The genus *Borassus* (Arecales) in West Africa, with a description of a new species from Burkina Faso

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*Borassus akeassii* Bayton, Ouédraogo & Guinko sp. nov. (Arecales) is described as a new species from western Burkina Faso in West Africa. It has been confused with the widely distributed African species *B. aethiopum* and more recently with the Asian *B. flabellifer*. However, it is distinguished by its glaucous, green leaves with weakly armed petioles and a characteristic pattern of lamina venation. The fruits have a pointed apex and are greenish when ripe, and the flowers of the pistillate inflorescence are arranged in three spirals. The pollen has a reticulate tectum and distinctive ornamentation. The distribution of *B. akeassii* is discussed and the status of the varieties of *Borassus aethiopum* (var. *bagamojensis* and var. *senegalensis*) is examined. © 2006 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2006, 150, 419–427.

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INTRODUCTION

The genus *Borassus* L. (Coryphoideae: Borassaeae) contains between five and seven species of massive dioecious fan palms that are distributed across tropical Africa and Asia. Species delimitation is problematic and several taxa were described from limited herbarium material. These massive palms do not easily conform to conventional collection and storage protocols, and, in addition, a number of type specimens are missing. The most recent taxonomic account of the genus is that of Beccari (1924), who recognized seven species. However, subsequent studies suggest that not all of these can be maintained (Dransfield, 1986a; Bayton, Obunyali & Ranaivojaona, 2003).

The taxonomy of African *Borassus* has received only limited attention. Beccari (1924) recognized two species (plus two varieties), although these were reduced to a single species (with no varieties) by Dransfield (1986a). Modern treatments follow Dransfield and recognize only *B. aethiopum* Mart. in mainland Africa (e.g. Tuley, 1995). However, in 1996, a description was published of a West African *Borassus* palm that differed morphologically from *B. aethiopum* and that resembled the Asian *B. flabellifer* L., as yet unknown in Africa (Aké Assi & Guinko, 1996). Subsequently, more detailed accounts of the morphology of this palm in Burkina Faso were published (Ouédraogo, 1999; Ouédraogo et al., 2002). In 2004, the present authors participated in a joint expedition in Burkina Faso, the purpose of which was to collect herbarium specimens of the native *Borassus* palms as part of an ongoing project by the first author to revise the genus *Borassus* across its geographical range. Inspection of living and herbarium material of the unidentified palm revealed several characters that distinguish it from both *B. aethiopum* and *B. flabellifer*, and it is described here as a new species.

MATERIAL AND METHODS

Herbarium material was kindly loaned by the following herbaria: Herbarium Jutlandicum of the Univer-
sity of Aarhus (AAU), the Bailey Hortorium of Cornell University (BH), Fairchild Tropical Botanic Garden, Miami (FTG), and the Muséum National d’Histoire Naturelle, Paris (P). In addition, the collections at the Royal Botanic Gardens, Kew (K), and the Université de Ouagadougou (OUA) were consulted. Most of the measurements and other details that follow are based upon inspection of herbarium material. However, living material of *Borassus* was examined *in situ* in Burkina Faso and Kenya.

In Burkina Faso, herbarium material was collected from *Borassus* populations in both the east and the west of the country. Ouédraogo *et al.* (2002) identified the populations in eastern Burkina Faso as *B. aethiopum*, while those in western Burkina Faso comprise the unidentified *Borassus* species attributed to *B. flabellifer* (Aké Assi & Guinko, 1996; Ouédraogo *et al.*, 2002). Material was collected at several localities in the eastern provinces of Kompienga and Tapoa, and in the western province of Comoé. Precise collection localities are given in Ouédraogo (2003).

Material of *B. aethiopum* was examined and collected by the first author at a number of sites in Kenya, and details of these localities can be found in Bayton *et al.* (2003).

Pollen was extracted from herbarium specimens of staminate palms and was acetolysed according to standard methods (Erdtman, 1969). The acetolysed pollen was placed on the surface of a specimen stub and left to dry. The stub was coated with gold using a sputter-coater, and was examined using a Hitachi S-2400 scanning electron microscope (SEM).

The conservation status of the new species was assessed using the IUCN Red List Category criteria (IUCN, 2001).

**DESCRIPTION**

**BORASSUS AKEASSII** Bayton, Ouédraogo & Guinko SP. NOV. (FIG. 1)

*Borassus flabellifer* L. affinis sed fructibus viridibus apicibus acutis, foliis glaucis et petiolis viridibus margine inermibus, pollinis granis monosulcatis gemmatis dense tectis recedit.

*Typus:* Burkina Faso: Comoé Province: Département de Banfora: 1 km south of Banfora, 20.i.2004 (♀), Bayton *et al.* 69 (holotypus K, isotypi FTG, OUA).

Diocious, pleonanthic palm. Trunk solitary and ventricose, to 15 m tall, grey, with prominent leaf scars. Leaves glaucous green, between 8 and 22 in crown, though leaf harvesting is common; costapalmate with costa 22–28 cm long; petiole rounded abaxially and flattened adaxially, 90–160 cm long, 3–7.4 cm wide at the junction with the lamina, vivid green in colour, margins black, with sharp edges or minute spines 0.2–0.6 cm long, juvenile palms with somewhat larger spines ± 1 cm long; adaxial hastula 1.1–2.4 cm long, abaxial hastula inconspicuous, 0.3–0.9 cm long; lamina divided to 60–99 cm, with 45–82 segments, segments 2.8–7.3 cm wide, some with brown indumentum, shortest segments between 58 and 147 cm long. Stamine inflorescence axillary, to 80 cm long, branching to 2 orders; prophyll not seen; peduncle short; peduncular bracts and rachis bracts similar, bicarinate, to 30 cm long, greenish yellow with green stripes, apices soft and blunted; rachis green, flattened, terminating in 1–3 rachillae; rachillae 23–36 cm long, 2.3–2.5 cm wide, green–brown in colour, with a constricted apex; rachillae catkin-like, densely covered in imbricate bracts forming small pits; cincinni of 5–10 flowers within pits, one to several flowers emerging at a time. Stamine flowers subtended by 2 bracteoles ± 2 × 0.5 mm, calyx ± 5 mm long, tubular, divided into 3 shallow lobes; receptacle ± 4.8 × 1.8 mm, bearing 3 petals to 1.4 mm long; stamens 6, filaments 3 × 1 mm, bearing anthers ± 0.9 × 0.5 mm; pollen yellow. Pistillate inflorescence to 110 cm long, unbranched, or branching to 1 or 2 orders, branching occurring either within the flower-bearing portion or below it; prophyll not seen;