland 2265 (K, KUM); Draw River Forest Reserve, 05° 07' 12" N-02° 12' 0" W, 26 May 1999, Sunderland 2266 (K, KUM).

8. *Laccosperma opacum* (G. Mann & H. Wendl.) Drude. Bot. Zeitung 35: 635 (1877).

Syn.: *Ancistrophyllum opacum* (G. Mann & H. Wendl.) Drude, *Calamus opacus* G. Mann & H. Wendl; *Calamus* (subgen. *Laccosperma*) *opacus* G. Mann & H. Wendl., *Neoancistrophyllum opacum* (Drude) Rauschert & J. Dransfield.

Palms growing in clumps of several individuals. Stem 5-20 m long and 1.5-1.8 cm in diameter, elliptical to cylindrical in cross-section. Leaves pinnate, up to 1.5 m long, leaf-sheath tubular, 12-20 cm long, densely armed with 1-1.5 cm long spines; petiole 4-18 cm long and 0.5-1.1 cm wide, flattened adaxially and convex abaxially, margins armed with 0.5-1 cm long spines; rachis 30-40 cm long and 3-4 mm wide,

covered with spines similar to those of the petiole; cirrus 0.5-2 m long and 2-3 mm wide, with hooks and spines, hooks 6-12 pairs, 1.5-2.5 cm long, spines 3-4 mm long; leaflets 15-20 pairs, papyraceous, elliptic-sigmoidal, apex acuminate, dark-green adaxially more or less pale abaxially, alternate, inserted every 2-4 cm, midrib unarmed and prominent on the adaxial surface; secondary veins inconspicuous, basal leaflets 9-23 cm long and 2-6 cm wide, median leaflets 16-25 cm long and 5-8 cm wide, apical leaflets 10-21 cm long and 3-6 cm wide. Inflorescence 2-order branched, up to 4 m long; prophyll not observed; peduncular bracts tubular; peduncle 5-10 cm long; rachis 20-45 cm long and 1.5-2 cm in diameter, covered by tubular bracts up to 19 cm long; partial inflorescences 20-38 cm long and 0.5-1 cm in diameter, covered by tightly packed conical bracts; rachillae up to 20, 10-15 cm long and 3-4 mm in diameter. Flowers hermaphroditic, calyx and corolla yellowish-green; anthers pale-yellow. Fruit globose, 1-2 cm long and 1.5- 2 cm wide, pericarp scaly, red orange at maturity.

Distribution and ecology

This species has a wide distribution, ranging from Sierra Leone to Nigeria and south to the Congolese basin (Sunderland 2007; Stauffer et al. 2014). It is



Fig. 17. Morphological diversity in *Laccosperma opacum*. **A.** Growth habit of an adult individual. South-east Côte d'Ivoire (photo Fred Stauffer); **B.** Growth habit of a young individual. South-east Côte d'Ivoire (photo Fred Stauffer); **C.** Detail of an infructescence at early stage of development. South-east Côte d'Ivoire (photo Doudjo Ouattara). **D.** Detail of an infructescence at late stage of development. South-east Côte d'Ivoire (photo Doudjo Ouattara).



Fig. 18. Distribution of *Laccosperma opacum* in Côte d'Ivoire, Ghana, Togo and Bénin.

the only rattan palm reported so far on the island of Bioko (Morakinyo, 1995). The palm grows in evergreen rainforests, but it tolerates heliophilous conditions; it prefers wet but well drained soils. Different Hymenoptera and Coleoptera could be observed in the inflorescences during anthesis.

Specimens examined

CÔTE D'IVOIRE: Sud-Comoé Region, Îles Ehotilés National Park. N 5°09' 40,26" – S 3°15' 54,09", 2 m, 6 September 2019, F. Stauffer et al. 902, 903 (G, CSRS).

GHANA: Ashanti Region: Kumasi, 1995, Cummins 229 (K); Amentia, Ashanti, 30 April 1927, Irvine 502 (GC); Banka, S. Ashanti September 1928, Vigne 1365 (K, KUM); Amentia, E. Region, 30 March 1930, Vigne 1875 (K, KUM). **Brong-Ahafo Region**: Awisa, December 1933, Irvine 2075 (K, GC). **Central Region**: Bimpong F. R., Foso, 16 February 1972, Enti 614 (GC); Kakum Forest Reserve/ secondary forest, 20 November 1964, Hall 2748 (GC, P); Kakum National Park 05°21' 21.7" N – 01° 23' 00".8" W, 161 m, 17 June 2011, Ouattara & Amponsah OD 15 (G). **Western Region**: Awoso, 24 December 1953, C. D. Adams 2407 (GC); Atwabo National Park, 28 February 1934, Irvine 2300 (GC); Awoso, 3 December

1958, Morton 3618 (GC); Ankasa Forest Reserve, 24 January 1970, Quansah s. n. (CCG); Axim Cocoa Station, 1957, West-Skinn 90 (K).

BÉNIN: Ouémé, Adjarra, near Tchakou, water course, branch of Adjarra river, leading to Nigeria and the Ouémé river, in watercourse, 06° 17' 5.27" N-02° 25' 27.48" E, 20 November 2000, Van Der Mae-sen, 7517 (BÉNIN).

9. *Laccosperma secundiflorum* (P. Beauv.) Künz- tze. Revis. Gen. Pl. 2: 729 (1891).

Syn.: *Ancistrophyllum majus* Burret; *Ancistrophyllum secundiflorum* (P. Beauv.) H. Wendl., *Calamus secundiflorus* P. Beauv., *Calamus* (*subgen. Ancistrophyllum secundiflorus*) G. Mann & H. Wendl., *Laccosperma laurentii* (De Wild) J. Dransfield, *Laccosperma majus* (Burret) J. Dransfield.

Palms growing in clump of 6-12 individuals. *Stem* 25-50 m long and 3-8 cm in diameter, circular in cross-section. *Leaves* pinnate, 2-3.5 m long; leaf-sheath 28-55 cm long, densely armed with black, 2-3 cm long spines, ocrea 27-30 cm long; petiole flattened, 2.2- 5 cm long and 1.5-6 cm wide, sometimes very short, armed with 1-3 cm long, yellow with spines, the latter brown-black towards the apex; rachis densely indumented, 2.5- 3 m long and



Fig. 19. Morphological diversity in *Laccosperma secundiflorum*. **A.** Juvenile individual of growing in understory conditions. Southern Ghana (photo Fred Stauffer); **B.** Adult individual at vegetative stage. Southern Ghana (photo Doudjo Ouattara). **C.** Growth habit of a mature individual in sunny-exposed conditions. Southern Ghana (photo Fred Stauffer); **D.** Detail of leaf blade of showing the well-developed flagellum as an extension of the leaf rachis. Southern Ghana (photo Fred Stauffer).



Fig. 20. Morphological diversity in *Laccosperma secundiflorum*. A. Large inflorescence of at pre-anthesis stage. Note the strongly hanging rachillae. South-east Côte d'Ivoire (photo Simona da Giau); B. Large inflorescence of at post-anthesis stage. Southern Côte d'Ivoire (photo Fred Stauffer).

1-5 cm wide, convex abaxially and adaxially flattened, bearing 1-1.2 cm long, yellow spines, the latter inserted in two different angles, cirrus 2- 2.5 m long and 4-9 mm wide, armed with hooks and spines, hooks 15-20 pairs, 1 -4.5 cm long and 3-4 mm wide, swollen at the base, alternating at the base of the cirrus, opposite towards the apex, inserted every 12-23 cm, spines 7.5-15 mm long; leaflets 60-73 pairs, regularly inserted, lanceolate, sub-opposite, apex acuminate, sometimes ending in a flagellum 1-3 cm long, midribs 2-4, with armed margins and veins; basal leaflets 31-44 cm long and 1-2 cm wide, densely covered by 5-10 mm long spines, separated by less than 1 cm, median leaflets 44-60 cm long and 3-4.5 cm wide, apical leaflets 20-29 cm long and 1.5-3 cm wide, alternating, inserted every 3-4 cm, margins armed with spines up to 3 mm long and inserted every 2-3 cm; midribs 1-3, prominent on the adaxial surface, weakly armed with 1-5 mm long spines inserted every 5-20 mm. *Inflorescences* terminal, 2-order branched; prophyll tubular, green, hard, 20-30 cm long; peduncular bracts at least 8 observed, coriaceous; peduncle 30-100 cm long, green, cylindrical; rachis 1.5-2.5 m long and 3-3.5 cm in diameter, circular in cross-section; partial inflores-

cences 13-16, 40-75 cm long and 0.8-2 cm in diameter, circular in cross section, spirally inserted, covered with conical bracts; rachillae 100-130, 40-70 cm long and 0.8-2.5 cm wide, almost circular in cross-section, densely covered with bracts. *Flowers* hermaphroditic, arranged in pairs. *Fruit* oblong, 1.5-1.6 cm long and 1.2-1.4 cm in diameter, pericarp covered with rhomboid scales.

Distribution and ecology

Laccosperma secundiflorum has a wide range of distribution at the continental level. Indeed, the species grows in the guineo-congolesian wet forest extending from Senegal to Congo (Sunderland 2012; Stauffer et al. 2014). Because of its high demand in light, this species can also grow in secondary forests conditions. Despite its climbing growth habit this palm can easily grow up to 5-6 m as an erect and solitary palm not relying on any external support.

Specimens examined

CÔTE D'IVOIRE: Lacs region (District of Yamoussoukro): Yamoussoukro, N'Gblékro, 06° 53' 31.4" N-05° 09' 10.1" W, 201 m, 26 July 2012, Da Giau & Ouattara SD007 (G). **Haut- Sassandra Region:** Daloa, Guedéguhé, 06° 53' 22.2" N-06° 26' 56.9" W, 205 m, 2 August 2012, Da Giau & Ouattara SD014 (G); 2 August 2012, Da Giau S. & Ouattara D. SD015 (G); 2 August 2012, Da Giau & Ouattara SD016 (G); Daloa, FC de Haut Sassandra, piste V12, 06° 59' N-06° 56' W, 14 February 1994, Kouamé & Chatelain 1113 (CSRS); **Bas-Sassandra Region (San- Pédro Region):** San Pedro, SOGB forest, 04° 42' 10.7" N-06° 58' 03.2" W, 37 m, 15 August 2012, Da Giau & Ouattara SD020 (G); San-Pédro, SOGB forest, 04° 39' 53.9" N-07° 05 46.3" W, 38 m, 15 August 2012, Da Giau & Ouattara SD022 (G); 15 August 2012, Da Giau & Ouattara SD025 (CSRS, G); **Cavally Region:** South-western region of the Taï National Park. Adjacent area to the village of Guirotou, trail departing from the Ecotel Touraco (OIPR), 05° 23' 31.30" N-07° 14' 48.55" W, 100-120 m, 11 June 2013, Stauffer et al. 853 (CSRS, G, K). **Sud-Comoé Region:** Nouamou, Forêt des marais Tanoé-Ehy (FMTE), 05° 10' 27.5" N-02° 50' 57.8" W, 16 m, 09 September 2012, Da Giau et al. SD025 (G); 09 September 2012, Da Giau et al. SD027 (G, K, CSRS); 09 September 2012, Da Giau et al. SD028 (CSRS, G); Nouamou, Forêt des marais Tanoé-Ehy (FMTE), 05° 10' 20.8" N-02° 50' 51.6" W, 23 m, 09 September 2012, Da Giau et al. SD031 (CSRS, G). **18 Montagnes Region (Tonkpi Region):** between Man and Biankouma, 07° 21' 52.45" N-07° 38' 26.19" W, 330 m, 19 Juin 2013, Da Giau & Luino SD034 (CSRS, G, K,); Guiglo, Ziriglo, Aké Assi

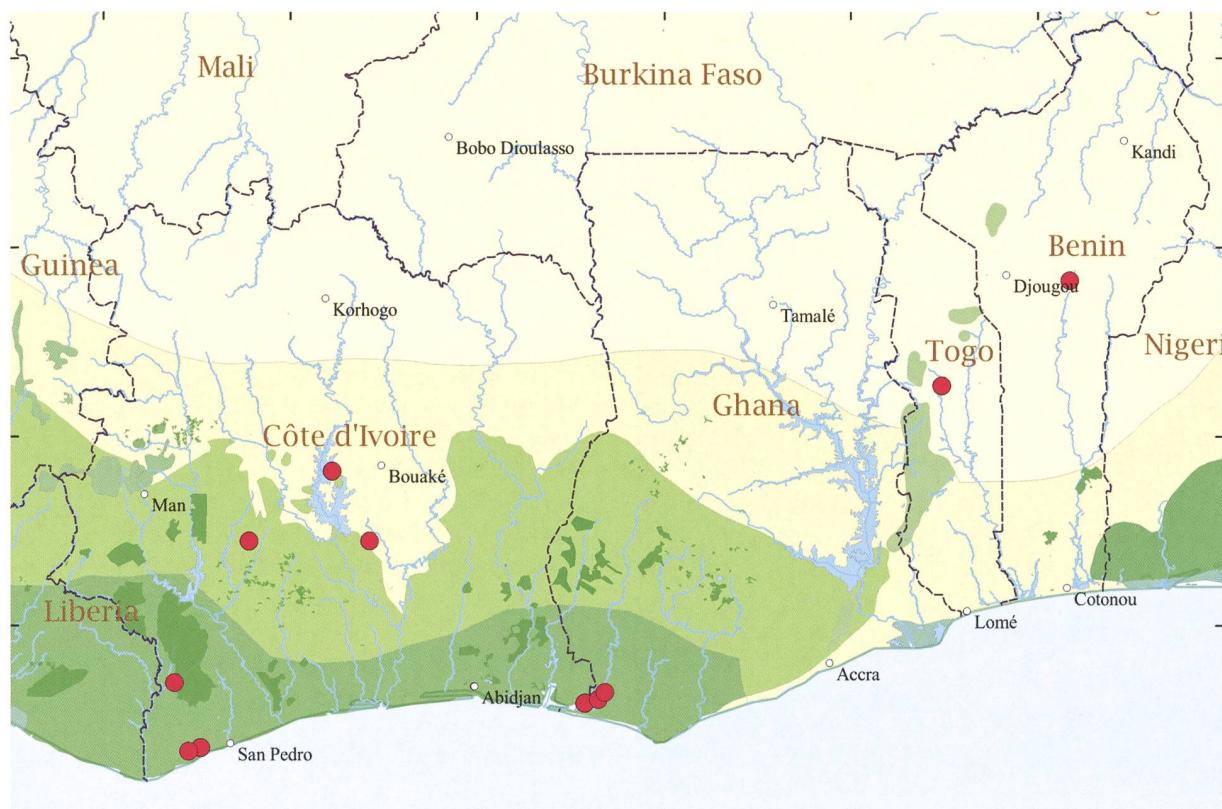


Fig. 21. Distribution of *Laccosperma secundiflorum* in Côte d'Ivoire, Ghana, Togo and Bénin.

12087 (G). **Sud-Bandama Region (Lôh-Djiboua Region)**: Tiégbé, 05° 36' 16.78" N-05° 07' 50.08" W, 71 m, 02 December 2013, Gaille & Ouattara EG7 (G, LILLE); Abidjan, Banco forest, 500 m South of Centre, 05° 13' 48" N- 04° 1' 48" W, 31 July 1975, Van der Burg, W. J., 719 (BRU).

GHANA: Ashanti Region: Bobiri F. R., 20 December 1957, Tomlinson s. n. (K, GC); Mampong Escarpment, 30 August 1932, Vigne 2410 (K, KUM). **Western Region**: Esaima-nkroful road, 2 March 1971, Enti & Moore 42647 (GC); River Nkroful, secondary forest, 18 August 1965, Hall 3371 (GC); Second-growth thickets beside road at Anagy between Axim Junction and Axim, 2 March 1971, Moore & Enti 9882 (GC); Esaima-Nkroful road, 7 March 1971, Moore & Enti 9892 (GC); Ankobra River, Axim, 18 August 1965, Morton 377 (GC); Ankasa Forest Reserve, 05° 12' 43.9" N- 02° 42' 16.6" W, 90 m, 20 October 2011, Ouattara & Stauffer OD 33 (G); Ankasa Forest Reserve, 05° 17' 14.9" N-02° 38' 06.0" W, 91 m, 21 October 2011, Ouattara & Stauffer OD 34 (G); Road from Tarkwa to Axim, 05° 12' 35.99" N-01° 0' 0" W, 25 May 25, 1999, Sunderland 2259 (K, KUM).

TOGO: «Région des plateaux»: Kloto (zone IV). Bavé, between Danyi Ndigbé and Amégo, 07° 08' 37.16" N-00° 40' 30.01" E, March 1987, Akpagana, K. 1560 (TOGO); «Galerie de Fufu», Togo mounts

meridional section, dense forests (zone IV), March 1987, Brunel, J. F. 10343 (TOGO); around the village of Kouma-konda, near Kpalimé, 06° 57' 17.64" N-00° 36' 3.95" E, 771 m, 18 June 2015, Michon 86 & 86a (G).

BÉNIN: Lokoli/Sisimè, in swampy forest, 07.03'58.8" N-02.15'17.5" E, 20.12.2002, Dan 685 (BRU); Togbota, lieu-dit Togbota agué, Gbadji. Num rel R13.16, 06° 25' 47.99" N-02°14' 24" E, 21 December 2000, Dan & Hanon 249 (BRU); Swamp, Adjarra (Ouémé), 06° 19' 12" N-02° 23' 59.99" E, 5-25 m, 06 December 1988, Hougnon, P., 4757 (BÉNIN); swampy forest, Zè/Sèdjé (Atlantique), 06° 25' 11.99" N- 02° 13' 47.99" E, 07 March 1989, Hougnon, P. 4950 (BÉNIN); Porto-Novo area, 06° 29' 13.09" N-02° 42' 36.54" E, 8 m, 20 November 2014, Michon 2 (G); swampy forest temporarily flooded, Tohoué (Ouémé), 06° 16' 52.67" N-02° 22' 22.8" E, 18 March 1985, Profizi. J. P. 1425f (BÉNIN); alongside track of RNIE 1, ca. 5 km W of Nigeria border, North of Kraké plage, swampy vegetation, in water, Adjarra (Ouémé), 06° 14' 6" N-02° 24' 21.6" E, 5 m, 11 November 1999, Van Der Maesen 6810 (BÉNIN).

Oncocalamus (G. Mann & H. Wendl.) H. Wendl.

Pleonanthic, monoecious, spiny palms; most often with high climbing, clustered stems, entire-bifid

leaves when juvenile and pinnate leaves at maturity, the latter with a cirrus emerging from the rachis apex, can be easily distinguished from all other African rattans due to the presence of a *Oncocalamus* complex floral arrangement. In fact, flowers are arranged in a central group of 1-3 female flowers flanked by 2 lateral cincinni of 2-4 male flowers. At juvenile stage, individuals of this genus can be otherwise confused with taxa in *Eremospatha* and *Laccosperma*.

Four species are currently recognized in this genus (Dransfield et al. 2008; Sunderland 2012), which occurs from equatorial West Africa to the Congo Basin; one species (*Oncocalamus wrightianus*) is found in the area concerned by our study. The flower clusters present in this genus are morphologically and evolutionarily intriguing, and useful to distinguish *Oncocalamus* from other rattan genera.



Fig. 22. Morphological diversity in *Oncocalamus wrightianus*. **A.** Growth habit of a juvenile plant; **B.** Detail of stem, leaf sheaths and pinnate leaves; **C.** Ant nest made of strongly folded leaflets.

All photos from the region of Adjara, Bénin (photos Didier Roguet).

10. ***Oncocalamus wrightianus*** Hutch. Kew Bull. 17: 181 (1963).

Clustered, slender to moderate, climbing palm. *Stem* up to 10 m long and up to 1 cm in diameter, lacking remaining leaf sheaths; *internodes* up to 15 cm long. *Leaves* sessile or shortly petiolate, pinnate, *leaf sheath* striate, moderately to sparsely armed with caducous brown-black spines, triangular, often getting loose, with a white caducous indumentum on mature sheaths; *ocrea* armed with concentrated, persistent spines, no conspicuous lobe, horizontally truncate, extending to approx. 3 cm; *petiole* absent or up to 2 cm long, flattened; *rachis* up to 60 cm long, adaxially channelled, abaxially compressed, distally circular in cross section, unarmed; *cirrus* up to 45 cm long, unarmed, with retrorse acanthophylls, the latter up to 1.8 cm long; *leaflets* up to 15 pairs, up to 15 cm long and up to 5 cm wide, lanceolate to ovate or sigmoid, apex slightly acuminate, dark green, in particular at the base armed on the margins with small, easily breakable, thin spines. Flowers and fruits have never been collected in the studied area.

This species is easily recognizable in the field due to its slender appearance and its leaflets relatively broad and sigmoid in shape. The classic work of Tuley (1995) regarded *O. wrightianus* as a juvenile form of *O. manni* and hence included the former as a synonym of the latter. However, Sunderland (2012) rejected this idea as the leaves of *O. wrightianus* are pinnate and also because all juvenile individuals in the genus present entire-bifid leaves. One specimen stored at BÉNIN (De Souza, S. 1501a) was originally identified by Laurent Aké Assi as *Oncocalamus manni*, a species that has been only reported from southern Cameroon and Gabon (Sunderland, 2007, 2012). Although the material stored at BÉNIN is fragmentary, T. Sunderland (pers. comm.) recently confirmed that the specimen corresponds indeed to *Oncocalamus wrightianus*, stressing also the difficulties to monitor populations of this species as there are no flowers or fruits of this palm represented in herbaria.

Distribution and ecology

The species occurs in Southern Bénin and along the Niger delta in Nigeria (Sunderland 2007, 2012). *Oncocalamus wrightianus* can be found in swampy forests and also in the ecotone forest-savannah. Dalziel (1937) pointed out that the species is restricted to swampy forests. In our studied area only in Benin

Herbarium samples studied

BÉNIN: Forêt marécageuse à inondation, Tohoné [aja], 11.02.1985, S. de Souza 1501a (BÉNIN). A



Fig. 23. Distribution of *Oncocalamus wrightianus* in Côte d'Ivoire, Ghana, Togo and Bénin.

specimen collected in Bénin (Aufsess 430-K) was studied by T. Sunderland and cited in his monograph (Sunderland, 2012).

Raphia P. Beauv. Fl. Oware 1: 75 t. 44-46 (1806).

Hapaxanthic, monoecious palms, with massive, solitary or clustered growth habit; leaves pinnate; leaf-sheaths curly or straight woody margins, the latter densely covering the stems; inflorescences interfoliar or suprafoliar, erect or pendent, branched to 2 orders; fruits densely covered by imbricate scales.

As currently understood, the genus *Raphia* is represented in our flora by only three species (*R. hookeri*, *R. palma-pinus* and *R. sudanica*). Other treatments (i. e. Russell 1965; Govaerts et al. 2021) report also the presence of *R. vinifera* in Bénin, but the taxonomy of this species remains complex (Mogue et al. 2019) and its presence in this country is still subject of controversy. Palisot de Beauvois (1752-1820) described *Raphia vinifera* in his «*Flore d'Oware et du Bénin*» (de Beauvois, 1804) as a short-size palm. Other authors (i. e. Beccari 1910; Chevalier 1932; Hutchinson and Dalziel, 1936; Russel, 1965) added some confusion on Palisot de Beauvois' original concept of the species based on the original drawings of *R. vinifera*, making almost impossible to establish the taxonomic entity of the species. Mogue et

al. (2019) undertook thorough studies on the type specimens associated to this palm and clearly demonstrated that the original material stored at G corresponds to the flabellate-type partial inflorescence corresponding to the drawings presented in the Palisot de Beauvois' original publication. *Raphia vinifera* remains an intriguing species that deserves further study and well-documented collections. As Mogue et al. (2019) pointed out that Palisot de Beauvois described the species to be common along the rivers of the Oware (Delta State) and Bénin (Edo State) of present day Nigeria, we have decided to exclude this palm from the current floristic study.

Some of the specimens gathered in the frame of our field trips to Côte d'Ivoire, Ghana, Togo and Bénin have been used to the recent molecular phylogenetic analysis of the genus *Raphia* (Helmstetter et al. 2020).

■ Identification key for the species

- 1a. Acaulescent palm; inflorescence erect, partial inflorescence rather cylindrical. **R. palma-pinus**
- 1b. Tall to mid-size palm; stem always aerial and well-visible; inflorescence curved (pendant); partial inflorescence flattened. **2**
- 2a. Clustered palm; stem less than 5 m tall; leaf-sheath margins entire or only with few fibers; in-



Fig. 24. Morphological diversity in *Raphia hookeri*. A. Growth habit of an adult individual at reproductive stage. South-west Ghana (photo Doudjo Ouattara); B. Growth habit of an adult Individual at fruiting stage. South-west Ghana (photo Fred Stauffer); C. Large, hanging inflorescences at early bud stage. Note the numerous bracts covering the reproductive rachillae. South-west Ghana (photo Fred Stauffer); D. Adult individual with the stem densely covered with curly woody leaf sheaths fibers. South-west Ghana (photo Fred Stauffer).



Fig. 25. Morphological diversity in *Raphia hookeri*. **A.** Infructescences bearing ripe fruits. Côte d'Ivoire (photo Didier Roguet); **B.** Fragment of infructescences with unripe fruits. South-west Côte d'Ivoire (photo Fred Stauffer); **C.** Detail of infructescences with ripe fruits. South-west Côte d'Ivoire (photo Fred Stauffer); **D.** Cross section of ripe seed showing the ruminate endosperm. South-west Côte d'Ivoire (photo Fred Stauffer).

florescence compressed and slightly recurved, rarely exceeding 1 m **R. sudanica**
2b. Solitary palm; stem more than 8 m tall; leaf-sheath margins with elongate, curly fibers; inflorescence elongate and pendant, at least 2 m long. **R. hookeri**

11. Raphia hookeri G. Mann & H. Wendl., Trans. Linn. Soc. London 24: 438 (1864).

Syn.: *Raphia angolensis* Rendle, *Raphia gigantea* A. Chev., *Raphia hookeri* var. *planifoliola* Otedoh, *Raphia hookeri* var. *rubrifolia* Otedoh, *Raphia longirostris* Becc., *Raphia maxima* Puechuel Lœsnck & Lœsche Loango, *Raphia sassandrensis* A. Chev.

Tall, solitary, hapaxanthic, monoecious palm, often growing in dense monospecific stands. *Stem* 8-15 m long and 15-30 cm in diameter, usually partially or completely covered by marcescent leaf-sheaths. *Leaves* pinnate, 8-15 m long, reduplicate; leaf-sheaths densely covered by the woody, curly margins that entirely cover the stem; petiole 4-5 m long and 5-10 cm in diameter, green with glaucous parts, triangular in cross-section; rachis 6-8 m long and 2-3 cm in diameter, unarmed, abaxial surface smooth, adaxial surface with a linear central keel; leaflets 90-110 pairs, the latter lanceolate and with an acute apex, bright green, inserted every 1.5-2.5 cm on the rachis, armed or not; spines (if present) arranged on the margins and on the midrib, 2-4 mm long, black, sometimes very little, inserted every 8-10 cm on the adaxial surface of the leaflets, midrib prominent, secondary veins several; basal leaflets 45-80 cm long and 1-2, 5 cm wide, median leaflets 1-2 m long and 2-4.5 cm wide, apical leaflets 30-70 cm long and 1-2.5 cm wide. *Inflorescence* 2-3 m long, 2-order branched, slightly erect at early stages, pendant at late bud stage and anthesis, prophyll tubular completely enclosing the peduncle; peduncular bracts at least 6 observed, 15-17 cm long, smooth, light yellow; rachis 1-2 m long; peduncle 5-10 cm long; partial inflorescences 10-20, arranged in several planes and completely covering the inflorescence rachis; each partial inflorescence 30-40 cm long and 6-10 cm wide; completely enclosed by subtending bracts in early development, bracts 3-4 cm long and 1.5-2 cm in diameter, tubular, apex triangular; last order rachillae subtended at the base by 0.5-1 cm long and 1-1.5 cm in diameter bracts, the latter tubular, flattened, yellow; basal to mid-height rachillae 12-15 cm long and 1-1.3 cm wide, bearing pistillate flowers at the base and staminate flowers at higher levels; apical rachillae 5-8 cm long and 0.6-1 cm wide, bearing only staminate flowers. *Flower* calyx and corolla welded and woody. *Fruit* oblong to obovate, 6-8 cm long and 3.7-4.2 cm in diameter, pericarp scaly, almost red at maturity, with an apical, woody protrusion of 1 cm long and 0, 4 cm; seed oblong to obovoid, 4-4.2 cm long and 2.2-2.6 cm in diameter.

Distribution and ecology

The species has been reported in most countries of the Gulf of Guinea, from Senegal east to Nigeria. In Central Africa the species is distributed from Cameroon to Angola including the Central African Republic and Democratic Republic of the Congo (Mbandu Luzolawo et al. 2020). This species is highly adapted to hydromorphic soils subject to permanent or seasonal flooding. It grows in sun-exposed conditions and hence present in forest natural clearings, riverine forests, secondary forests, or even disturbed areas produced by human-induce fires.

Specimens examined

CÔTE D'IVOIRE: Bas-Sassandra Region (Cavally Region)

South-western region of the Taï National Park, adjacent area to the village of Guiroutou, trail departing from the Ecotel Touraco (OIPR), 05° 23' 25.2" N-07° 14' 43" W, 100-120 m, 13 June 2013, Stauffer et al. 860 (CSRS, G); **Lacs Region (Agnéby-Tiassa Region)**: Lamto, sur une île du Bandama, 24 April 1989, Denise & Laurent Gautier-Beguin 1199 (CSRS); Lamto, bord du Bandama, 24 April 1989, Denise & Laurent Gautier-Beguin 1223 (CSRS). **Lagunes Region (District of Abidjan)**: Côte d'Ivoire, Lagune Adjin, 10 May 1974, Frédoux 252 (G).

Sud-Bandama Region (Lôh-Djiboua Region): Zikidiès, 05° 36' 13.92" N-05° 07' 48.67" W, 182 m, 05 December 2013, Gaille & Ouattara EG12 (G, LILLE); 05 December 2013, Gaille & Ouattara EG13 (G, LILLE); 05 December 2013, Gaille & Ouattara EG14 (G, LILLE); Divo, 05° 36' 28.67" N-05° 09' 25.08" W, 85 m, 30 November 2013, Gaille & Ouattara EG2 (G, LILLE); Zikidiès, 05° 46' 55.65" N-05° 29' 7.27" W, 188 m, 20 January 2013, Gaille & Maxime EG88 (G, LILLE).

GHANA: Ashanti Region

Bobiri Forest Reserve, 06° 41' 19.1" N-01° 20.32.1" W, 237 m), 20 May 2011, Ouattara, D., P. Aman, O. Adoma & K. Bridget OD 1 (G); Bobiri Forest Reserve, 06° 41' 22.2" N-01° 20' 29.4" W, 234 m), 20 May 2011, Ouattara, D., P. Aman, O. Adoma & K. Bridget OD 2 (G); Bobiri Forest Reserve, vers la rivière Yahaya, 06° 43' 12.6" N-01° 15' 40.8" W, 207 m, 26 May 2011, Ouattara, D., P. Aman, O. Adoma & K. Bridget OD 7a (G); Bobiri Forest Reserve, vers la rivière Yahaya 06° 43' 12.6" N-01° 15' 40.8" W, 207 m, 26 May 2011, Ouattara, D., P. Aman, O. Adoma & K. Bridget OD 7b (G). **Central Region**: Kakumdu, January 08, 1963, Hall 2442 (CCG); Abrafo-Odumasi, entre Cape coast et Kakum N. P., 05° 20' 14.6" N-01° 22' 43".9" W, 54 m, 18 June 2011, Ouattara OD 19 (G).

BÉNIN: Adjohoun (Ouémé), Sissèkpa, swampy forest on sando-clayey soil, 06° 24' 33.12" N- 02° 17'



Fig. 26. Distribution of *Raphia hookeri* in Côte d'Ivoire, Ghana, Togo and Bénin.

58.55" E, 3 m, 29 November 2000, Adjakidjé 3904 (BÉNIN); Kraké, 06° 23' 30.58" N-02° 40' 37.30" E, 7 m, 20 November 2014, Michon 1 (G).

12. *Raphia palma-pinus* (Gaertn.) Hutch., Fl. W. Trop. Afr. 2: 387 (1936).

Syn.: *Raphia gaertneri* G. Mann & H. Wendl.; *Raphia gracilis* Becc.; *Sagus palma-pinus* Gaertn.

Acaulescent, massive, hapaxanthic, monoecious palm. Leaves 30-35, regularly pinnate, 7-12 m long; leaf-sheath almost absent, directly emerging from the ground; petiole 4-5 m long, 7-8 cm in diameter, more or less cylindrical in cross-section, olive green; rachis 6-8 m long, 4-5 cm diameter at the base, 3.5-4 cm at mid-height and 1-2 cm towards the apex, armed with 1-2 mm long spines; leaflets 112-137 pairs, inserted in at least two angles on the rachis, dark green, lanceolate, with an acuminate apex, margins armed with 2-3 mm long spines, midrib prominent, on the adaxial surface, armed with 2-3 mm long spines, inserted every 3.5 cm; basal leaflets 53-55 cm long and 1-2 cm wide, median leaflets 1.5- 1.6 m long and 5.5-6 cm wide, apical leaflets 30-50 cm long and 0.5-2 cm wide. Inflorescence 2-order branched, erect when young and anthesis, becoming pendulous in fructification, 1.8-2.2 m long, 14 cm wide at the base, 8 cm wide at mid-height, 6 cm wide at the apex; prophyll not

observed; peduncular bract tubular, 5-6 cm long; peduncle 5-10 cm long, densely enclosed by the bracts; rachis 1-1.5 m long; partial inflorescences 40-45, yellowish-green, subtended with 22-25 cm long bracts, the latter imbricate, basal partial inflorescences 40-42 cm long and 3-4 cm in diameter, median partial inflorescences 32-34 cm long and 2-2.2 cm in diameter, apical partial inflorescences 15-17 cm long and 2-2.5 cm in diameter. Staminate flowers conspicuously exerted from the rachilla bracts, calyx tubular, woody, 3-lobed, corolla exceeding the calyx, woody, with 3 elongate triangular lobes; stamens 15-24, anthers elongate. Pistillate flowers rarely exerted from the rachilla bracts, calyx tubular, 3-lobed, the corolla longer than the calyx, woody, with 3 elongated triangular lobes; gynoecium 3-carpellate, topped by a short style and a conical 3-lobed stigma, staminodes 8-12, forming an epipetalous ring bearing irregular and marginal teeth. Fruit oblong 5.5-6.5 cm long and 2.5-3.5 cm wide, covered by a densely scaly pericarp, scales rhomboidal 1.2-1.5 cm long and 1.2-1.5 cm wide, stigmatic remains apical, 2 mm long; seed oblong to ovoid, 3 cm wide.

Distribution and ecology

Raphia palma-pinus is an endemic palm from the wet forest of West Africa. The species has been re-



Fig. 27. Morphological diversity in *Raphia palma-pinus*. **A.** Growth habit of a young individual at vegetative stage. South-west Ghana (photo Fred Stauffer); **B.** Young Individual displaying the acaulescent growth habit typical of the species. Southern Côte d'Ivoire (photo Didier Roguet); **C.** Well-developed inflorescence at pre-anthesis stage. South-west Ghana (photo Fred Stauffer); **D.** Infructescence bearing fruits at late stage of development. South-west Ghana (photo Fred Stauffer).



Fig. 28. Distribution of *Raphia palma-pinus* in Côte d'Ivoire, Ghana, Togo and Bénin.

ported in Senegal, Guinea, Gambia, Sierra Leone, Liberia, Côte d'Ivoire and Ghana (Stauffer et al. 2014). The presence of this palm in Mali and Burkina Faso has been reported by some authors; however, the lack of suitable growth conditions for the development of the palm in these countries does not support this statement and this is also confirmed by the lack of herbarium specimens of this palm attributed to Mali and Burkina Faso.

Specimens examined

CÔTE D'IVOIRE: Bas-Sassandra Region (Cavally Region): South-western region of the Taï National Park. Adjacent area to the village of Guirotoutou, trail departing from the Ecotel Touraco (OIPR), 05° 23' 46.5" N-07° 14' 45.52" W, 100-120 m, 12 June 2013, Stauffer et al. 857 (CSRS, G). **Agnéby Region (Agnéby-Tiassa Region):** Azaguié, 6 Juin 1966, Aké Assi 8915 (G). **Grands Ponts Region:** Department of Grand-Lahou, Azagny National Park, entering the park from the village of Irobo, 130 km west from Abidjan, 05° 13' 48,8" N-04°49' 35,1" W, 10 m, 26 November 2017, Stauffer et al. 895, 896 (CSRS, G)

GHANA: Central Region: Kakum National Park, 05° 21' 15.6" N-01° 22' 59.2" W, 152 m, 16 June 2011, Ouattara & Amponsah OD 12 (G); Kakum National Park, 05° 21' 19.7" N-01° 22' 58".1" W, 147 m, 17

June 2011, Ouattara & Amponsah OD 13 (G); Jukwa (Cape Coast), 15 May, 1958, Tomlinson s. n (GC); **Western Region:** Bonsaso, east of Tarquah, 28 April 1913, Chipps 428 (KUM); Ankasa F. R., 14 February 1921, Enti 42633 (GC); Beyin-Lake Amansuri Febr 22, 1965, Hall 2917 (CCG); Ankasa F. R., 05 January 1969, Hall & Enti 39164 (GC); Ankasa Forest Reserve, near Ankasa river, 4 March 1971, Moore & Enti 9889 (GC); Near akobra river, Axim, 29 March 1954, Morton A375 (GC); Ankasa Forest Reserve, 05° 15' 04.2" N-02° 38' 32.2" W, 76 m, 19 October 2011, Ouattara & Stauffer OD 29 (G).

13. *Raphia sudanica* A. Chev. Bull. Soc. Bot. France 55 (1908).

Syn.: *Raphia bandamensis* A. Chev., *Raphia heterostris* Becc., *Raphia humilis* A. Chev.

Tall, rarely acaulescent, hapaxanthic, monoecious palm. Stem 1-5 (-8) m long and 30 cm in diameter. Leaves 1.5-5 (8-12) m long, pinnate, erected; leaf-sheath 6-7 cm long and 10-12 cm wide; petiole of 4-10 (-20) cm long; rachis 1-4 m long, basal portion 2.5 cm wide, abaxially smooth, adaxially channeled, unarmed to slightly armed; if spines present 1-2 cm long, inserted in approximately 4 rows; leaflets 40-60 pairs, linear-lanceolate, with apex longly acuminate, alternating, margins and midrib densely armed with 2-5 mm long spines, the latter



Fig. 29. Morphological diversity in *Raphia sudanica*. **A.** Growth habit of at different stages of development. Central Côte d'Ivoire (photo Didier Roguet); **B.** Young individuals growing in a savanna riverine forest. Central Bénin (photo Loïc Michon).

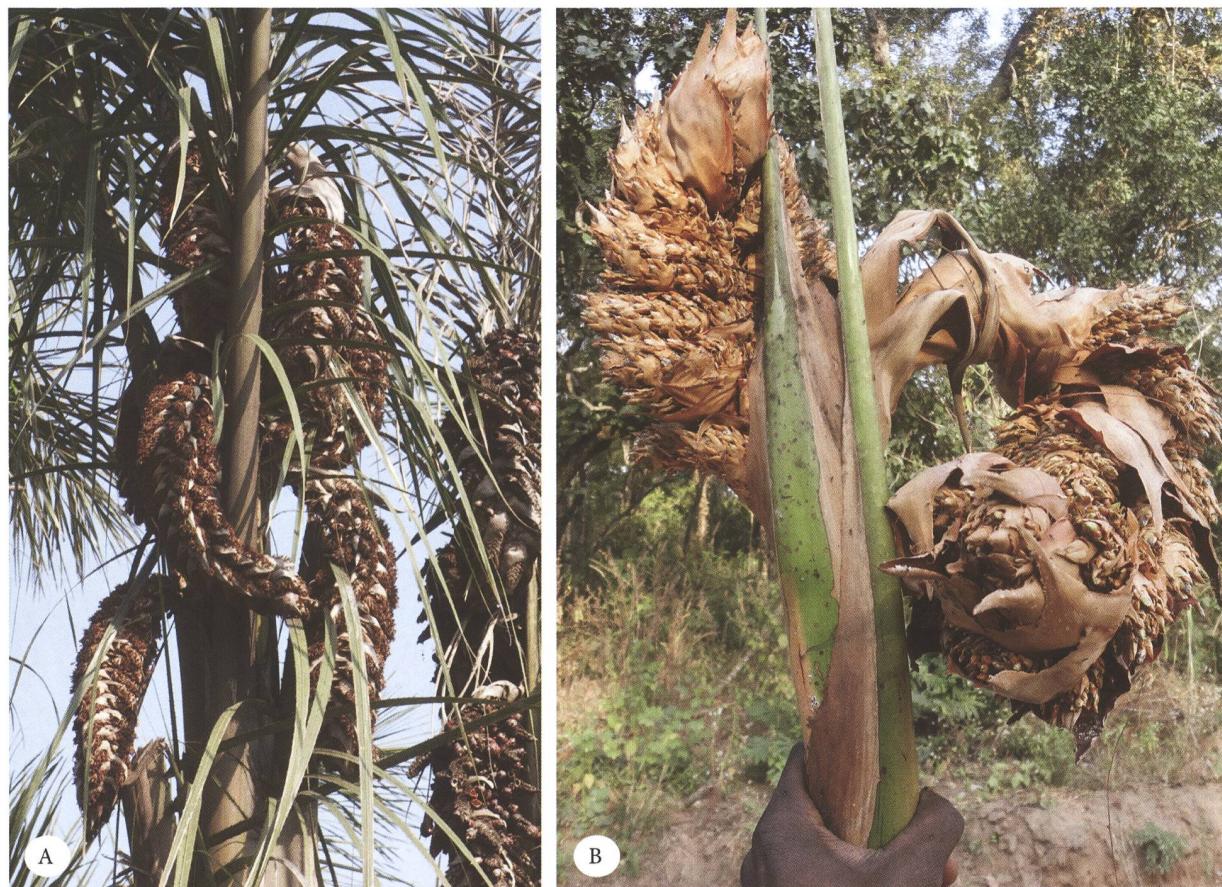


Fig. 30. Morphological diversity in *Raphia sudanica*. **A.** Individual at reproductive stage with multiple, relatively short and curved inflorescences, typical of this species. Central Bénin (photo Loïc Michon); **B.** Early developing inflorescences. Central Ghana (photo Doudjo Ouattara).

inserted every 1.5-2 cm; midrib prominent on the adaxial surface, inconspicuous secondary veins; basal leaflets 45-50 cm long and 1.5-1.9 cm wide, inserted every 3-4 cm, median leaflets 77-80 cm long and 2-2.5 cm wide, apical leaflets 20-45 cm long and 0.9-1.5 cm wide, inserted every 1.5 cm. *Inflorescence* 1-1.5 m long, unisexual, 2-order branched; prophyll papery and tubular, 10-15 cm long; peduncular bracts at least 6, tubular, 5-10 cm long; peduncle 35-40 cm long and 4 cm in diameter; rachis 0.4-1 m long and 5 cm wide, cylindrical in cross section; partial inflorescences 8-10 cm long and 6 cm wide, densely covered by 5-10 cm long and 6-6.5 cm wide, cartaceous bracts, the latter overlapping at the base, presenting two rows of rachillae; rachillae tight and short, 2-4 cm long, curved and terminated by a short tip, 2/3 of their length covered by bracteoles. *Staminate flowers*: sepals fused in a cup-shape structure, 1-2 mm long, greyish, completely enclosed by flower bracteoles, petals 1-2 cm long and 0.4 cm wide, brown, valvate, stamens 10-12. *Pistillate flowers*: sepals 1-2 mm long, with the cupular, similar to the ones of staminate flowers, 1-3 mm long; gynoecium syncarpous, 1-locular, stigma 2-2.5 cm long. *Fruits* 4.7-5 cm long and 2.9-3 cm in diameter, oblong-obvoid with 0.7-1 cm long and

0.3-0.5 cm wide apical stigmatic remains, the fruits densely covered by 1-2 cm long and 1-1.2 cm wide, rhomboidal scales; seed elongated, 3-4 cm long and 1.9-2 cm in diameter.

Taxonomic note: During his botanical expeditions in Guinea the French botanist and explorer Auguste Chevalier (1873-1956) collected this palm and described it as new to science in 1908. Two syntypes were cited in the protologue of this publication: Chevalier 12531 (P) and Chevalier 12867 (P). Our investigations in the herbarium of Paris (P) allowed us to locate these samples and following the recommendations of the International Code of Botanical Nomenclature (Mcneill et al. 2006) a lectotype has been designated (Ouattara et al. 2014). Perhaps due to its particular ecology this species has developed morphological and reproductive characteristics that allow a clear differentiation from other species of *Raphia*.

Distribution and ecology

Raphia sudanica is mainly distributed to low altitude, inland savannas, from Senegal to Cameroon (Stauffer et al. 2014). It grows frequently along small to mid-size streams, forming dense populations.

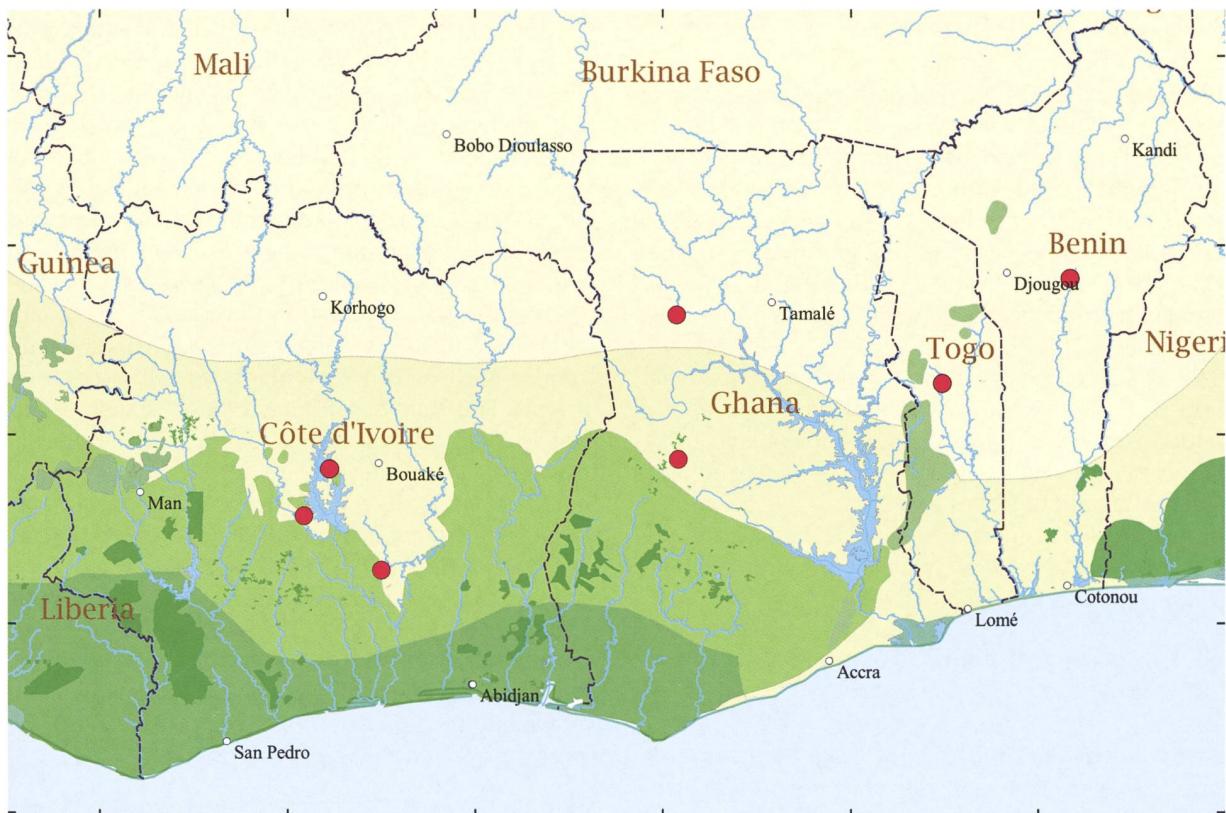


Fig. 31. Distribution of *Raphia sudanica* in Côte d'Ivoire, Ghana, Togo and Bénin.

Raphia sudanica is the only palm species strictly belonging to the so-called Soudano-zambezian area (Aké Assi 1995). It is a heliophilous palm but demanding in ground humidity.

■ Specimen examined

CÔTE D'IVOIRE: Lacs Region (District of Yamoussoukro): Yamoussoukro, N'Zéré, 06° 56' 15.21" N-05° 10' 23.88" W, 209 m, 25 July 2012, Da Giau & Ouattara SD005 (G); **Bélier Region:** 5 km au sud de Toumodi, 27 March 1989, Denise & Laurent Gautier-Beguin 1222 (CSRS); surroundings of the city of Toumodi, Bélier Region, in inundated plain. Forming dense populations at the entrance of the city, 06° 33' 37.36" N-05° 00' 02.40" W, 140 m, 03 December 2017, Stauffer et al. 900 (CSRS, G). **Marahoué Region:** Bouaflé, Zangoufla/Basiafla, 07° 08' 07.6" N-05° 49' 41.8" W, 198 m, 29 July 2012, Da Giau & Ouattara SD008 (G). **Zanzan Region (Bounkani Region):** Bouna, 05° 25' 47.74" N-07° 10' 14.05" W, 290 m, 28 June 2013, Da Giau et al. SD 038 (G, K, CSRS). **Haut-Sassandra Region:** Vavoua, 20 August 1966, Aké Assi 9115 (K).

GHANA: Ashanti Region: Wenchi, 08 August 1961, J. B. Hall 2040 (GC); N. W. Ashanti Region, May 1934, Irvine 2488 (GC). **Brong-Ahafo Region:** Sampa, 25 April 1958, Tomlinson s. n. (GC).

Northern Region: Mole Game Reserve, s. d., Hall & Houston 45030 (GC); A côté du Mole National Park, au bord de la rivière Baraa, non loin du village de Murugu, 09° 15' 37.7" N-01° 51' 02.2" W, 189 m, 23 November 2011, Ouattara OD 39 (G).

TOGO: «Near Sokodé», 08° 58' 41.71" N-01° 8' 38.22" E, December 1980, n. c. 7133 (TOGO); «Fosse aux Lions», 10° 27' 36.03" N- 00° 07' 11.99" E, December 1980, n. c. 7184 (TOGO); Baga, «depression à l'w», riverside (region II), 25 March 1987, Koumantega 224 (TOGO); on the left side of the road RN1, just before Atakpamé, 07° 30' 56.08" N-01° 09' 2.39" E, 08 June 2015, Michon 45 & 46 (G); on the right side of the road N14, between Tchamba and the **Bénin** border, 08° 58' 59.42" N-01° 29' 34.68" E, 10 June 2015, Michon 56 (G); on the right side of the road dir. Kabou from Kara, at the bridge level, 09° 28' 39.76" N-01° 6' 15.58" E, 13 June 2015, Michon 67 & 68 (G); on the right side of the road RN1, between Mango and Dapaong dir. Dapaong, 10° 36' 43.78" N-00° 14' 0.88" E, 15 June 2015, Michon 78 (G); around the village of Kouma-konda, near Kpalimé, 06° 57' 53.99" N-00° 34' 45.48" E, 18 June 2015, Michon 84 (G).

BÉNIN: ±5 km de piste étroite à gauche à partir de Hounkpogon (école), route Dassa-Cové direction Cové, 07.55826° N-002.19247° E, 23 November 2014, Michon 9 & 10 (G); Agoua, fields on the right of the road Dassa-Natitingou direction Natitingou, 08.31830° N, 001.94989° E, Michon 11, 12 & 13 (G).

Borassus L. Sp. pl. 1187 (1753).

Pleonanthic and dioecious palms; stems massive, solitary, frequently ventricose in the upper regions of the stem; leaves costapalmate; inflorescences strongly dimorphic and bearing unisexual flowers; fruits normally quite large, orange-green or yellow (*B. aethiopum*) or greenish (*B. akeassii*) when ripe, often 3-seeded. The identification of male and female individuals at vegetative stage is impossible.

This is an extremely valuable genus in West Africa; however intensive overexploitation of leaves and fruits over several years has been reported to severely reduce the periodicity of the flowering, and the production of leaves and fruits. One species (*B. aethiopum*) is reported in the studied region and the presence of *B. akeassii*, although arguably very possible, is still to be confirmed.

15. *Borassus aethiopum* Mart. Hist. Nat. Palm. 3: 221 (1838).

Syn.: *Borassus aethiopum* var. *bagamojense* Becc., *Borassus aethiopum* var. *senegalense* Becc., *Borassus deleb* Becc., *Borassus flabellifer* var. *aethiopum* (Mart.) Warb.

Tall, solitary, pleonanthic, dioecious palm. Stem 15-25 m long and 30-60 cm in diameter, strongly swollen (ventricose) in the upper regions of the stem, smooth, light to dark grey, at early stages of development and rarely in adult palms, the stem is densely covered by leaf sheaths. Leaves 25-40, 1.5-2.5 m long and 3-3.5 m wide, costapalmate, with induplicate segments; costa 37-65 cm long and 3-7 cm wide, indumentum present or not, if present concentrated on the abaxial face of the costa and basal segments at their points of insertion in the costa; leaf-sheath 10-15 cm long and 15-10 cm wide at the base, often divided to the mid-length; petiole 1.5-1.7 m long and 8-13 cm wide, convex abaxially slightly concave adaxially, blackish on the lower half towards the leaf-sheath and green on the upper half, margins blackish, bearing curved and sharp spines that disappear with age, sometimes presence of a green indumentum; spines if present 1.7-2.1 cm long and 0.6 cm wide, oriented in several directions, inserted each 2.1-4.6 cm; segments up to 100, apex entire, welded over a portion of 52-72 cm, basal segments 100-105 cm long and 5-5.2 cm wide, median segments 154-160 cm long and 8-9 cm wide, apical segments 140-162 cm long and 8-9 cm wide. *Staminate Inflorescence* 1-branched, curved; prophyll of at least 5-6 cm long; peduncular bracts tubular, tightly imbricate; peduncle cylindrical, 15-20 cm long and 3-5 cm in diameter; rachillae with a sterile portion of 33-35 cm long and 1.6-2.5 cm in diameter, circular in cross-section, a fertile portion of 46-48 cm long and 4-5.3 cm in diameter at the base and 3-3.5 cm wide at the apex, circular in cross-section, the fertile portion covered by 1-2 bracteoles, the latter 23-26 cm long, tubular at the base, open at the apex. *Flowers* scattered and solitary on the rachillae, perianth extremely reduced, stamens 6, yellow. *Pistillate inflorescence* 40-130 cm long and 4-8 cm in diameter, unbranched; prophyll similar to the one observed in the staminate inflorescence; peduncular bracts 5-6, 30-40 cm long and 2-4 cm in diameter, tubular and smooth with black vertical stripes on at least 10-15 cm of its length, open upwards; peduncle 55-62 cm long and 2-2.5 cm wide, circular in cross-section and enclosed by several bracts; rachillae 40-60 cm long, with an apex acute, densely covered by overlapping bracteoles. *Flowers* with three sepals and three petals, of similar shape (tepals) and gibbous in shape, coriaceous and persistent, buds 5 cm long and 5.3 cm in diameter, green, globular, spirally inserted each 4-4.5 cm. Fruit 9-15 cm long and 9-14 cm wide, globose to oblong, greenish in development and yellow-orange when ripe; seeds 3 or rarely only one developing.

The natural history of *Borassus aethiopum* Mart. starts with the French botanist Michel Adanson (1727-1806). Indeed, in 1750 Adanson first observed this palm in West tropical Africa, and more precisely in Senegal, where Ouolof populations called it as «Ronn», later becoming the common name of «rônier», widely used in West Africa to designate this palm.

Borassus aethiopum was for a long time regarded as the only species of the genus *Borassus* in Africa, but Aké Assi and Guinko (1996) suggested that another species or subspecies could be attributed to this genus. Their hypothesis was confirmed by the studies of Bayton et al. (2006) and Bayton (2007) who recognized another species (*Borassus akeassii* Bayton et al.), honouring the celebrated Côte d'Ivoire botanist Laurent Aké Assi, and pioneer of floristic studies in West Africa.

Distribution and ecology

The species is widely distributed in Africa, especially in countries covered with extensive savannas. This is the palm that dominates the landscape called «rônier savanna», where it can form dense populations called «rôneraies» in French speaking countries. In West Africa, the species is spread in Bénin, Burkina Faso, Côte d'Ivoire, Gambia, Guinea, Guinea Bissau, Liberia, Mali Nigeria, Senegal and Sierra Leone (Stauffer et al. 2014). For some authors the presence of the rônier in the southern savannas may be evidence



Fig. 32. Morphological diversity in *Borassus aethiopum*. **A.** Adult individuals cultivated in the Botanical Garden of the University of Accra, Ghana (photo Fred Stauffer); **B.** General aspect of the crown and ripe infructescences. Central Côte d'Ivoire (photo Doudjo Ouattara).



Fig. 33. Morphological diversity in *Borassus aethiopum* **A.** Costapalmate leaf blade abaxial view showing the costa; Doudjo Ouattara holding mature male inflorescences. East Ghana (photo Fred Stauffer); **B.** Ripe fruits. East Ghana (photo Fred Stauffer); **C.** Longitudinally sections ripe fruit. Central Togo (photo Loïc Michon).

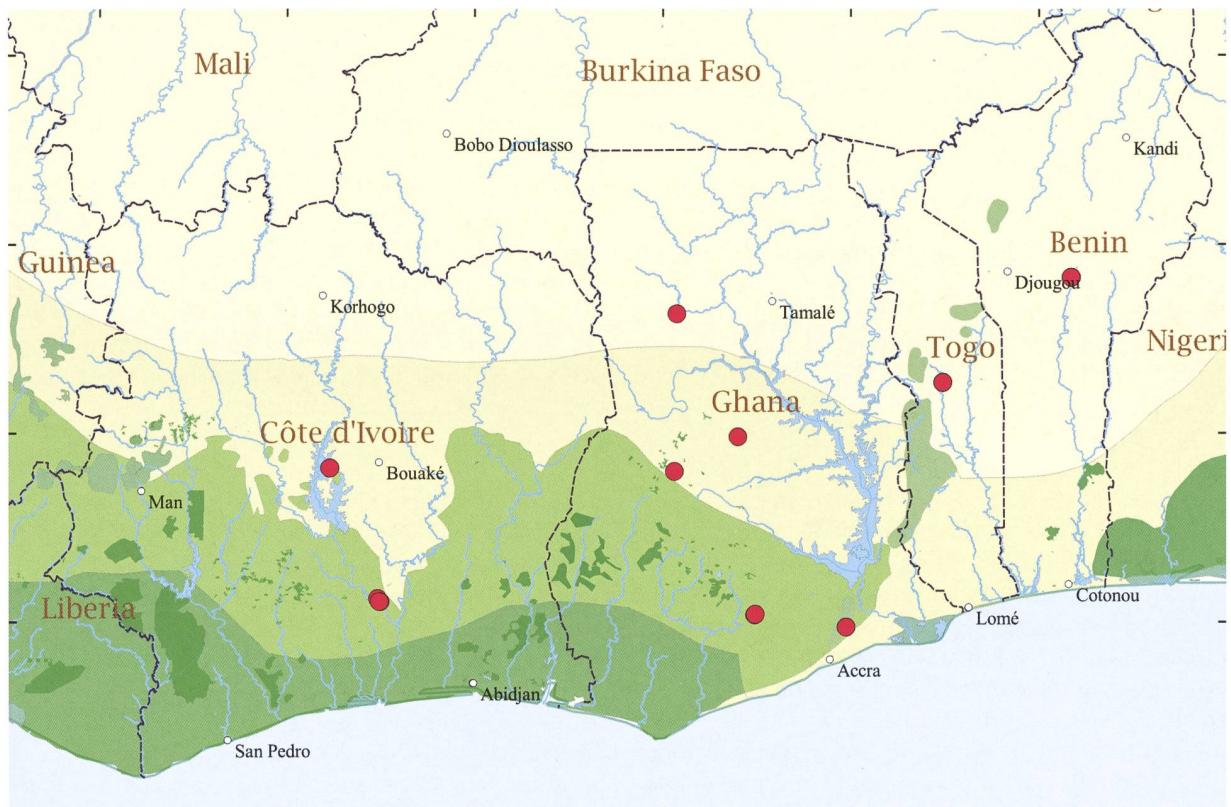


Fig. 34. Distribution of *Borassus aethiopum* in Côte d'Ivoire, Ghana, Togo and Bénin.

of ancient introductions. *Borassus aethiopum* is a plant indicator of soils with superficial water level, but it does not tolerate permanent flooded conditions. Baboons, among other animals, were identified as fruit dispersal agents of *Borassus aethiopum* (Lieberman *et al.* 1979). Thione (2000) identified in Senegal, several insects that potentially would facilitate the pollination of this species, the most important being Diptera (*Chrysomyia* sp., *Rhinia opicalis*), Hymenoptera (*Apis mellifica*, *Nomia* sp.) and Lepidoptera (*Eupista* sp.). According to this author, 73 % of the pollination of this species is assured by insects, whereas 23% is assured by the wind.

Specimens examined

CÔTE D'IVOIRE: Lagunes Region (Bélier Region): Zougoussi, 06° 14' 56.1" N-05° 02' 36.5" W, 127 m, 22 July 2012, Da Giau & Ouattara SD003 (G); village de Zougoussi, sur tas de sable à proximité du village, 15 September 1986, Denise & Laurent Gautier-Beguin 1284 (CSRS); **Agnéby-Tiassa Region:** Lamto, réserve de, bord de piste principale 06° 13' N-05° 02' W, 26 April 1989, Denise & Laurent Gautier-Beguin 1196 (CSRS); 16 April 1989, Denise & Laurent Gautier-Beguin 1197 (CSRS); Natural Reserve of Lamto, V-Baoulé Region, in direction to the village of Zougoussi. Savanna with patches of forest,

06° 13' 00.7" N-05° 01' 32.1" W, 123 m, 02 December 2017, Stauffer et al. 899 (CSRS, G).

GHANA: Ashanti Region: Ejura, 1921, Chipp 773 (K). **Brong-Ahafo Region:** **Brong-Ahafo**, 07° 39' 54" N-02° 06' 18" W; 350 m, 06 February 1995, C. C. Jongkind 2030 (WAG); entre Techiman et N'koranza, 07° 35' 36.7" N-01° 53' 02.9" W, 401 m, 23 May 2011, Ouattara et al. OD 4 (G); entre Techiman et N'koranza, 07° 35' 37.7" N-01° 53' 02.6" W, 406 m, 23 May 2011, Ouattara et al. OD 5 (G); entre Techiman et N'koranza, 07° 35' 36.7" N-01° 53' 02.9" W; 401 m, 23 May, 2011, Ouattara et al. OD 6. **Greater Accra Region:** Shai Hills Resource Reserve, 05° 56' 35.6" N-00° 03' 20.1" E, 64 m, 13 June 2011, Ouattara OD 11b (G); Accra, 1899, Sanders s. n. (K). **Northern Region:** Mole National Park, 09° 15' 43.3" N-01° 51' 21.2" W, 175 m, 23 October 2011, Ouattara OD 37 (G). **Volta Region:** Agbozume, 06° 04' 20.0" N-01° 01' 49.8" E, 17 m, 15 October 2011, Ouattara & Stauffer OD 21 (G); Agbozume, 06° 04' 44.7" N-01° 01' 27.1" E, 18 m, 15 October 2011, Ouattara & Stauffer OD 22 (G).

TOGO: Village of Agové, région maritime, 06° 29' 44.20" N-01° 35' 10.57" E, 97.5 m, 07 June 2015, Michon 34 (G); Village of Agové, on the right at the village exit, reg. Maritime, 06° 29' 7.40" N-01° 34' 45.66" E, 82.8 m, 07 June 2015, Michon 35 (G); on the village of Sotouboua, road RN1 between Atak-

pamé and Sokodé, 08° 05' 59.52" N-01° 08' 7.64" E, 274.1 m, 09 June 2015, Michon 48 (G); in the village of Bafilo, on the left side of the road RN1 dir. Kara 9° 18' 20.31" N-01° 14' 12.64" E, 741.8 m, 12 June 2015, Michon 64 (G).

BÉNIN: Savannah near Pahou, 6.384117N-2.212178 E, 28 January 1983, P. Hougnon 1502 (HNB); on «terre de barre» soil, Abomey-Calavi (Atlantique), 06° 27' 8.46" N-02° 20' 58.22" E, 16 September 1975, Hougnon 1502a (HNB); Savannah near Natitingou, 10° 17' 45.53" N-01° 22' 52.02" E, January 1985, s. c 3546 (HNB); Abomey-Calavi campus, 06° 25' 1.71" N-02° 20' 29.67" E, 01 November 1987, s. c 4158 (HNB); «Cotonou Agglomeration», 06° 21' 50.30" N-02° 23' 30.12" E, s. d, s. c (HNB); Between Savè and the toll, fields on the right 100 m before the toll, 8° 5' 34.54" N-02° 32' 11.43" E, 204 m, 22 November 2014, Michon 06 & 06bis (G); Between Savè and the toll, fields on the right 100 m before the toll, 08° 05' 34.54" N-02° 32' 11.43" E, 204 m, 22 November 2014, Michon 08 & 08bis (G); Fields on the right of the road Dassa-Natitingou direction Natitingou, 08° 46' 44.61" N-01° 38' 52.58" E, 362 m, 27 November 2014, Michon 14; Fields on the right of the road Dassa-Natitingou direction Natitingou, 08° 46' 44.61" N-01° 38' 52.58" E, 362 m, 27 November 2014, Michon 15; Sémé forest station, 06° 22' 47.028" N- 02° 37' 22.07" E, 25 m, 18 December 2014, Michon 21 (G); Cotonou, «route du bord de mer», on the right after Fidjrossè, 06° 21' 39.81" N-02° 22' 4.11" E, 3 m, 21 December 2014, Michon 25 (G).

■ Notes on *Borassus akeassii* Bayton, Ouédraogo & Guinko

This species has been more or less recently described and it has been frequently misidentified with the widespread *Borassus aethiopum*. Aké Assi & Guinko (1996) first described a West African palm slightly different from *B. aethiopum* and suggested some resemblances with *B. flabellifer*. Further studies on this palm were undertaken in Burkina Faso (Ouédraogo, 1999) and in 2004 Aké Assi and Guinko collected new samples in this country in order to better define its taxonomic identity. Most information issued from this field mission was used by Ross Bayton to propose a second species of *Borassus* for continental Africa: *B. akeassii* Bayton, Ouédraogo & Guinko (Bayton et al. 2006).

This palm can be distinguished from *B. aethiopum* by its glaucous and green leaves, weakly armed petioles and a particular secondary vein arrangement, the latter particularly conspicuous on the studies we made one the isotype of the species deposited in OUA, studied by us in 2018, as well as the holotype deposited at K and studied by us during early 2020. The

fruits of *B. akeassii* have a clearly oblong shape and a pointing apex, and they are green-purple when ripe. The pistillate flowers are arranged in three spirals on the rachillae, and the pollen has a reticulate tectum and a distinctive ornamentation (Bayton et al. 2006). Although *B. akeassii* is cited as present in Bénin by (Govaerts et al. 2021), we were not able to identify populations of this palm in any of our field trips in the northern regions of Côte d'Ivoire, Bénin and Togo, where it was most probably located. Although we have excluded this palm in our treatment, further field work may confirm its presence in the northernmost regions of the countries concerned by our study.

■ *Hyphaene* Gaertn., Fruct. Sem. Pl. 28 (1788).

Pleonanthic, dioecious palms; stems often massive and tall, basally clustered (twin stems), or solitary and aerially branched to 2-3 orders, leaves costapalmate; inflorescences dimorphic and bearing unisexual flowers, fruits oblong, pear-shaped or sometimes conspicuously polymorphic. The presence of branched stems in *Hyphaene thebaica* represents a unique character with respect to other members of the palm family in the countries covered by our study. This character has only been rarely observed in some populations of *Borassus aethiopum*; in this case most probably due to an artificial branching associated to a mechanical traumas of the stem or associated to a pathological damage of the apical meristem.

The genus includes approximately eight species distributed in the more or less dry zones of Continental Africa, Madagascar, on the coast of the Red Sea and the Gulf of Eilat, in Arabia and on the north -west of India (Dransfield et al. 2008; Stauffer et al. 2018). In the studied region the species of *Hyphaene* grow in in-land and coastal savannas, often associated with dry or semi-arid soils but where groundwater is available throughout the year. Most of the species are used by local inhabitants and the original distribution of the palm may be largely influenced by accidental or voluntary introductions (Dransfield 1986). *Hyphaene thebaica* and *H. guineensis* have been collected in the studied region and the presence of *H. macrocarpa*, proposed by some authors (i. e. Govaerts et al. 2021), requires further confirmation.

■ Identification key of the species

Stem always branched, (3-)8-15 m in height and 30-45 cm in diameter; petiole bearing thin spines on the margins; fruits (4-) 5-6 cm long, 4-5 cm in wide, highly variable in shape and size (shouldered, asymmetrical, oblong-ovoid, obovoid, rarely ovoid, usually pear-shaped)

Hyphaene thebaica



Fig. 35. Morphological diversity in *Borassus akeassii*. **A.** Growth habit. Casamance, Senegal (photo Didier Roguet); **B.** Detail of a young individual cultivated at the campus of the University of Ouagadougou, Fred Stauffer and Amadé Ouedraogo standing in front of the palm. Ouagadougou. Burkina Faso (photo Fred Stauffer); **C.** Detail of leaf crown and almost ripe infructescences. South-west of Burkina Faso (photo Amadé Ouedraogo).

Stem solitary or 2-3 stems apparently growing from the same seed, 3-12 m tall and up to 30-40 (-50) cm in diameter; petioles bearing robust spines on the margins; fruits 6-7.5 cm in length and 6-7 (-10) cm wide, usually pear-shaped, with two conspicuous protrusions near the base

H. guineensis

16. *Hyphaene guineensis* Schumach. & Thonn., *Beskr. Guin. Pl.*: 445 (1827)

Syn.: *Hyphaene depressa* Becc., *Hyphaene doreyi* Furtado, *Hyphaene grossweileri* Furtado, *Hyphaene luandensis* Gosswe., *Hyphaene mateba* Becc., *Hyphaene nephrocarpa* Becc., *Hyphaene welwitschii* Furtado.

Tall, solitary, tall, armed, unbranched, pleonanthic, dioecious palm. Stem erect, solitary or 2-3 stems apparently growing from the same seed, 3-12 m tall and up to 30-40 (-50) cm in diameter, grey, young individuals often covered with remnant leaf sheaths whereas the aged palms present naked stems and the leaf sheaths leaving conspicuous ring. Leaves (13-) 30-40 per crown, costapalmate, up to 1.8 m long, spirally arranged, green, dark green-bluish, the blade covered with small brown dots becoming darker when the leaf dries; leaf sheath up to 25 cm long, 10-15 cm in width, brown, with a triangular cleft at the base, margins fibrous, armed from the middle with robust, triangular, upward pointing black spines; petiole (0.5-)1-2 m long and 4-6 cm in width, green-yellowish to light orange, covered with a brown-cream indumentum, when present densely present between the petiole spines, slightly channelled or flattened adaxially and abaxially convex, then dorso-ventrally compressed in cross-section, margins armed with robust, triangular, reflexed or upward pointing black spines, 0.8-2 cm long and 0.5-0.8 cm wide at the base, the latter with different shapes and distanced 1-3 cm; costa 45-70 cm long and up to 3 cm wide at the base, strongly recurved, light green, smooth, covered with a light-brown indumentum; leaf blade up to 110 cm long and 80 cm wide, divided at 1/3 of its length into 45-62 (-70) regular, induplicate segments, basal segments 40-85 cm long, 1.3-2.5 (-3) cm wide, middle segments 80-110 (-125) cm long, (2-)5-7 cm wide, apical segments up to 0.7-1.2 m long and up to (1-) 4-6 cm wide, each segment single-folded and with a 4 cm long, slightly bifid apex, black interfold filaments up to 48 cm long; brown, light and smooth indumentum at the base of the leaf blade and along the ribs, especially on young leaves, becoming caduceous in old leaves. Inflorescences interfoliar, unisexual, pistillate and staminate inflorescences barely similar, erect; staminate inflorescence up to 120 cm long, erect then slightly pendulous towards the end of

anthesis; prophyll tubular, 36 cm long towards the apex, covered with a brownish indumentum; peduncle 10-30 cm long and 2-3 cm in diameter, elliptical in cross section; peduncular bracts 3, tubular, 45-50 cm long, usually covered with a red-brownish indumentum; peduncle 15-20 cm long and 2-3 cm in diameter, circular in cross section; rachis 50-60 cm long, 1-1.5 cm in diameter, circular in cross-section, covered throughout its length by the peduncular bracts; rachillae (3-) 5-12, catkin-like, up to 25 cm long and 1-1.5 cm in cross-section, sterile part of 20-22 cm, fertile part of 40-50 cm long, 1 cm wide, circular in cross sections, inserted in clusters of 3-5 rachillae emerging from the same point of the main rachis; rachillae bracts 6 mm long, spirally arranged, striate, connate laterally and partially adnate to the rachilla and originating pits, spirally arranged on the rachilla, each pit containing 3 flowers arranged in a cincinnus; pistillate inflorescences 5-6 growing simultaneously, branching to 2 orders, up to 1,1 m long, morphologically similar to the male inflorescence; peduncle 35-50 cm long, 2-3 cm in diameter, circular to elliptical in cross section; prophyll 35 cm long; peduncular bracts 7, up to 42 cm long, tubular, covered with a brown-reddish indumentum; rachis 0.7-1 m long, (1-) 2-4 cm in diameter, elliptical in cross section; at least one bract attached to the peduncle, 26 cm long, 6 cm wide, covered with a wholly indumentum; rachillae 4-6, solitary, rarely in pairs, alternating in the rachis; sterile part 20-30 cm long, 1 cm wide, adaxially concave, fertile part 16-40 cm long and 1,1-2 cm in diameter, slightly circular in cross section, with a sterile and pointed apex of 1 cm long; each rachilla subtended by a bract similar to the ones observed in the staminate inflorescence, densely hairy, each pit containing a single flower, larger than the male flower. Flowers unisexual, 3-merous; staminate flowers borne in a cincinnus of 3 flowers, one flower emerging at a time, arranged in more or less 8 parallel rows, slightly displaying a basipetal anthetic pattern, yellow, scentless, subtended by a minute, membranous bracteole; calyx tubular at the base, lobes 3, acute, elongated; corolla with a stalk-like base, lobes 3, ovate, hooded, valvate, striate; stamens 6, inserted at the base of the corolla, filaments with a swollen base, anthers medifixed, versatile, latrorse to introrse; pistillode 3-lobed, minute. Pistillate flowers borne solitary in each pit, subtended by a membranous bracteole, supported by a short, thick, densely hairy pedicel; sepals 3, distinct, triangular-rounded, imbricate, striate; petals 3, similar to the sepals but more flexible; staminodes 6, fused in an epipetalous ring, sagittated, flattened, with undeveloped and empty anthers; gynoecium globose, carpels 3. Fruits 1-seeded, 6-7.5 cm in length and 6-7 (-10) cm wide, usually pear-shaped, with two conspicuous protrusions near the base, borne on a well-differentiated pedicel



Fig. 36. Morphological diversity in *Hyphaene guineensis*. **A.** Twin stem growth habit of an adult individual. South-East Ghana (photo Fred Stauffer); **B.** Detail of leaf blade. Note the strongly curved costa in the abaxial side. South-East Ghana (photo Doudjo Ouattara); **C.** Detail of male rachillae showing male flowers at full anthesis. South-East Ghana (photo Fred Stauffer); **D.** Detail of male rachillae showing male flowers at different stages of development. Note the asynchronous development of flowers. South-East Ghana (photo Fred Stauffer).

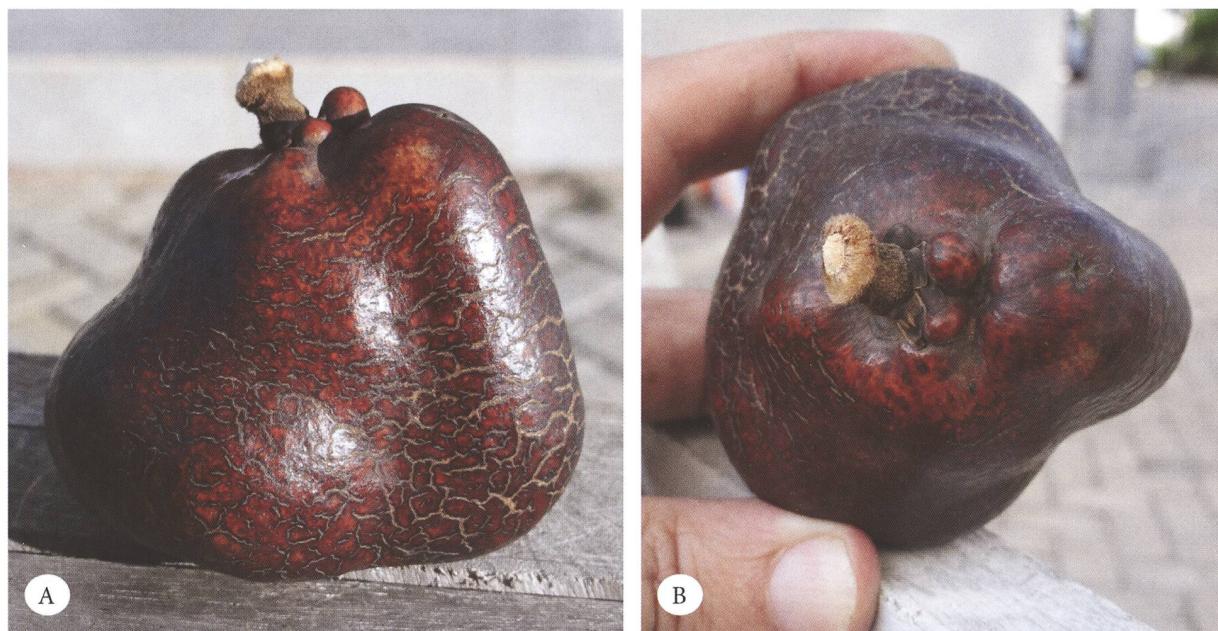


Fig. 37. Morphological diversity in *Hyphaene guineensis*. **A.** Detail of ripe fruit in lateral view. Note pronounced pear-shape morphology of the fruit and sterile carpels in the basal region. South-East Ghana (photo Fred Stauffer); **B.** Detail of ripe fruit in upper view. Note the sterile carpels in the basal region. South-East Ghana (photo Fred Stauffer).

up to 6-8 mm long, basal stigmatic remains; epicarp olive-green in young fruits, red to brown or dark-brown when ripe, smooth, shiny, waxy, often with the presence of small dots; mesocarp fibrous, up to 8 mm thick, sweet; endocarp well developed. Seeds 3.2 cm long, 2.9 cm wide, endosperm white; eophyll linear, lanceolate, plicate.

Hyphaene guineensis Schumach. & Thonn. was first collected by Peter Thonning (1775-1848) when exploring the coastal savannas of Ghana between 1799 and 1803 in the frame of the supervision of several plantations settled by the Danish crown (Furtado 1967, 1970). The type specimen of this palm (Thonning 332) was deposited in the herbarium in Copenhagen in Denmark and destroyed during the bombardment of the city in 1807 by the English army. A specimen collected in Ghana (Colonial & Indian Exhibition K-92) was later designated as the neotype of *H. guineensis* (Furtado 1970; Van Valkenburg and Dransfield, 2004). Our studies in the studied region confirm that *Hyphaene guineensis* and *H. thebaica* are completely allopatric and do not share the same ecological requirements.

Distribution and ecology

This species has been reported in West Africa (Benin, Ghana, Guinea Bissau, Guinea, Togo, and its absence in Côte d'Ivoire may be due to the destruction of its natural habitats and overexploitation of the palm populations due to the useful leaves. In

Central Africa it is present in Gabon, Congo, Democratic Republic of the Congo and also reported for Angola (Van Valkenburg and Dransfield 2004; Mbandu Luzolawo et al. 2020; Govaerts et al. 2021). In the studied area the species is particularly represented in the coastal savannas from Tema in Ghana, with dense populations in the region of Agbozume, up to south-western Togo. The palm is present in areas with superficial groundwater but apparently does not support permanently flooded soils.

Specimens examined

GHANA: Greater Accra Region: Accra plains, 05° 52' 06" N-00° 13' 12" E, 100 m, 14 February 1995, C. C. Jongkind & D. K. Abbiw 2041 (WAG); Accra, near Prampram, 05° 43' 0" N-00° 07' 18" E, 20 m, 25 February 1995, C. C. Jongkind & D. K. Abbiw 2055 (WAG); Ghana, loc. incert., 1886, Colonial & Indian Exhibition 92 (K); Tema paradise beach, 08 May 1968, Hosain 37578 (GC). **Volta Region:** Sonuto near Agbozume, 02 June 1968, Hossain & Enti 38676 (GC); Agbozume, 06° 5' 16.1" N-01° 01' 50.9" E, 22 m, 15 October 2011, Ouattara, D & Stauffer OD 23 (G); Agbozume, 06° 05' 54.2" N-01° 02' 21.7" E, 29 m, 15 October 2011, Ouattara & Stauffer OD 24 (G); Agbozume, 06° 04' 45.2" N-01° 01' 27.6" E, 16 m, 15 October 2011, Ouattara & Stauffer OD 25a (G); Agbozume, 06° 04' 45.2" N-01° 01' 27.6" E, 16 m, 15 October 2011, Ouattara & Stauffer OD 25b (G), 06° 04' 45.2" N-01° 01' 27.6" E, 16 m; Lower Volta Agbozume District, at Sonuto near Keta lagoon, s. d.



Fig. 38. Distribution of *Hyphaene guineensis* in Côte d'Ivoire, Ghana, Togo and Bénin.

Quartey & Ayittey 37579 (GC); District of Ketu Senthé, Glevime, Village of Bosokakorpe, 06° 01' 45.68" N- 00° 48' 1.15" E, 14 May 2015, Stauffer et al. 862 (G, GC); District of Ketu Senthé, Glevime, Village of Bosokakorpe, 06° 01' 47.28" N- 00° 48' 2.15" E, 14 May 2015, Stauffer et al. 863 (G, GC); Village of Agbozume, near housing in the Eastern borders of the village, former savanna now replaced by housing, 06° 5' 15.58" N-01° 1' 51.96" E, 15 May 2015, Stauffer et al. 864 (G, GC); Village of Agbozume, near housing in the Eastern borders of the village, 06° 5' 15.58" N-01° 1' 51.96" E, 15 May 2015, Stauffer et al. 865 (G, GC); 2 km East from the village of Agbozume, 06° 7' 6.97" N-01° 2' 49.14" E, 15 May 2015, Stauffer et al. 866 (G, GC)

TOGO: on the left side of the road Lomé-Aného, 6° 12' 26.13" N-01° 28' 0.56" E, 06 June 2015, Michon 27, 28 (G); on the left side of the road Lomé-Aného, 06° 12' 26.13" N-01° 28' 0.56" E, 21 June 2015, Michon 92 (G).

17. *Hyphaene thebaica* (L.) Mart., Hist. Nat. Palm. 3: 226 (1838) (Figs. 39A-B, 40A-B, 41A-B).

Syn.: *Chamaeriphe crinita* (Gaertn.) Kuntze, *Chamaeriphe thebaica* (L.) Kuntze, *Corypha thebaica* L., *Cucifera thebaica* (L.) Delile, *Douma thebaica* (L.) Poir., *Hyphaene baikieana* Furtado, *Hyphaene crinita* Gaertn., *Hyphaene dahomeen-*

sis Becc., *Hyphaene dankaliensis* Becc., *Hyphaene macrosperma* H. Wendl., *Hyphaene nodularia* Becc., *Hyphaene occidentalis* Becc., *Hyphaene santoana* Furtado, *Hyphaene sinaitica* Furtado, *Hyphaene togœnsis* Dammer & Becc., *Hyphaene tuleyana* Furtado, *Palma thebaica* (L.) Jacq.

Tall, solitary or forming clumps of (3-) 5-7 stems almost emerging from the same point and at different stages of development, armed, pleonanthic, dioecious palm. *Stem* (3-) 8-15 m in height and 30-45 cm in diameter, branched to 1-4-order dichotomies, with the first one appearing (1.7-) 2.5-4 (-6) m above ground, producing up to 16 leaf crowns; the stem covered or not with remnant leaf sheaths which fall off in aged individuals, grey, leaving conspicuous, 1-3 cm thick ring scars when young, then the scars becoming closer in older individuals. *Leaves* (8-) 10-18 (-25) per crown, costapalmate, spirally arranged, dark green to bluish; leaf sheath 24-30 cm long, 16-20 cm wide, grey-brown, with a triangular cleft at the base, often remaining below the leaf crown or throughout the length of the stem in young individuals, margins fibrous, armed from the mid-length with robust, triangular, upward pointing black spines; petiole (0.5-) 1-2 m long, (2-) 5-10 cm wide at the base and 3-4 cm at mid-length, green-grey to black, at the base adaxially channelled and abaxially rounded, towards the apex dorso-ventrally compressed in cross-section, margins armed with



Fig. 39. Morphological diversity in *Hyphaene thebaica*. **A.** Growth habit of an adult individual growing in a corn field. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau); **B.** Detail of leaf blade showing the strongly recurved costa and the heavily armed petiole margins. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau).

robust, triangular, reflexed or upward pointing black spines, up to 2 cm long and 0.8-1 cm wide at the base, displaying different shapes; hastula 1.5-6 cm long, green, with slightly black margins; costa (30-) 40-60 cm long and 1.5-2.2 cm in width, light green, smooth, conspicuously recurved, triangular in cross-section; leaf blade olive-green, 1-2 m long, showing small brown dots becoming darker when the leaf dries, divided at 1/3 of its length into (32-)50-60 regular segments, main veins prominent on the abaxial side, basal segments 30-50(-70) cm long and 1.5- 2.5(-4) cm wide, middle segments 50-60 (-90) cm long and (2.5-) 5-7 cm wide, apical segments 35-50(-60) cm long and 1.5-4.5(-6) cm wide, single-folded, with a slightly bifid apex up to 4-7 cm long, presence of interfold filaments between segments of up to 60 cm long, a brown, light and smooth indumentum present at the base of the leaf blade and encompassing the mid veins, especially on young leaves, and becoming caduceus on aged leaves. *Inflorescences* unisexual, interfoliar, pistillate and staminate inflorescences similar. Staminate inflorescence 1-branched, 5-6 on the same individual, 1.2-2 m long, digitate, erect at juvenile stage and becoming pendent at anthesis; peduncle (20-)30-50 cm long and (1.5-)3-4 cm, dorsoventrally compressed; prophyll tubular, eventually appearing

dorso-ventrally compressed, opening apically as a lanceolate projection; peduncular bracts up to 16, basal bracts 28-30 cm long and 4-5 cm wide, medial bracts 12-15 cm long and 3-4 cm wide, apical bracts 6-10 cm long and 1-2 cm wide; rachis 30-60 cm long, 1.5-2 cm wide; rachillae (2-) 4-6, catkin-like (ending in 4 apical segments), up to 45 cm long, sterile part of 27 cm and the fertile one up to 17 cm long; rachillae bracts 7-8 mm long and 2-3 mm wide, spirally arranged, striate, connate laterally and partially adnate to the rachilla, subtending pits containing 3 flowers arranged in a cincinnus. Pistillate inflorescence 1-branched, 5 on the same individual, (0.4-) 1-15 m long, peduncle 17-45 cm long, 1-1.5 cm in diameter, prophyll 20-25 cm long, apically opening with two longitudinal slits, coriaceous, brown, with a spongy indumentum towards the apex, peduncular bracts 3-5, smooth, similar to the prophyll, rachis 40-48(-60) cm long, rachillae 5-8, catkin-like (ending in 3-5 apical segments); basal rachillae with a sterile part of 19 cm and a fertile part of 20 cm, middle rachillae with a sterile part of 20 cm and a fertile part of 20-21 cm, apical rachillae with a sterile part of 20 cm and a fertile part of 23 cm; rachillae bracts resembling the ones of the male inflorescence, densely hairy, each pit containing a single flower, clearly larger than the male flower. *Flowers* unisexual,



Fig. 40. Morphological diversity in *Hyphaene thebaica*. **A.** Abundant male inflorescences of at early stage of development emerging from the leaf sheaths. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau); **B.** Female inflorescences at early bud stage. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau).



Fig. 41. Morphological diversity in *Hyphaene thebaica*. **A.** Fruits of at very early stage of development. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau); **B.** Ripe infructescences emerging from the leaf axes. North of Côte d'Ivoire (photo Doudjo Ouattara and Simona Da Giau).

3-merous. Staminate flowers borne in a cincinnus of 3 flowers, one flower emerging at a time, subtended by a minute, membranous, green bracteole; calyx basally tubular, apically with 3 acute, elongated lobes; corolla with a stalk-like base, valvate, lobes 3, ovate, hooded, striate; stamens 6, connate at the base to the corolla, filaments with a swollen base, anthers medifixed, versatile, latrorse to introrse; pistillode 3-lobed, minute. Pistillate flowers larger than staminate, borne solitary in each pit, subtended by a membranous bracteole, supported by a short, thick, densely hairy pedicel; sepals 3, distinct, triangular-rounded, imbricate, striate; petals 3, similar to the sepals but more flexible; staminodes 6, fused in an epipetalous ring, sagittated, flattened, anthers undifferentiated; gynoecium globose, 3-carpellate, 3-ovulated but only reaching maturity. *Fruits* 1-seeded, (4-) 5-6 cm long, 4-5 cm in wide, highly variable in shape and size (shouldered, asymmetrical, oblong-ovoid, obovoid, rarely ovoid, usually pear-shaped), borne on a 6-8 mm long pedicel, basal stigmatic remains; epicarp ranging from orange, red to brown or dark-brown in ripe fruits, smooth, shiny, waxy, often presence of small dots; reduced sterile carpels (1-2) usually visible towards the base of the fruit; mesocarp conspicuously fibrous, up to 8 mm

thick, sweet; endocarp well developed. Seeds as diversely shaped as the fruits, basally attached, endosperm white, with a coconut flavour when young, with a central hollow cavity when ripe; germination remote-tubular, cotyledonary petiole buried up to 80 cm underground; eophyll linear-lanceolate, pli-cate.

This emblematic palm has been extensively described by many authors (Hutchinson and Dalziel 1936; Dalziel 1937; Irvine 1961; Tuley 1995; Burkil, 1997). However, as already indicated by some authors its aerially branched growth habit remains an important source of taxonomic confusion. Indeed, there is a generalized tendency to identify as *Hyphaene thebaica* any palm displaying a branched stem, independently of its origin. Aerial branching is nowadays also recognized in other species of *Hyphaene* (*H. compressa*, *H. dichotoma*), none of them present in West Africa. Another important source of taxonomic confusion in *H. thebaica* is associated to the highly polymorphic fruits, the latter leading to a proliferation of superfluous descriptions of the species and nowadays represented by more than 17 synonyms.

Distribution and ecology

The distribution of *Hyphaene thebaica* remains incompletely known and is somehow also intriguing. This may be due to the fact that all organs of the palm are extremely useful and local populations may bring their seeds when they move from one region to another, often also crossing country borders. The palm has been reported in the Sahelian countries (Burkina Faso, Mali, Niger, Tchad) and in West African countries present in northern Côte d'Ivoire, Ghana, and Senegal). This palm is also present in Cameroon, Somalia, Sudan and Ethiopia (Tuley 1995; Arbonier 2009, Hedberg et al. 2009; Darbyshire et al. 2014); its presence in Angola needs to be confirmed (Baker 2008). The species has been also reported in Madagascar (Dransfield and Beentje (1995) and in the Red Sea region, and the coasts of the Gulf of Eilat, Arabia (Dransfield et al. 2008). *H. thebaica* is well-adapted to the dry climates of the Sahel and the Sudanese savannas; it is often associated to well drained, sandy and also often salty soils, where the water table is relatively superficial. According to Jahiel (1993) the palm also tolerates seasonally flooded conditions.

Specimens examined

CÔTE D'IVOIRE: Zanzan Region (Bounkani Region)

Bouna, Assoum 1 village, 09° 12' 55.44"

N-03° 8' 22.70" W, 289 m, 28 August 2013, Da Giau et. al SD036 (CSRS, G, K); Bouna, 07° 10' 14.05" N-05° 25' 47.74" W, 291 m, 28 August 2013, Da Giau et. al SD037 (CSRS, G, K).

GHANA: Upper East Region: Talensi-Nabdam District, Bolgatanga-Kongo road, open savannah grassland, interspersed with cultivated fields along roadside, 10° 49.84' N-0° 43.77' W, 14 December 2005, Ekpe P., J. Amponsah, F. Chimsah, J. Baba SH 418 (GC); Bolgatanga, dans un champ de mil, 10° 48' 58.9" N-00° 49' 57.3" W, 230 m, 29 October 2011, Ouattara OD 38 (G).

TOGO: Kabiye, March 1974, « licence student », n. n. (TOGO); on the right side of the road Lomé-Aného, 06° 12' 26.13" N-01° 28' 0.56" E, 06 June 2014, Michon 27 & 28 (G); on the left side of the road RN1 before Notsé, reg. Plateau, 06° 49' 5.87" N-01° 10' 51.95" E, 08 June 2014, Michon 37&38 (G); Notsé, reg. Plateau, 06° 57' 11.21" N-01° 10' 17.29" E, 08 June 2014, Michon 39 (G); Village Rodokpe, on the road RN1, between Tsévié and Gleï, 07° 02' 45.2112" N-01° 9' 21.80" E, 08 June 2014, Michon 40 (G); on the left side of the road RN1, between Ayengre and Sokodé, 08° 40' 46.68" N-01° 1' 31.49" E, 09 June 2014, Michon 50 & 51 (G); on the left side of the road N17, between Sokodé and Bassari, 09° 15' 9.81" N-00° 47' 21.37" E, 11 June 2014, Michon 61 (G); Village of Bassar, on the right side of the road N17, 09° 15' 9.81" N-00° 47'



Fig. 42. Distribution of *Hyphaene thebaica* in Côte d'Ivoire, Ghana, Togo and Bénin.

21.37" E, 11 June 2014, Michon 62 (G); on the left side of the road N17, between Sokodé and Bassari, 09° 1' 16.36" N-01° 6' 44.71" E, 11 June 2014, Michon 63 (G); in the village of Bafilo, on the left side of the road RN1 dir. Kara, 09° 18' 20.31" N-01° 14' 12.64" E, 12 June 2014, Michon 65 (G); on the left side of the road RN1 between Niamtougou and Kandé, 09° 55' 58.58" N-01° 5' 39.87" E, 15 June 2014, Michon 72 (G); Dapaong, 10° 52' 31.60" N-00° 12' 8.14" E, 16 June 2014, Michon 81 (G); on the right side of the road Lomé-Aného 06° 12' 26.13" N-01° 28' 0.56" E, 21 June 2014, Michon 92 (G); Kodjola (zone II), 1984, Takeda, 14 (TOGO).

BÉNIN: Savannah near Natitingou, 10° 17' 45.75" N-01° 22' 51.26" E, January 1985, n. c., 3547 (BÉNIN); «Concession Natitingou», 29 June 1989, n. c., 5073, (BÉNIN); Adjiro. Small village on the right of the road Dassa-Djougou-Natitingou, 08° 55' 5.77" N-01° 38' 20.25" E, 27 November 2014, Michon 16 & 17 (G); On the left side of the road Tanguiéta-Burkina Faso, few km after Tanguiéta, 10° 42' 49.60" N-01° 12' 50.39" E, 28 November 2014, Michon 18 (G); Séché forest station, 06° 22' 47.02" N-02° 37' 22.07" E, 09 December 2014, Michon 19 & 20 (G); Séché forest station, 06° 22' 47.02" N-02° 37' 22.07" E, 08 December 2014, Michon 22 & 23 (G).

Notes on *Hyphaene macroisperma* H. Wendl.

The species *H. macroisperma* H. Wendl. is taxonomically accepted and reported as endemic to Bénin (Govaerts et al. 2021). The original description of this palm was proposed by the celebrated German botanists H. Wendland (1881) based on a single fruit. Wendland indicated that the original material was collected in «Central Afrika» by Mr. Baiki. We suppose that he meant William Balfour Baikie (1825-1864), a Scottish explorer who visited the river Niger and many of its tributaries in at least two different expeditions. According to Wendland's original description of the species, the fruit is ovate to rather obtuse, very flat at the top, slightly swollen on the ventral side, 7 cm long and 6 cm in diameter, resembling that of *H. thebaica* but more round in shape, and more obtuse and duller in color. The seed was described as round to ovoid, 45 mm long and 40 x 45 mm in diameter. The Florentine botanist Odoardo Beccari (1908) indicated that he studied the type specimen proposed by Wendland and compared it with its original descriptions. He noticed that it did match well with the descriptions of *Hyphaene dahoemeensis* Becc., which has been proposed by several authors (i. e. Tuley 1995; Stauffer et al. 2014; Govaerts et al. 2021) as a synonym of *H. thebaica*.

Although previous reports indicate that the species is endemic to Bénin, its origin should be further

verified as it may be also attributed to Nigeria. Additional information on this intriguing species may be found in any of the travel reports produced by Baikie. The ecology of this species remains unknown and no information was provided in its original description. In the frame of our palm inventories in Bénin and Togo during 2015-2016 we were not able to identify this palm and the only populations of this genus that were spotted in the northern regions of these countries correspond to *H. thebaica*. Indeed, we cannot rule out that *H. macroisperma*, long-time regarded as an independent, yet poorly known taxonomic entity, could be rather interpreted as a morphologic variant of the widely distributed *H. thebaica*. Waiting for further evidence of its presence in the studied countries we have decided to exclude this taxon from the current treatment.

***Phoenix* L., Sp. pl. 1188 (1753).**

Pleonanthic, dioecious palms. Stems forming dense clumps, dwarf to mid-size, rarely very tall; leaves regularly pinnate; leaf-sheath fibrous, often persistent on the stem, leaflets induplicate, basal leaflets modified in longspines; inflorescences interfoliar, subtended only by a prophyll; flowers unisexual; fruits 1-seeded.

This genus is composed of 14 species, most of them present in Asia (Dransfield et al. 2008), one species endemic to the Canary Islands (*P. canariensis* H. Wildprecht) and one species restricted to Cape Vert Islands (*P. atlantica* A. Chev.). Only *Phoenix reclinata* Jacq. is present in the studied area. The date palm (*Phoenix dactylifera* L.) is usually cultivated in the countries visited, mainly due to its economic importance or for its ornamental value.

18. *Phoenix reclinata* Jacq. Fragm. 1: 27 (1801).

Syn.: *Phoenix abyssinica* Drude, *Phoenix baoulensis* A. Chev., *Phoenix djalonensis* A. Chev., *Phoenix dybowskii* A. Chev., *Phoenix comorensis* Becc., *Phoenix equinoxialis* Bojer, *Phoenix spinosa* Schumach. & Thonn., *Phoenix leonensis* Lodd. & Kunth, *Phoenix reclinata* var. *comorensis* (Becc.) Jum. & H. Perrier, *Phoenix reclinata* var. *madasgascarensis* Becc., *Phoenix reclinata* var. *somalensis* Becc.

Tall, rarely acaulescent, clustered or solitary, dioecious palm. Stem 2-8 m in height and 20-25 cm in diameter, straight, sometimes decumbent, with remnant leaf-sheaths in some areas of the stem. Leaves pinnate, 1-3 m long; leaf-sheath with fibrous margins; petiole 15-17 cm long and 3.5-4.5 cm wide, flattened, green,



Fig. 43. Morphological diversity in *Phoenix reclinata*. **A.** Growth habit of in inland savanna. Central Côte d'Ivoire (photo Didier Roguet); **B.** Growth habit of a young reproductive individual. Plant cultivated in the Botanical Garden of the University of Accra (photo Fred Stauffer); **C.** Dwarf growth habit of an individual already at reproductive stage. Coastal area of Côte d'Ivoire (photo Didier Roguet).



Fig. 44. Morphological diversity in *Phoenix reclinata*. **A.** Detail of a female inflorescence at early developing stage. Note the leaflets inserted at different angles. Southern Ghana (photo Doudjo Ouattara); **B.** Detail of male inflorescence at early developing stage. Note the spiny basal leaflets present at the proximal region of the petiole. Plant cultivated in the Botanical Garden of the University of Ghana (photo Fred Stauffer); **C.** Detail of young infruktescence. Southern Ghana (photo Doudjo Ouattara).

unarmed; rachis 1-2.5 m long and 5-6 mm wide, triangular in cross-section, unarmed; leaflets 80-120 pairs, alternating, induplicate, lanceolate, long acuminate at the apex, basal leaflets transformed 8-12 pairs of spines, the latter 4-9 cm long and 0.5 cm wide; basal leaflets 25-27 cm long and 1-1.3 cm wide, median leaflets 30-49 cm long and 1.7-2.1 cm wide, inserted each 1.5-2 cm, apical leaflets 12-34 cm long and 1 cm wide; main vein prominent on the abaxial surface. *Staminate inflorescence* 1-order branched, at first enclosed by prophyll; peduncle 30-45 cm long; peduncular bracts absent; rachis of the inflorescence 22-35 cm long; rachillae 18-25 cm long. *Staminate flowers* with white petals and yellow-brown stamens. *Pistillate inflorescence* 1-order branched; prophyll 30-35 cm long, margin entire, tubular and open at the apex, slightly rigid; peduncular bracts absent; peduncle 33-35 cm long and 2.5 cm wide, flattened, greenish-yellow; rachis 20-25 cm long and 2 cm wide; rachillae 38-45, 15-30 cm long and 2-3 mm in diameter, sterile basal portion of 6-7 cm long, apical portion thin and sharp. *Pistillate flowers* cream coloured, with pointed petals and sepals. *Fruit* 35-45 on each rachilla, 1-1.5 cm long, ovoid to subovoid, with a 2-3 mm long, pointed stigmatic remain, dark green in development, red-orange at maturity and becoming brownish in herbarium conditions.

The only species of *Phœnix* currently recognize in the studied area is *Phœnix reclinata* Jacq. Another species was described for the region (*P. spinosa* Schumach. & Thonn.), but the latter was proposed by Barrow (1998) as a synonym of the widespread *P. reclinata*.

Indeed, the question whether *Phœnix spinosa*, a palm originally collected in Ghana, is a distinct taxonomic entity is still highly pertinent and other authors (i. e. Tuley 1995) claim that *P. spinosa* can be distinguished from *P. reclinata* due to its dwarf habit growth and its distribution along the West African coastal savannas and littoral vegetation, normally associated with well-drained, sandy soils and high rainfall values. Observations by Jean-Christophe Pintaud (1970-2015) from material of Bénin and our own collections of dwarf and clustered individuals of *Phœnix* in southern Côte d'Ivoire (along the road Abidjan-Grand Bassam) and in Ghana (along the road between Cape Coast and Elubo) highlight the possibility of a second species for continental Africa, but this should be tested on the light of molecular phylogenetic studies.

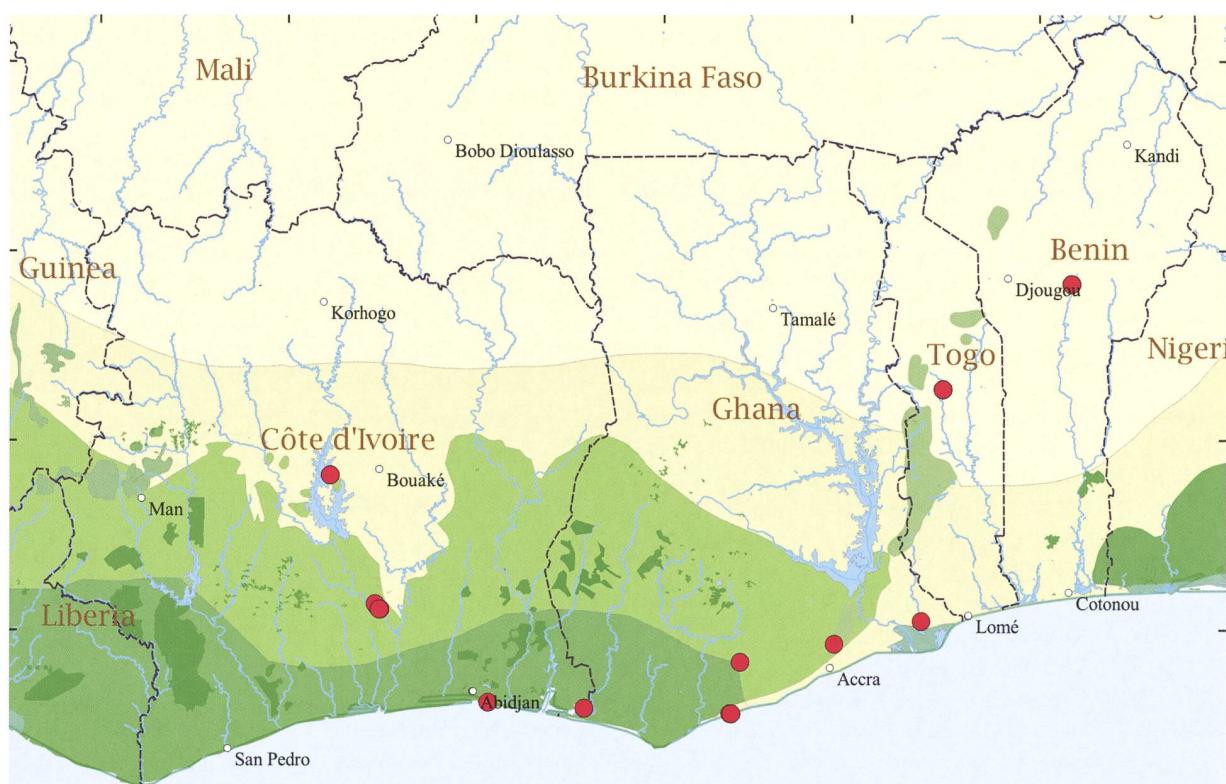


Fig. 45. Distribution of *Phœnix reclinata* in Côte d'Ivoire, Ghana, Togo and Bénin.

Distribution and ecology

Phoenix reclinata is together with *Calamus deeratus* one of the most widely spread palms in tropical and subtropical Continental Africa, also been reported in the north and south-western Madagascar, as well as in the Comoro Islands (Barrow 1998; Dransfield et al. 2008). The palm forms large thickets in coastal and inland savannas in the countries visited, in the latter case subject to seasonal flooding. The fruits of this palm have been reported to be dispersed by animals (birds, elephants, lemurs, and monkeys), which are attracted by their bright orange color and their fleshy and sweet mesocarp (Barrow 1998). Abundant Diptera and Hymenoptera have been observed by us visiting the male and female inflorescences of this palm.

Specimens examined

CÔTE D'IVOIRE : Lacs Region (Bélier Region): Zougoussi, 06° 15' 03.6 N-05° 03' 08.7" W, 127 m, 20 July 2012, Da Giau & Ouattara SD001 (G); **Agnéby-Tiassa Region:** Lamto, Tiassalé, 16 December 1987, Denise & Laurent Gautier-Beguin 716 (CSRS, G); Natural Reserve of Lamto, V-Baoulé Region, savanna with patches of forest. Associated with *Borassus aethiopum* Mart., 06° 13' 00.7" N-05° 01' 32.1" W, 45 m, 02 December 2017, Stauffer et al. 897 (CSRS, G). **Bélier Region:** Taboo, 06° 16' 26.3" N-05° 04' 12.3" W, 134 m, 21 July 2012, Da Giau & Ouattara SD002 (CSRS, G); **Sud-Comoé Region:** between Abidjan and Grand Bassam, 05°10' 20.7" N-02° 50' 51.6" W, 41 m, 10 September 2012, Da Giau & Ouattara SD033 (G); Road Abidjan-Grand Bassam; coastal savanna (disturbed area on sandy soil), 05° 14' 3.87" N-03° 52' 6.527" W, sea level, 8 June 2013, Stauffer et al. 851 (CSRS, G). **Zanzan Region (Bounkani Region):** Bouna, 09° 13' 50.80" N-03° 3' 40.03" W, 290 m, 28 June 2013, Da Giau et al. SD035 (G, K, CSRS).

GHANA : Brong-Ahafo Region: on the border of Volta river, 25 January, 1962, Enti 1483 (KUM); Wenchi District, Bui National Park, 08° 17' 28" N-02° 17' 08" W, 3 March 1999, H. H. Schmidt, J. Stone, Amponsah & M. Chintoh 3284 (GC); North of Banda (Wenchi area), 22 December 1953, Morton 25199 (GC); Menji (Wenchi area), 23 December 1953, Morton 25219 (GC); Sampa, December 1934, Vigne 3493 (KUM, K). **Central Region:** Cape Coast, derrière University of Cape Coast, 05° 06' 50.9" N-01° 16' 52.4" W, 43 m, 18 June 2011, Ouattara & Amponsah OD 18 (G); Cape coast, derrière University of Cape Coast, 05° 06' 57.5" N-01° 17' 47.6" W, 49 m, 20 June 2011, Ouattara OD 20 (G). **Eastern Region:** Aburi, 05° 51' 0" N-00° 11' 0" W, 440 m, 10 June 2011, Ouat-

tara OD 10 (G). **Greater Accra Region:** University Botanical Gardens (University of Ghana, Legon-Accra), 05° 39' 34.2" N-00° 11' 10.7" W, 95 m, 29 November 2011, Ouattara OD 40 (G); **Weija**, near Accra, 20 January 1957, Tomlinson s. n. (GC). **Western Region:** Princes Town, to 10 mn by lagoon, 28 March 1954, Morton A324 (GC); Axim beach, 05 December 1901, W. H. Johnson 876 (GC). **Volta Region:** side road Accra-Agbozume, nearby the village of Tordziniu, 06° 05' 16.52" N-00° 44' 40.04" E, 15 May 2015, Stauffer et al. 867 (G, GC)

TOGO: Hill near Livo Mount (region IV), Brunel, J. F. 10124 (TOGO); Blitta, 08° 19' 17.19" N- 00° 58' 45.27" E, Brunel, J. F. 6754 (TOGO); Near Zobé (region 5a), Brunel, J. F. 9294 (TOGO); Zobé (region 5a), Brunel, J. F. 9293 (TOGO); on the right side of the road, after Aného before the bridge, direction Tabligbo, 06° 14' 32.56" N-01° 36' 46.69" E, 06 June 2015, Michon 31 (G); on the left side of the road, direction Tsévié, reg. maritime, 06° 31' 36.24" N- 01° 32' 24.64" E, 07 June 2015, Michon 36 (G); on the right side of the road N14, between Tchamba and the Bénin border, 08° 58' 59.42" N-01° 29' 34.68" E, 10 June 2015, Michon 53 (G); on the ride side of the pist N9 Notsé – Kpalimé, 06° 54' 7.21" N-00° 54' 50.11" E, 17 June 2015, Michon 83 (G); around the village of Kouma-konda, near Kpalimé, 06° 57' 53.01" N-00° 34' 38.97" E, 18 June 2015, Michon 85 (G); on the left of the road N5 Kpalimé – Lomé, 06° 47' 30.17" N-00° 47' 49.30" E, 20 June 2015, Michon 87 (TOGO); on the right of the road N5 Kpalimé – Lomé, 06° 44' 8.18" N-00° 49' 8.19" E, 20 June 2015, Michon 88 (G); road Tabligbo Haho, 06° 35' 38.90" N-01° 28' 31.08" E, B + H, 6251 (TOGO).

BÉNIN: Grand-Popo (Mono), Avlo, mangrove, sandy soil, 06° 10' 47.99" N-01° 32' 24" E, Adjakidjè, V. 3852 (BÉNIN); Dassa (campus), 06° 10' 47.99" N-01° 32' 24" E, 21 November 2014, Michon 03 (G); Savè, 07° 44' 41.09" N-02° 10' 26.25" E, 22.11.2014, Michon 05 & 5bis (G); between Savè and the toll, fields on the right 100 m before the toll, 08° 2' 32.24" N- 02° 29' 21.37" E, 22 November 2014, Michon 07 & 7bis (G).

Cocos L., Sp. pl. 1188 (1753).

Pleonanthic, monococious palms, with solitary, erect, ringed stems; leaves regularly pinnate; leaf sheaths with fibrous margins; leaflets lanceolate; inflorescences 1-branched, protected by a large and woody peduncular bract; flowers unisexual, the female ones present from the base to the first quarter of length of the rachilla whereas the male ones are present from the mid-length up to the apex. Fruits large, ovoid to oblong, green to yellow (size and colour largely depending on the cultivar), 1-seeded.



Fig. 46. Morphological diversity in *Cocos nucifera*. **A.** Stand of the coconut palm in the coastal savanna. South-western Côte d'Ivoire (photo Fred Stauffer) ; **B.** Detail of leaf crown and leaf fibrous sheaths. Southern Togo (photo Loïc Michon) ; **C.** Detail of leaf crown, leaf sheaths and developing inflorescences. Southern Togo (photo Loïc Michon).



Fig. 47. Morphological diversity in *Cocos nucifera*. **A.** Young inflorescence showing male and female flowers at bud stage. Southern Ghana (photo Fred Stauffer); **B.** Infructescence at very young stage; note the well-developed woody peduncular bract and the young fruits occupying a basal position in the rachillae. Southern Ghana (photo Fred Stauffer); **C.** Infructescence bearing ripe fruits. Southern Ghana (photo Fred Stauffer).

This is a monotypic genus largely cultivated in coastal and inland areas throughout West Africa and elsewhere in the tropics. The species is highly adapted to sandy and saline soils. *Cocos nucifera* ranks among the most economic important palms in the countries visited, not only from an industrial perspective, in particular in the coastal region, but also due to its high value in rural economy given the many uses attributed to the stem (construction material), the leaves (thatching, handcraft, palm heart) and the edible fruits (consumption of the fresh or dry endosperm, sauces, oil extraction), among others.

19. *Cocos nucifera* L., Sp. pl. 1188 (1753).

Syn.: *Calappa nucifera* (L.) Kuntze; *Cocos indica* Royle; *C. mamillaris* Blanco; *C. nana* Griff.; *C. nucifera* var. *angustifolia* Hassk.; *C. nucifera* var. *aurea* auct.; *C. nucifera* var. *javanica* G. V. Narayana; *C. nucifera* var. *microcarpa* Hassk. ex F. W. T. Hunger (nom. superfl.); *C. nucifera* var. *nana* (Griff.) G. V. Narayana; *C. nucifera* var. *pumila* Hassk.; *C. nucifera* var. *rubescens* Hassk.; *C. nucifera* var. *spicata* K. C. acob; *C. nucifera* var. *synphyllica* Becc.; *Diplothemium henryanum* F. Br.; *Palma cocos* Mill. (nom. superfl.).

Tall, solitary, monoecious palm. Stem 15-30 m in height and 30-50 cm in diameter, conspicuously ringed, striated. Leaves abundant, 4-7 m long, re-

gularly pinnate; leaf-sheath with fibrous margins; petiole 2-2.5 m long and 10-15 cm wide, channelled adaxially, rounded abaxially; rachis up to 5 m long, slightly keeled adaxially, rounded abaxially, unarmed; leaflets 200-250 pairs, regularly inserted on one plane, linear and with an acuminate apex, glabrous adaxially, green abaxially and with dot-shaped scars, midrib prominent on the adaxial surface; basal leaflets 30-45 cm long and 2-3 cm wide, median leaflets 40-100 cm long and 3-5 cm wide, apical leaflets 30-40 cm long and 2-3 cm wide. Inflorescences unisexual, 1-1.5 m long, 1-order branched, yellow to yellow-orange; prophyll 30-40 cm long and 10-15 cm wide, tubular, fibrous and persistent; peduncular bract 80-100 cm long and 10-15 cm wide, strongly woody, tubular, completely covering the young inflorescence; peduncle 30-50 cm long and 6-8 cm in diameter, green; rachis more or less similar to the peduncle; rachillae numerous, 30-50 cm long and 2-4 cm wide. Flowers: staminate small, concentrated in the mid-apical portion of the rachilla, sepals 0.3-0.4 cm long, petals 1-1.3 cm long, stamens 6, anthers 0.8-1 cm long, filament short; pistillate flowers at the base lower third of the rachilla, larger than staminate, 2.5-3 cm in diameter, globose at bud stage, ovoid at anthesis, sepals and petals 1.2-1.6 mm long. Fruits 10-15 cm diameter, ellipsoidal to ovoid, green, yellow, turning brown when dry, stigmatic remains persistent.



Fig. 48. Distribution of *Cocos nucifera* in Côte d'Ivoire, Ghana, Togo and Bénin.

Distribution and ecology

This is a frequently cultivated palm all over West Africa, being particularly spontaneous in coastal savannas and littoral habitats. Its presence in semi-natural and ruderal conditions surrounding villages is largely favoured by local inhabitants due to the high economic importance of the palm. *Cocos nucifera* was rarely observed in a few northern areas of the countries visited; however, the palm is clearly not adapted to the arid Sudanese conditions, where it might require artificial irrigation.

Specimens examined

COTE D'IVOIRE : Lôh-Djiboua Region: Zikidiès, 05° 47' 51.06" N-05° 28' 36.03" W, 195 m, 21 January 2014, Gaille & Irié EG98 (G, LILLE).

GHANA : Western Region: Apowsika, 02 April 1978, J. K. Affum 4618 (CCG). Several individuals and plantations observed in Ashanti Region, Central Region, Greater Accra Region, Eastern Region and Volta Region.

TOGO: no material studied for this country

BÉNIN: Sandy soil in mangrove swamp, Avlo, Mono, Grand-Popo, 6.18° N-1.54° E, 27 November 2000, Adjakidjé, V. et al. 3851 (BÉNIN); Plantation on Abomey-Calavi campus, Atlantique, 06° 10' 47.99" N-01° 32' 24" E 1979, Hougnon 1205b (BÉNIN); Cotonou, «route du bord de mer», on the left after Fidjrossè, 06° 21' 39.81" N- 02° 22' 4.11" E, 3 m, 21 December 2014, Michon 24 & 26 (G).

Elaeis Jacq., Select. Stirp. Amer. Hist. 280 (1763).

Pleonanthic, monoecious palms. Stems solitary and erect, sometimes slightly procumbent; leaves regularly pinnate, rarely with joined segments then almost displaying an entire-bifid appearance. Inflorescences unisexual, emerging from the base of the leaf sheaths. Infructescences compact, frequently armed with woody and sharply spiny floral bracts. Fruits laterally flattened, ovoid or oblong, yellow, orange to red when ripe (size and colour largely depending on the agronomic cultivar).

This genus includes two species, one from Africa (*Elaeis guineensis* Jacq.) and the other (*Elaeis oleifera* (Kunth) Cortés) patchily distributed in tropical America (Dransfield *et al.* 2008).

20. *Elaeis guineensis* Jacq., Select. Stirp. Amer. Hist. 280 (1763).

Syn.: *Elaeis dybowskii* Hua; *E. guineensis* f. *androgyna* A. Chev.; *E. guineensis* f. *caryolitica* Becc.; *E. guineensis* f. *dioica* A. Chev.; *E. guineensis* f. *dura* Becc.; *E. guineensis* f. *fatua* Becc.; *E. guineensis* f. *ramosa* A. Chev.; *E. guineensis* f. *semidura* Becc.; *E. guineensis* f. *tenera* Becc.; *E. guineensis* subsp. *nigrescens* A. Chev. (nom. inval.); *E. guineensis* subsp. *virescens* A. Chev.; *E. guineensis* var. *albescens* Becc.; *E. guineensis* var. *angulosa* Becc.; *E. guineensis* var. *ceredia* A. Chev.; *E. guineensis* var. *compressa* Becc.; *E. guineensis* var. *gracilinux* A. Chev.; *E. guineensis* var. *idolatrifica* A. Chev.; *E. guineensis* var. *intermedia* A. Chev.; *E. guineensis* var. *leucocarpa* Becc.; *E. guineensis* var. *macrocarpa* A. Chev.; *E. guineensis* var. *macrocarya* Becc.; *E. guineensis* var. *macrophylla* A. Chev.; *E. guineensis* var. *macrospurma* Welw.; *E. guineensis* var. *madasgascariensis* Jum. & H. Perrier; *E. guineensis* var. *microsperma* Welw.; *E. guineensis* var. *pisifera* A. Chev.; *E. guineensis* var. *repanda* A. Chev.; *E. guineensis* var. *rostrata* Becc.; *E. guineensis* var. *sempernigra* A. Chev.; *E. guineensis* var. *spectabilis* A. Chev.; *E. macrophylla* A. Chev. (nom. nud.); *E. madagascariensis* (Jum. & H. Perrier) Becc.; *E. melanococca* Gaertn.; *E. nigrescens* (A. Chev.) Prain (nom. inval.); *E. virescens* (A. Chev.) Prain; *Palma oleosa* Mill.

Tall, solitary, monoecious palm. Stem 4-10 m long, straight, or rarely procumbent, up to 20 m in height and 30-50 cm in diameter, often bearing remnants of the leaf sheath bases. Leaves up to 5 m long, regularly pinnate; leaf-sheath woody, with fibrous margins; petiole 0.5-1.5 m long and up to 10 cm wide at the base, green, adaxially flat, abaxially convex, smooth, margins armed with spines, the latter 1-2 cm long and 0.5-0.8 cm wide, green to black depending on the stage of development; rachis 1-5 m long, unarmed; leaflets 50-160 pairs, lanceolate and with an acuminate apex, reduplicate, alternate to sub-opposite, inserted in 2-4 rows on the rachis, unarmed, basal leaflets 15-25 cm long and 0.2-0.4 cm wide, turned into long spines after the disappearance of the blade, median leaflets 60-100 cm long and 1-2 cm wide, apical leaflets 30-50 cm long and 5-1 cm wide; main vein prominent on the adaxial surface. Inflorescences unisexual, male and female alternating on the same individual. Staminate inflorescences 1-order branched, prophyll not observed; peduncular bract at least 1 observed, 10-15 cm long, black-greyish, cartaceous; rachillae 30-100, cylindrical, 7-15 cm long and 1.5-3 cm in diameter; peduncle 20-30 cm long; rachis 20-50 cm long. Pistillate inflorescence 1-order branched, prophyll and peduncular



Fig. 49. Morphological diversity in *Elaeis guineensis*. **A.** Stands growing in inland savanna. Southern Ghana (photo Doudjo Ouattara); **B.** Individual growing in riverine forest. Southern Ghana (photo Fred Stauffer); **C.** Cultivated individual in a small-scale plantation. Southern Côte d'Ivoire (photo Didier Roguet).

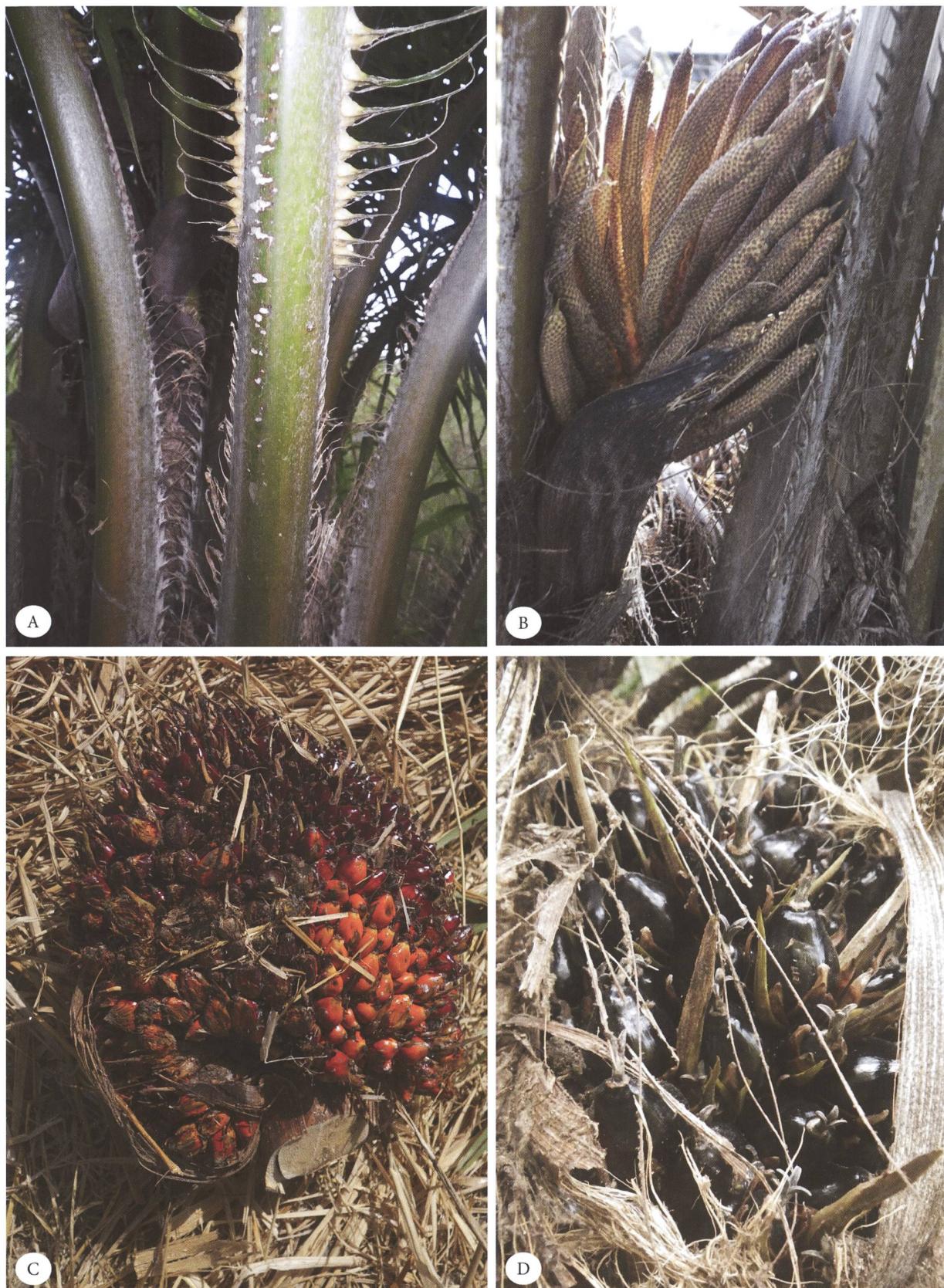


Fig. 50. Morphological diversity in *Elaeis guineensis*. **A.** Base of the petioles displaying the highly modified basalmost pinnae with swollen proximal region. Southern Ghana (photo Doudjo Ouattara); **B.** Young stage male inflorescence. Note the acute apex of the rachillae. Southern Ghana (photo Doudjo Ouattara); **C.** Mature infructescence bearing ripe fruits. Southern Ghana (photo Fred Stauffer); **D.** Mature fruits densely covered by remnants of peduncular bract. Note the woody and spiny subtending bracts. Central Togo (photo Loïc Michon).

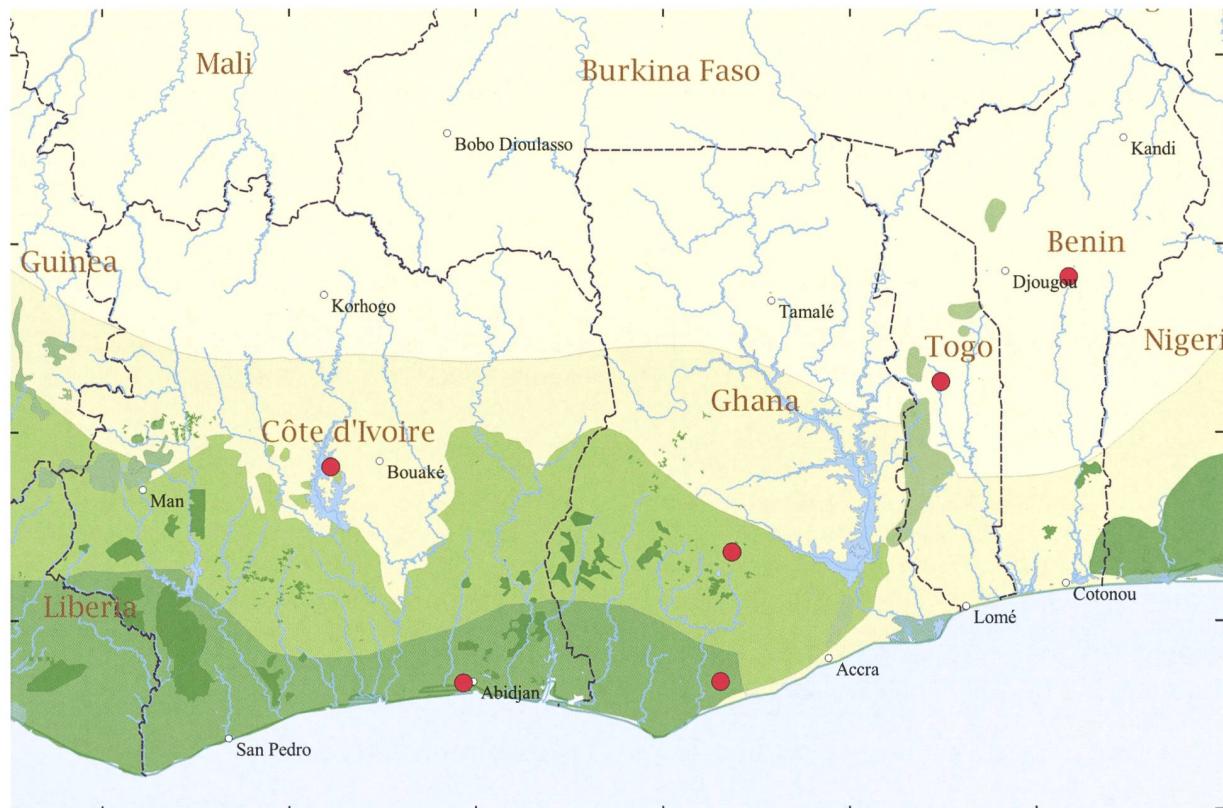


Fig. 51. Distribution of *Elaeis guineensis* in Côte d'Ivoire, Ghana, Togo and Bénin.

bracts not observed; peduncle 15-30 cm long; rachis 5-6 cm long, rachillae 10-12 cm long and 3-5 cm wide. *Staminate flowers* numerous and densely packed on the rachilla, 2-3 mm long, subtended by a short floral bract. *Pistillate flowers* 3-3.5 cm long. *Fruits* 2-5 cm long and 1-2 cm in diameter, ovoid, with a conspicuous stigmatic remain, bright red, black, purple, and orange, depending on the agronomic cultivar, tightly packed in the infructescence.

In many West African countries local inhabitants often exclusively refer as «palm» the oil palm *Elaeis guineensis*, whereas other representatives of the Arecaceae would be designated by more specific vernacular names (i. e. rônier, rotin, raffias, date palm). The species is well represented both in rural and urban areas, either due to its extreme economic importance, by far the useful palm in West African countries, or due to its ornamental value. This species has been treated in detail in most classical floristic studies including West African palms (i. e. Dalziel 1937; Irvine 1961; Tuley 1995) and their economic importance Burkhill (1997).

Distribution and ecology

Elaeis guineensis is widely distributed in lowland, humid areas of West Africa and the Congo Basin. It has been also reported in riparian locations in East

and Southern Africa, Madagascar (probably introduced in the past) and the off-shore of Indian and Atlantic Ocean islands (Tuley 1995; Dransfield et al. 2008; Stauffer et al. 2014).

The palm can be observed in the transition between the rain forest and the savanna, particularly represented in the southern regions of the countries included in this inventory. In the northern regions it will be less frequent and part of the riverine forests, or even associated with *Raphia sudanica* along streamlets of inland savannas.

As an extremely useful palm, its distribution is strongly linked to human settlements. On the trails leading to the village plantations, we can often observe young isolated or grouped individuals of the palm. The oil palm grows well in the secondary forests, but very ancient individuals were observed in the primary rain forest (Ankasa Forest Reserve, Ghana) were seed of the palm probably germinated in natural, well sunny-exposed clearings. In forest conditions the palm will display a completely different morphology to that commonly observed when growing in the savanna. According to Maley (1999) the oil palm may represent one of the rare tall palms nowadays present in dry lands to have survived the important palm extinction in Africa, being an evidence of the natural vegetation of the continent.

Specimens examined

CÔTE D'IVOIRE: Lagunes Region (District of Abidjan): CSRS, Adiopodoumé, dans le parc de la station, 9 December 1989, Denise & Laurent Gautier-Beguin 994 (CSRS, G); 9 December 1988, Denise & Laurent Gautier-Beguin 995 (CSRS, G); région d'Abidjan, route de Bingerville, entre Cocody et Anono, 18 October 1967, Aké Assi 9674 (G).

GHANA: Ashanti Region: Bobiri Forest Reserve, 06° 43' 27.4" N-01° 15' 44.8" W, 215 m, 26 May 2011, Ouattara, D., P. Aman, O. Adoma & K. Bridget OD 8 (G). **Central Region:** Kakum National Park, 05° 21' 04.3" N-01° 23' 02".9" W, 185 m, 17 June 2011, Ouattara & Amponsah OD 17 (G). **Greater Accra Region:** Near Ada junction, 02 June 1968, Enti & Hossain 38666 (GC); **Western Region:** Apowsika, 02 April 1978, J. K. Affum 4617 (CCG).

TOGO: on the right side of the road N14, between Tchamba and the Bénin border, 352.4 m, 08° 58' 59.42" N- 01° 29' 34.68" E, 10 June 2015, Michon 54 (G); village on Dague, on the right side of the road N2 dir. Aného, 12.4 m, 06° 12' 8.76" N-01° 24' 31.39" E, 21 June 2015, Michon 91 (G, TOGO).

BÉNIN: «terre de barretray, Abomey-Calavi campus, 06° 26' 28.02" N-02° 21' 4.06" E, 03 October 1975, n. c., 201 (BÉNIN); Fallow on ferrallitic soil, Ifangni (Ouémé). 36 m, 06° 24' 22.67" N-02° 25' 37.2" E, 25 August 2001, Dan 393 (BR); Cotonou, street 231, villa universitaire, private space P3, 06° 21' 5.24" N- 02° 25' 6.61" E, 22 July 1999, Genco 37 & 53 (BR); Cotonou, Chinese cultural center, private green space P4, 23 July 1999, Genco 74 (BR).

Notes on *Elaeis guineensis* var. *idolatrifica* A. Chev.

A remarkable morphological divergence from the classical pattern was observed in some individuals growing in Côte d'Ivoire, Ghana, Togo and recently also observed in southern Bénin. Former palm studies have attributed this form as *Elaeis guineensis* var. *idolatrifica*, a palm that was described by the French botanist August Chevalier in 1910 and nowadays recognized as a synonym of *Elaeis guineensis* Jacq. The striking morphology associated to the almost completely entire-bifid leaf blades of this palm, makes of it and potentially interesting candidate for ornamental purposes. We propose here below a brief description of this palm.

Tall, robust, solitary, pleonanthic, monoecious palm. Stem erect, 3-10 m in height, 30-50 cm in diameter, old leaf sheaths and petioles often remaining on the stem, the latter becoming bare in aged individuals,

leaf scars wide, oblique. Leaves numerous, irregularly pinnate with fused segments or displaying an entire-bifid morphology, green to dark green, clearly appearing darker than the leaves of *E. guineensis*; leaf sheath base tubular, up to 30 cm long and 25-30 cm wide, white to light brown adaxially, brown abaxially, with abundant, dense brown, multi-oriented and strong marginal fibers, giving a filamentous, braided aspect to the stem; the leaf sheaths protected by those filaments and only the petiole visible; petiole 110-120 cm long, green-yellowish, with armed margins, spines ending in a single strong fiber; leaf rachis up to 460 cm long, green; leaflets 130 pairs, many of them partially or completely fused, making the palm easily distinguishable from *E. guineensis* in the distance; basalmost leaflets reduced and transformed into swollen spines, the apical ones with bifid apex. Staminate and pistillate flowers in separate inflorescences on the same plant. Fruits black, red and fleshy when ripe, slightly smaller than those observed in the oil palm.

Distribution and ecology

The distribution of this palm overlaps that of *E. guineensis*, but it is apparently not cultivated as is the case for the latter. We observed only few individuals at different ages in Côte d'Ivoire, **Ghana and Togo**. The palm grows spontaneously in the coastal region, mainly on sandy soil, along villages and main roads. According to locals a particular squirrel is often found on both *E. guineensis* and the var. «*idolatrifica*», and they are supposed to attack humans when disturbed. Ants and ant nests can be often found in the leaf sheaths of this palm.

Sclerosperma G. Mann & H. Wendl., Trans. Linn. Soc. London 24: 427 (1864).

Pleonanthic, monoecious palms, with acaulescent or very short stems; leaves irregularly pinnate to almost entire-bifid, conspicuously ascending; inflorescences interfoliar, solitary, spicate, bearing male and female flowers, often covered by a fibrous peduncular bract. Fruits globose, 1-seeded.

The genus *Sclerosperma* is composed of three species (Van Valkenburg et al. 2008), endemic to western and equatorial Africa. We observed populations of these palms in the understory of the dense and humid rainforest of western Ghana (Ankasa Natural Reserve), and our palm surveys in Côte d'Ivoire, particularly in the dense forests of the Tai National Park and in the south-eastern regions bordering Ghana, could not confirm their presence in the country. Togo and Bénin lack the ecological conditions



Fig. 52. Morphological diversity in *Elaeis guineensis* var. *idolatrifica*. **A.** Adult individual cultivated in the gardens of the Swiss Center of Scientific Research (Adiopodoumé, Côte d'Ivoire, photo Doudjo Ouattara); **B.** Young individual displaying partial entire-bifid leaves. Southern Ghana (photo Doudjo Ouattara); **C.** Stemless individual with erect, entire-bifid leaves. Southern Côte d'Ivoire (photo Fred Stauffer).

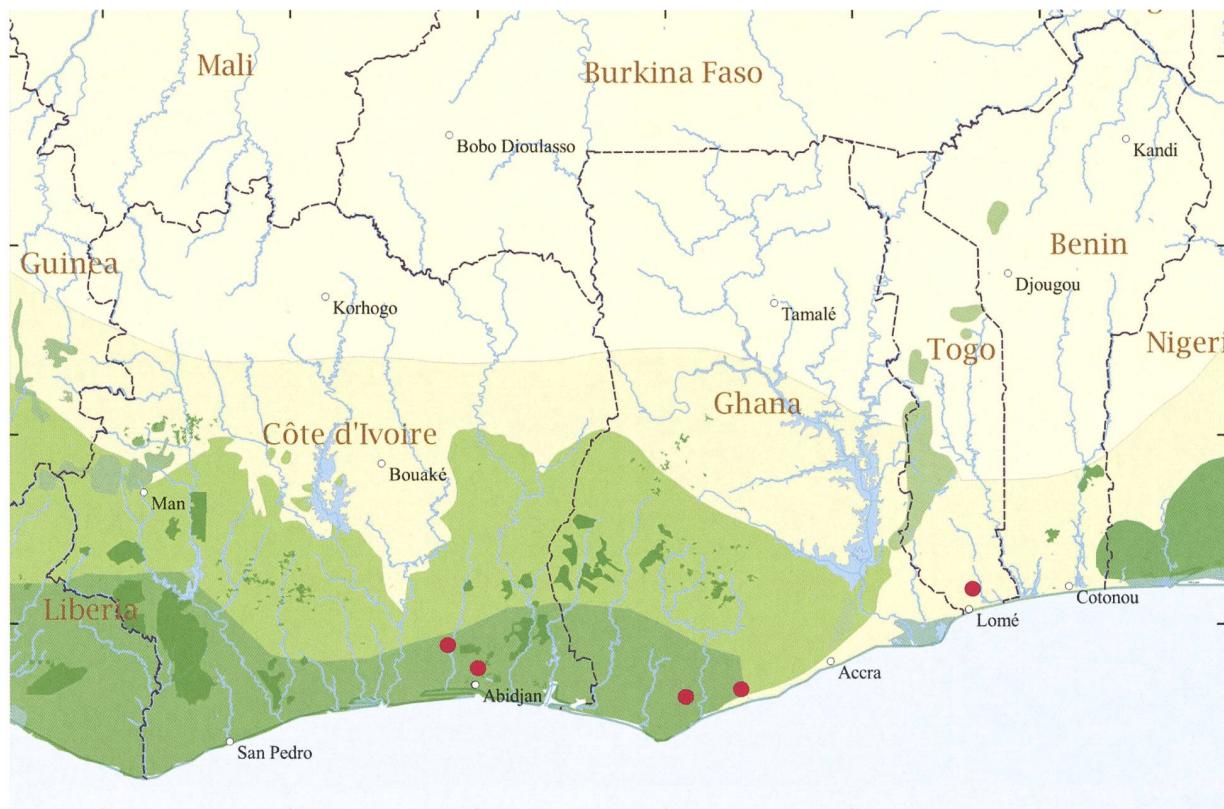


Fig. 53. Distribution of *Elaeis guineensis* var. *idolatrata* in Côte d'Ivoire, Ghana, Togo and Bénin.

necessary for the development of this palm. *Sclerosperma profizianum* Valk. & Sunder. is the only species reported in the studied area.

21. *Sclerosperma profizianum* Valk. & Sunder.

Kew Bull. 63: 82 (2008),

Acaulescent, monœcious palm. Leaves numerous, emerging from the ground, entire-bifid, 1-3.5 m long and 19-34 cm wide at the basal and median portions and 35-52 cm towards the apical portion ending in 20-23 cm long lobe, unarmed, margins serrate, ending by a flagellum at the apex (extension of the midrib), dark green adaxially, grey-green to white abaxially, sometimes covered with a waxy indumentum, midrib yellow, prominent on both surfaces, secondary veins parallel to each other and inserted at an angle of 20-25 degrees with respect to the midrib, some prominent on the adaxial surface, others on the abaxial surface, distance between two consecutive secondary veins 1-1.5 cm; leaf-sheath almost absent; petiole 1-1.8 m long, channelled at the base and cylindrical towards the apex, olive green. Inflorescence solitary, spicate, 20-30 cm long and 6-10 cm wide, usually emerging from the ground between the petioles; prophyll 15-17 cm long and 2-3 cm wide, cartaceous, emerging from the base of the peduncle; peduncular bract 22-24 cm long and 3-4.5 cm wide, inserted at the base

of the peduncle, more or less tubular at the base and median portion, conspicuously fibrous and enclosing the entire inflorescence or infructescence; peduncle 11-12.5 cm long and 1-2 cm wide, slightly elliptical in cross-section; rachis 20-25 cm long, entirely covered with flowers. Staminate flowers concentrated in the medio-apical portion of the rachis, 1-2 cm long, stamens numerous; pistillate flowers concentrated at the base of the rachis, 2-3 cm long. Fruits 30-40 in one infructescence, 1.2-2.6 cm long and 3 cm wide, brown, smooth, spherical to ovoid, with three lobes more or less triangular in cross-section, with an apical, 3 mm long mucron.

Distribution and ecology

Sclerosperma profizianum has a discontinuous distribution. Populations of the species thrive in Gabon and at the tributary of the Congo River in Central Africa (Van Valkenburg et al. 2008; Mbandu Luzolawo et al. 2020). In Western Africa, the species has been only observed in Ghana, where it is in the Southwest of the country on the border with Côte d'Ivoire. The most important populations were reported in the Ankasa Forest Reserve and its surroundings. It is a species of the understory of the evergreen, wet and dense forest, but soil conditions may play a determining in its distribution.



Fig. 54. Morphological diversity in *Sclerosperma profizianum*. **A.** Young individuals growing in understory conditions. South-west Ghana (photo Fred Stauffer); **B.** Cespitosous growth habit of a young individual growing under sunny-exposed conditions. South-west Ghana (photo Doudjo Ouattara); **C.** Detail of a ripe infructescence represented in a herbarium specimen stored at GC. South-west Ghana (photo Fred Stauffer).



Fig. 55. Distribution of *Sclerosperma profizianum* in Côte d'Ivoire, Ghana, Togo and Bénin.

Specimens examined

GHANA: Western Region: Neung F. R. 2 February 1973, Enti 43661 (GC); Ankasa F. R., 29 June, 1966, Hall s. n. (K); Ankasa F. R., 29 December 1966, Hall 36150 (GC, K); Ankasa F. R., 28 June, 1966, Hall & Enti 35615 (GC); Ankasa F. R., 05 January 1969, J. B. Hall & Enti 39203 (GC); Plantation à côté d'Ankasa Forest Reserve, 05° 13' 28.4" N-02° 41' 42.4" W, 65 m, 21 October 2011, Ouattara & Stauffer OD 35 (G); Ankasa Forest Reserve, 05° 13' 31.1" N-02° 41' 35.8" W, 41 m, 21 October 2011, Ouattara & Stauffer OD 36 (G); Enchi, Boi Tano Forest Reserve, deep inside Boi Tano Forest Reserve, about half way toward western boundary and southern boundary with Tano River, 2 November 2000, Hawthorne 200B 183 (GC, WAG); Neung North Forest Reserve, Adaieye hamlet (few huts), near «mile 7» by mining road /track that runs W from tarkwa-Takoradi road, branching w just S of Tarkwa, fairly close to a huge open mining area, and to the northern boundary of Neung forest reserve, 15 November 2005, Hawthorne 205C 001 (WAG).

General features on the native palms of Côte d'Ivoire, Ghana, Togo and Bénin

Taxonomic and floristic diversity

The palm flora of Côte d'Ivoire, Ghana, Togo and Bénin is represented by three subfamilies (Calamoideae, Coryphoideae, Arecoideae) of the five currently recognized for the Arecaceae, being largely dominant the Calamoideae, which includes in the studied area the ecologically important genus *Raphia* (3 spp.) and members of the African clade Ancystrophillinae (9 spp.). In West Africa, the only member of the exclusively south-east Asian subfamily Nypoideae (*Nypa fruticans*) results from several introductions from 1906 to 1946 (Sunderland & Morakinyo, 2002). This palm is currently spreading from Lagos in Nigeria to the Wouri Estuary near Douala in Cameroon and its invasive potential threatens the native mangrove vegetation. Its presence in the coasts of Bénin should be closely surveyed given the danger that this palm represents for the mangrove ecosystem.

The four countries included in our study comprise more than 60% of the native species reported for West Africa (Stauffer et al., 2017), although further field research efforts in remaining large, and still well-preserved forested areas, particularly in sou-

th-west Côte d'Ivoire (Tai National Park) and south-west Ghana (Ankasa Conservation Area), may eventually increase the number of species. While most taxa of Coryphoideae and Arecoideae appear to be taxonomically well understood, further efforts should be undertaken on the genus *Raphia*, which is largely undercollected and taxonomically imperfectly understood. The same applies to the rattan genera, which are challenging to collect and hence in most cases fragmentary represented in herbaria only by vegetative material and often leading to inaccurate identifications.

Growth habit and morphologic diversity

In spite of the moderate number of taxa, the palms included in our study display an important diversity concerning growth habit. Tall, solitary palms such as members of Borasseae (*Borassus*, *Hyphaene*) and *Elaeis* dominate the open, savanna ecosystems (i. e. in-land, coastal savannas). The savanna date palm (*Phoenix reclinata*), with its clustered growth habit and moderate size, is the only exception to that. Clustered palms are much more associated to forest, understory conditions. Climbing, spiny palms (all members of Ancistrophilinae) are always clustered and mainly restricted to forested areas, independently whether present in main land or major river islands. In understory conditions most rattans will first develop solitary stems and reaching a certain height a prolific clustering growth habit, reinforced by extensive rhizome development, will appear. Other palms growing in understory conditions, such as the massive *Raphia palma-pinus* and *Sclerosperma profizianum*, display also a clustered growth habit.

Concerning leaf morphology, the pinnate model largely dominates, whereas entire leaf blades only appear in the members of Borasseae and the arecoid palm genus *Sclerosperma*. In the latter, the large entire-bifid leaves will display some segmentation in aged individuals. This transitional type of leaf development can be also observed in most rattans species, where entire-bifid leaves characterize young individuals growing in the lowest levels of the understory and replaced by the pinnate pattern with age.

Regarding sexual expression and floral structures a wide range of diversity can be observed. Unisexual flowers, whether present in the same individual (monoecy) or in different individuals (dioecy) is largely dominant, whereas the presence hermaphroditic flowers is unique in the rattan genera *Eremospatha* and *Laccosperma*. In the case of monoecious taxa, the unisexual flowers can be either present in different inflorescences of the same individual (i. e. *Elaeis*) or

inserted in the same inflorescence (i. e. *Cocos*, *Raphia*, *Sclerosperma*), very often the female flowers grouped towards the base of the rachillae and the male ones concentrated from mid-length towards the apex. With respect to dioecious taxa, the unisexual flowers will evenly distribute throughout the whole inflorescence and throughout a single rachillae.

Palm ecological regions

The 21 native palm species reported in the studied area are well adapted to specific ecologic conditions and only few of them, in particular the oil palm *Elaeis guineensis*, may be eventually found in a wide range of habitats given its high adaptation to a wide range of ecological conditions. Although several abiotic factors may be responsible in shaping current palm distribution and ecology, the most important include sun tolerance, water table level, soil type, drainage, and rainfall, among others.

The palm taxa included in this contribution can be often found in at least one of the four different large «Palm eco-regions» proposed here: 1) Coastal savannas, 2) Swampy, open forests with «Raphiales», 3) Tall, rain forests and 4) inland savannas. To these natural landscapes we should also add a fifth category which corresponds to the disturbed areas of anthropogenic origin, the latter hosting a reduced, yet economically important group of palms. In each of these eco-regions, palms are not only fundamental for human populations but they play a major ecological role as they represent a major food source for the terrestrial fauna (i. e. insects, rodents, primates), as well as bird populations. The «Palm eco-regions» described here below are unequally represented in the four countries visited, and this may be explained by the different geologic and climatic features prevailing in each country, as described earlier in this contribution; however, their uneven representation may be also attributed to the massive human-induced loss of natural areas.

We are aware that the definition of these regions is rather artificial; however, our field experience has shown that members of the palm family are reliable ecological indicators in these landscapes and hence their easy recognition is potentially useful for a wide range of fundamental and applied disciplines. Here a brief description of the «Palm eco-regions» identified in Côte d'Ivoire, Ghana, Togo and Bénin:

1. – Coastal savannas

Coastal savannas occupy extensive areas in the southernmost regions of the studied countries, often intermixed with increasing disturbed areas of an-

thropogenic origin. As a consequence, this landscape is heavily threatened and becomes very rare. The dominant conditions in this landscape include sandy, salty and relatively well drained soils, as well as exposure to permanent sea winds and harsh sun exposure. Palms such as *Hyphaene guineensis* and *Phoenix reclinata*, in particular populations of a dwarf phenotype observed in Côte d'Ivoire, are extremely well adapted to these conditions, whereas *Borassus aethiopum* may be also present but according to our observations most probably associated to past human introductions from northern regions given its economic importance.

2. – *Swampy, open forests with «Raphiales»*

The swampy, open forests are characterized by the presence of *Raphia* populations, the latter sometimes extremely dense and becoming almost dominant with respect to other plant groups. The large stands of *R. hookeri* observed in southern Côte d'Ivoire and Ghana display the perfect adaptation of these palms to permanently or seasonally flooded conditions, often associated to heavy soils. Palm individuals here reach up to 6-8 meters and become the tallest representatives in the landscape, whereas shrubby plants occupy mid-height levels of the vegetation and a rich aquatic plant flora develops when water is guaranteed throughout all seasons. The landscape usually occupied by the *Raphia* stands is subject of intense drainage, most often associated to the settlement of rice plantations. The poorly collected rattan species *Oncocalamus wrightianus*, so far only collected in southern Benin, has been reported in these type of swampy forest.

3. – *Tall, rain forests (including evergreen, moist semi-deciduous and coastal forests)*

The tall, evergreen forests present in West Africa are remnants of the once massive Upper Guinean Forest, spreading from the Casamance, in southern Senegal, to southern Nigeria. In the studied countries these highly biodiverse areas (one of the world's hotspots of biodiversity) are nowadays only patchily distributed and restricted to natural reserves and national parks. The Ankasa Forest Reserve in Ghana and the Tai National Park in Côte d'Ivoire are probably the best examples of this type of vegetation and they host a selected group of palm species highly adapted to specific wet, forest conditions. As rainfall values are extremely high in these areas (sometimes above 2500 mm/year) micro-topography and soil type are responsible of seasonally flooded conditions favouring a high taxonomic diversity and dense populations in the rattan genera *Eremospatha* and *Laccosperma*, the latter developing most of their life cycle in understory conditions and only reaching

the canopy of the forest at mature, reproductive stage. Among the three *Raphia* species reported in the studied countries, *Raphia palma-pinus* is well adapted to rain forest conditions, equally observed on terra firme or along seasonal streamlets in the forest. Its presence is clear evidence of undisturbed vegetation. This species is present in evergreen forest but absent in semi-deciduous forests while *Raphia hookerii* can be found in these two types of forest and even in the transitional forest-savanna zones. Among the Arecoideae, the genus *Sclerosperma* is also associated to the tall, evergreen forest, normally growing in shadow, understory conditions, but it tolerates more exposed, sunny conditions, as observed in some forest edges in south-west Ghana.

4. – *Inland savannas*

The inland savannas cover extensive regions of the countries studies and are directly influenced by the strong seasonal climatic conditions. The dominant savanna is often intermixed with patchily distributed semi-deciduous forests and gallery forest, the latter associated to streamlets or more important water courses. The benchmark palms of the West African savannas are *Borassus aethiopum*, *B. akeassi* and to a much lower degree the doum palm *Hyphaene thebaica*. In particular the first two species may form large stands, but for which the presence of juveniles may be compromised as a consequence of natural or human-induced fires. In the savanna, patches of mid-height deciduous forests may host the savanna date palm (*Phoenix reclinata*), the rattan palm *Calamus deerratus* and rarely *Laccosperma secundiflorum* as observed in the region of Yamoussoukro in Côte d'Ivoire. These species require of fully sunny-exposed conditions but only *C. deerratus* will be present as long as seasonally flooded conditions are available. Also following water courses in the savannas can be observed *Raphia sudanica*, a palm that can form compact stands along streamlets.

5. – *Disturbed areas of anthropogenic origin*

These include larges areas of human-induced destruction, in particular associated to urban expansion of cities and villages, as well as increasing agronomic activities. The later may vary from relatively small scale, subsistence crops (i. e. corn, cassava, yam, bean, peanut) to large scale, industrial plantations (often oil palm and coconut). Disturbed areas may be particularly suitable for *Elaeis guineensis*, which can form compact stands or only be represented by scattered individuals. To a lower extent also *Borassus aethiopum* can be identified growing in disturbed areas, although clearly under less severe conditions than in the precedent case. In such areas we did not find any rattan species, which highlights

their close dependency with their specific ecological conditions.

Ethnobotanical and economic importance

Palms fulfil a wide range of needs in rural areas of the four countries studied. At a village scale, but occasionally also observed in some main cities (i. e. Accra, Abidjan, Cotonou, Lome, Porto-Novo, San Pedro), different palm organs provide an important source of food and beverage, construction material, handcraft and furniture, combustion material, traditional clothing, cosmetics and cultural animist artefacts. Here below we describe the main uses observed. Some of them, such as building material, foods and cosmetics, are huge of economic importance.

1. – Food and beverage

Human populations often eat and commercialize in street markets palm fruits for their edible mesocarp or as a source of oil. In the case of *B. aethiopum* and *Hyphaene thebaica* the liquid and jelly endosperms, as well as the ripe mesocarps, are frequently consumed in the countryside. The pressed mesocarp of *Elaeis guineensis* provides a highly appreciated red oil that is not only frequently used in traditional dishes, but also incorporated in the manufacture of soaps. The seed is pressed to obtain the palmist oil (yellow color), specially used for cosmetics and in the soap and detergent industry.

With respect to vegetative organs, the consumption of edible palm hearts has been mainly reported in *Elaeis guineensis* and the rattan palm *Laccosperma secundiflorum*, and the hypocotyl axis resulting from remote germination in *Borassus aethiopum* is frequently commercialized in southern Benin. An allegedly edible mushroom growing on palm stems (*Volvariella volvaceum* on i. e. *Elaeis guineensis*), that have been fell off has been reported in several regions of Côte d'Ivoire and Benin. This mushroom is even said to be cultivated in Ghana. Palm wine extraction using several methods (cutting of the apical meristem, incision on the peduncle of the inflorescence) has been observed in different palm species (i. e. *Borassus aethiopum*, *Elaeis guineensis*, and *Phoenix reclinata*). In some cases, further distillation of the palm wine will result in highly alcoholic spirits (koutoukou in Côte d'Ivoire, akpeteshie in Ghana, sodabi in Benin), which have become important ceremonial drinks, very popular in parties, weddings and funerals.

2. – Construction material

Palm vegetative organs are frequently used as construction material of houses in the villages or more temporary structures in the countryside. The stems of *Borassus aethiopum* are used as columns, to produce planks or as stilts supporting wooden huts above the marshes in some villages of south-east Côte d'Ivoire. Palm petioles, rachises and leaflets of raffia palms (i. e. *Raphia hookeri*) are extensively used for roofing and building in southern Côte d'Ivoire, Benin (i. e. Ganvié) and Ghana. Where large palm stands available, the large leaf blades of *Borassus aethiopum* will be used to roof houses or construct fences. In southwest Ghana, the large entire bifid leaves of *Sclerosperma profizianum* are used to thatch and also fencing.

3. – Handcraft and furniture

A large diversity of handmade objects of daily uses are produced from palm organs. In particular the pinnae of *Elaeis guineensis* and leaf blade segments of *B. aethiopum*, and *Hyphaene thebaica* can be used to produce all kind of basketry, mats, fans, hats, ropes, fire starter, among others. Basketry is also produced from the ribbons of canes of rattan palms such as *Eremospatha macrocarpa* and *Laccosperma secundiflorum*. The stiff main veins of *Elaeis guineensis* and *Raphia hookeri* are also widely used to produce brooms and brushes in all studied countries. With respect of furniture made of palm stems or canes, we have observed in the cities of Abidjan, Grand-Bassam, Cotonou and Accra street sellers commercializing couches, chairs, stools, tables, bed frames made of *Raphia hookeri* and canes of rattan palms (*Eremospatha spp.*, *Laccosperma spp.*). More towards the North of the countries visited the furniture will be produced from the stems of *Borassus aethiopum* and the petioles of *Raphia sudanica*. Palm stems as building material is particularly interesting when used as stilts (i. e. Ganvié, Benin), given their lower weight compared to traditional wood and their resistance to termite damage. Traditional ropes made from the juvenile leaves of *Phoenix reclinata* were observed in south-east Ghana and Cotonou.

4. – Combustion material

Wood for fire becomes scant in West Africa as severe deforestation is a critical issue. An important source of combustion material is repre-

sented by a side product of oil palm production. After cooking and pressing the *Elaeis guineensis* fruits, the waste material (mesocarp and seed), still rich in oil content and of high calorific power, is packed in compact blocks that are commercialized in the villages as combustion material.

5. – Traditional clothing and artefacts

The young leaves of some raffia palms (i. e. *R. hookeri*) provide resistant fibers which are weaved for a wide range of traditional clothing. The Dida ethnic group in central-south Côte d'Ivoire is an excellent example of traditional weaving of fibers for the confection of ceremony clothes, known in the country as «pagnes dida». Exceptional pieces wore for the celebration of weddings, or the transition of the young lady to the mature stage, are time consuming and require of particular skills from the side of the weavers. This patrimonial and traditional weaving is manually carried out, but nowadays the weavers use simple looms to commercialize their production. Although rather expensive, wearing these clothes for special ceremonies is deeply rooted in the Dida ethnic culture and families will not spare any effort to buy (or rent) them. The traditional clothes are usually stained with dyes of vegetal or mineral origins, with the same pattern of colors. Fetishes and symbolic artefacts made from palm leaves are observed in ceremonies of most animist territories, particularly in Benin.

■ Conservation status

With only very few exceptions, palms in West Africa face important levels of threat and in absence of concrete conservation measures their survival will be clearly compromised in a near future. The main threats identified in our field surveys include: 1) human-induced destruction of natural habitats and 2) overexploitation of economically important species.

Severe destruction of natural habitats, either due to urban expansion or increase of agricultural and livestock farming activities, can be clearly observed in surrounding areas of cities and villages. As urban constructions expand, an increasing number of natural habitats suitable for palms are fragmented or in some extreme cases completely destroyed. The expansion of human populations is closely associated to the development of new surfaces dedicated to crop fields and livestock farming at different scales (smallholders, industrial). As a consequence, only isolated, adult palm individuals can be observed in these plantations and the recruitment of juveniles is

no longer possible. The central-southern and coastal regions of all countries studied are particularly under pressure, as large areas formerly occupied by natural savannas with *Hyphaene guineensis* and *Phoenix reclinata*, evergreen, rain forests with rattan palms (*Eremospatha* spp., *Laccosperma* spp.), several species of *Raphia* (i. e. *Raphia hookeri*, *R. palma-pinus*), and the rare arecoid genus *Sclerosperma*, are now completely destroyed.

The threat of overexploitation concerns all those palm groups for which one or more commercial uses have been identified. In the case of West African native palms this includes species in the genera *Borassus*, *Hyphaene*, *Eremospatha*, *Laccosperma* and *Raphia*. Overexploitation of leaves (petioles, rachis, and leaf blades) represents a severe threat for species such as *Borassus akeassii*, *B. aethiopum*, *Hyphaene thebaica* and *Raphia hookeri*, whereas the canes of *Eremospatha macrocarpa* (probably also those of *E. dransfieldii*) and *Laccosperma secundiflorum* become very rare due to their uncontrolled harvest for the manufacture of furniture. Palm wine extraction can be also considered as a potential threat for some palm species. In the case of *Borassus aethiopum*, overexploitation of palm wine is normally associated with a destructive method of tapping, the latter permanently damaging the apical meristem and leading to the death of the individual. An even more destructive method of palm wine tapping has been observed for *Elaeis guineensis* in Côte d'Ivoire, where instead of climbing the palm for tapping, the young individuals are sometimes felled off for this purpose.

An important number of areas visited in the frame of our study are preserved by a conservation status (i. e. National Park, National Reserve, and Forest Reserve); however, palm populations are only truly protected in conservation areas with more restrictive regulations (National Parks and National Reserves). Their presence in Forest Reserves or classified forests is clearly compromised given the wide range of activities and tolerance allowed there. Villagers in the surroundings of these preserved zones do not hesitate to fulfil their needs in construction material using the useful palms of the forest (rattan palms, *Raphia* spp.), and this was particularly true in the case of Côte d'Ivoire, where two ethno-political conflicts in the past 20 years devastated the country and largely put great pressure in the rich, forested areas in the south-west of the country. One interesting case is that of the «Sacred Forest», which represent small to mid-size forests usually preserved by the villagers for animistic ceremonies of initiation. These forests, for which no access is allowed to non-initiated people and botanical research in general, are becoming real sanctuaries of biodiver-

sity as they host palm species disappeared long time ago in surrounding areas. Indeed, they should be regarded as the last refuge for West African palms, in particular poorly known or undescribed species in the rattan genera (*Eremospatha*, *Laccosperma*), *Raphia* spp. and *Sclerosperma* spp. The islands of the rivers, especially those present in the four major rivers of Côte d'Ivoire (Comoé, Bandama, Sassandra, Cavally), also represent interesting sites to survey. In fact, preliminary studies carried out on at least one of these islands on the Sassandra river made it possible to observe interesting populations of rattans.

The project Multipalms (www.multipalms.org), a 3-year, multidisciplinary project carried out by the Conservatory and Botanical Gardens of Geneva, the Swiss Center for Scientific Research in Côte d'Ivoire (CSRS) and the University Abomey Calavi (Bénin), aims to contribute to the conservation of threatened native palms in West Africa by better understanding their vegetative and reproductive multiplication. Developing standardized protocols of palm reproduction under local nursery conditions will be a starting point to encourage local communities to preserve palm resources and to raise awareness on different ways of sustainable exploitation.

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Literature cited

- African Plants Database (version 3.4.0). Conservatoire et Jardin botaniques de la Ville de Genève and South African National Biodiversity Institute, Pretoria, «Retrieved on November 2020 from <<http://www.ville-ge.ch/musinfo/bd/cjb/africa/>>.
- Aké Assi L. 1995. Les palmiers (Arecaceae): taxonomie, chorologie, écologie et les diverses utilisations traditionnelles en Côte d'Ivoire. *G. Bot. Ital.* 129: 481.
- Aké Assi L. 2002. Arecaceae. In: Flore de la Côte d'Ivoire: Catalogue Systématique, Biogéographie et écologie. II. *Boissiera* 58: 202-205.
- Aké Assi L, Guinko S. 1996. Confusion de deux taxons spécifiques ou subspécifiques au sein du genre *Borassus* en Afrique de l'Ouest. In: Van der Maesen LJGX, Van der Burgt M, Van Medembach R (eds.), The Biodiversity of African Plants: 773-779. Proceedings.14th AETFAT Congress.
- Aké Assi L, Van der Maesen JG, Dransfield J. 2006. Arecaceae. In: Flore Analytique du Bénin (Van der Burg WJ, Van der Maesen JG, eds.) Wageningen Agricultural University papers, Backhuys Publishers. pp. 50-62.
- Arbonier M. 2009. Arbres, arbustes et lianes des zones sèches d'Afriques de l'Ouest. 3^e édition. Quae, MNHN, Paris, France 573 p.
- Baker WJ. 2008. Palmae. In: Plants of Angola (Figereido E, Smith GF, eds.) *Strelitzia* 22: 172-173.
- Baker WJ. 2015. A revised delimitation of the rattan genus *Calamus* (Arecaceae). *Phytotaxa* 197: 139–152.
- Barrow S. 1998. A Monograph of *Phoenix* L. (Palmae: Coryphoideae). *Kew Bull.* 53: 513-575.
- Bayton RP. 2007. A revision of *Borassus* L. (Arecaceae). *Kew Bull.* 62: 561-586.
- Bayton, RP, Ouédraogo A, Guinko S. 2006. The genus *Borassus* (Arecaceae) in West Africa, with a description of a new species from Burkina Faso. *Bot. J. Linn. Soc.* 150: 419-427.
- Beccari O. 1908. Le palme «Dum» od «*Hyphaene*» e più specialmente quelle dell'Africa italiana. *Agric. Colon.* 2: 137–183.
- Beccari O. 1910. Studio monografico del genere *Raphia*. *Webbia* 3 (1): 37-130.
- Brunel JF, Scholz H, Hiepko P. 1984. Flore analytique du Togo. Phanérogames. GTZ, Eschorn, 571 p.
- Burkhill HM. 1997. The Useful Plants of West Tropical Africa, (Families M-R), vol. 4, 2nd Ed. Royal Botanic Gardens, Kew.
- Chatelain C, Ake Assi L, Spichiger R, Gautier L. 2011. Cartes de distribution des plantes de Côte d'Ivoire. *Boissiera* 64: 1-327.
- Chevalier A. 1932. Nouvelles recherches sur les palmiers du genre *Raphia* (suite et fin). *Revue de Botanique Appliquée et d'Agriculture Coloniale* 12 : 198-213.
- Chevalier A, Dubois R. 1938. Les palmiers *Hyphaene* et *Borassus* de l'Afrique occidentale. *Revue internationale de botanique appliquée et d'agriculture tropicale* 198: 193-103.
- Combres JC, Eldin M. 1979. Éléments généraux du climat. In: *Atlas de Côte d'Ivoire*. Paris (FRA), ORSTOM, Office de la recherche scientifique outre mer, service cartographique.
- Dalziel JM. 1937. The useful plants of west tropical Africa. Crown Agents for the Colonies, London. 612 p.
- Donkor BN, Vlosky RP. 2003. A Review of the Forestry Sector in Ghana. Louisiana Forest Products Development Center, Working Paper, No. 61.
- Dransfield J. 1986. Palmae. In: *Flora of Tropical East Africa* (Polhill RM. ed.), Balkema AA, Rotterdam, Netherlands. 466 pp.
- Dransfield J, Uhl NW, Asmussen CB, Baker WJ, Harley MM, Lewis C. 2008. Genera Palmarum. The evolution and classification of Palms. Kew Publishing. Royal Botanic Gardens, Kew. 732 pp.
- Furtado CX. 1967. Some notes on *Hyphaene*. Garcia de Orta, *Revista de Junta de Investigacoes do Ultramar* 15: 427-460.
- Furtado CX. 1970. A new search for *Hyphaene guineensis* Thonn. GBS. 25: 311-334.
- Govaerts R, Dransfield J, Zona S, Hodel DR, Henderson A. 2020. World Checklist of Arecaceae. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet: <http://wcsp.science.kew.org/> Retrieved on May 2, 2021.
- Hawthorne W, Jongkind C. 2006. Palmae. Woody plants of Western African forests. A Guide to the forest trees, shrubs and lianes from Senegal to Ghana. Kew Publishing, Richmond. pp. 866-873.
- Hedberg I, Friis I, Persson E. 2009. Arecaceae. Flora of Ethiopia and Eritrea. Uppsala, vol. 1, p. 269.
- Hutchinson J, Dalziel JM. 1936 Palmae. In: Hutchinson J, Dalziel JM (Eds) *The flora of tropical West Africa*. 1, 2. Crown Agents for the Colonies, London, 386-392 pp.
- Irvine FR. 1961. Woody plants of Ghana. Oxford University Press. 868 pp.
- Jessell MW, Liégeois J-P. 2015. 100 years of research on the West African Craton. *Journal of African Earth Sciences* 112: 377– 381.
- Kahn F, Luxereau A. 2008. Doum palm habit and leaf collecting practices in Niger. *Palms* 52: 23-29
- Kouassi KE. 2007. Flore de la Forêt Classée de la Haute DODO, dans le Sud-Ouest de la Côte d'Ivoire. Etude de quelques de espèces commercialisées : Cas de *Garcinia afzelii* (Clusiaceae), des Rotins (Palmiers Lianes) des Genres *Calamus*, *Eremospatha* et *Laccosperma* (Araceae). Université de Cocody, Abidjan, 279 p.
- Kouadio K, Kouassi KE, Kouame NF, Traore D. 2005. Polymorphisme foliaire des espèces de rotins de la forêt classé de la Haute Dodo (Côte d'Ivoire). *Rev. Ivoir. Sci. Technolo.* 6: 259-279.
- Lieberman D, Hall JB, Swaine MD, Lieberman M. 1979. Seed dispersal by baboons in the Shai Hills, Ghana. *Ecology* 60: 65-75.
- Mann G, Wendland HA. 1864. On the palms of western tropical Africa. *Philosophical Transactions of the Linnean Society* 24: 421–439.
- Mbandu Luzolawo P, Lubini Ayingweu C, Mogue Kamga S, Stauffer FW. 2020. Palmae. Flore d'Afrique Centrale (Ed. M. S. M. Sosef). Jardin Botanique de Meise. 84 pp.

- Michon L, Adeoti J, Koffi K, Ewedje E, Stauffer FW. 2018. Notes on *Borassus aethiopum* Mart., a multiple purpose palm in Togo and Bénin. *PALMS* 62: 57-69.
- Mogue Kamga S, Sonké B, Couvreur TLP. 2019. *Raphia vinifera* (Arecaceae; Calamoideae): Misidentified for far too long. *Biodiversity Data Journal* 7: 1-16.
- Morakinyo AB. 1995. Profiles and pan-African distributions of the rattan species (Calamoideae) Recorded in Nigeria. *Principes* 39: 127-209.
- Neuenschwander P, Sinsin B, Gørgen G. 2011 Protection de la nature en Afrique de l'Ouest: Une Liste Rouge pour le Bénin. *Nature conservation in West Africa: Red List for Bénin*. IITA, Ibadan, Nigeria, 1-365.
- Niang I, Ruppel OC, Abdrabo MA, Essel A, Lennard C, Padgham J, Urquhart P. 2014. Africa. In: *Climate Change 2014: Impacts, Adaptation, and Vulnerability. Part B: Regional Aspects. Contribution of Working Group II to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change* [Barros VR, Field CB, Dokken DJ, Mastrandrea MD, Mach KJ, Bilir TE, Chatterjee M, Ebi KL, Estrada YO, Genova RC, Girma B, Kissel ES, Levy AN, MacCracken S, Mastrandrea PR, White LL (eds.)]. Cambridge University Press, Cambridge, United Kingdom and New York, NY, USA, pp. 1199-1265.
- Nicholson SE. 2005. On the question of the « recovery » of the rains in the West African Sahel. *Journal of Arid Environments* 63: 615-641.
- Otedoh, MO. 1982. A revision of the genus *Raphia*. *J. Nig. Inst. Oil Palm Res.* 6: 145-189.
- Ouattara D, Stauffer FW, Bakayoko A. 2014. Lectotypification de *Raphia sudanica* A. Chev. (Arecaceae, Calamoideae), et commentaires sur la biologie et la conservation de l'espèce. *Adansonia* 36: 53-61.
- Ouattara D, Ekpe P, Bakayoko A, Stauffer FW. 2015. Ethnobotany and conservation of palms from Ghana. *Palms* 59: 85-103.
- Ouattara D, Ekpe P, Bakayoko A, Stauffer FW. 2017. Aperçu sur l'importance socio-économique des palmiers (Arecaceae) au Ghana. *Principes* 2-3: 95-112.
- Ouédraogo A. 1999. Biomorphologie des rôniers (*Borassus* L.) du Burkina Faso. Mém. DEA. Université d'Ouagadougou, Burkina Faso. 69
- Palisot de Beauvois AM. 1804. Flore d'Oware et de Bénin en Afrique. Fain Jeune et Compagnie, Paris, 464 pp.
- Pan A, Jacobs B, Dransfield J, Baker W. 2006. The fossil history of palms (Arecaceae) in Africa and new records from the Late Oligocene (28–27 Mya) of north-western Ethiopia. *Botanical Journal of the Linnean Society* 151: 69–81.
- Russell TA. 1965. The *Raphia* palms of West Africa. *Kew Bulletin* 19 (2): 173-196.
- Sambou B, Goudiaby A, Ervik F, Diallo D, Camara MC. 2002. Palm wine harvesting by Bassari threatens *Borassus aethiopum* populations in north-western Guinea. *Biodiv & Cons.* 11: 1149-1161.
- Stauffer FW, Ouattara D, Stork AL. 2014. Palmae. pp 326-354 in Lebrun, JP, Stork AL (eds.). *Tropical African Flowering Plants: Monocotyledons* 2, vol. 8. Conservatoire et Jardin botaniques de la Ville de Genève, Switzerland.
- Stauffer FW, Ouattara DN, Roguet D, da Giau S, Michon L, Bakayoko A, Ekpe P. 2017. An update to the African palms (Arecaceae) floristic and taxonomic knowledge, with emphasis on the West African region. *Webbia* 72: 17-30.
- Sunderland TCH. 2001. Les ressources en rotin et leur utilisation en Afrique occidentale et centrale. *Unasylva* 52: 18-24.
- Sunderland TCH. 2003. Two new species of rattan (Palmae: Calamoideae) from the forests of West and Central Africa. *Kew Bull.* 58: 987-990.
- Sunderland TCH. 2007. Field guide to the rattan palms of Africa. Kew publishing, Royal Botanic Gardens, Kew, Richmond, United Kingdom. 66 p.
- Sunderland TCH. 2012. A taxonomic revision of the rattans of Africa (Arecaceae: Calamoideae). *Phytotaxa* 51: 1-76.
- Thione LA. 2000. Biologie de la reproduction et étude de l'impact de l'exploitation des feuilles et des fruits sur la productivité de *Borassus aethiopum* Mart. PhD Thesis: Cheikh Anta Diop University, Dakar.
- Tuley P. 1995. The Palms of Africa. The Trendrine Press, UK, 189 pp.
- Van Valkenburg JLCH, Dransfield J. 2004. *Hyphaene guineensis*. *Palms* 48: 10-16.
- Van Valkenburg JLCH, Sunderland TCH. 2008. A revision of the genus *Podococcus* (Arecaceae). *Kew Bull.* 63: 251-260.
- Van Valkenburg JLCH, Sunderland TCH, Couvreur TLP. 2008. A revision of the genus *Sclerosperma* (Arecaceae). *Kew Bull.* 63: 75-86.
- Villeneuve M, Cornée JJ. 1994. Structure, evolution and palaeogeography of the western African craton and bordering belts during the Neoproterozoic: *Precambrian Research* 69: 307-326.
- White F. 1983. La végétation de l'Afrique. Paris, UNESCO. 385 p.

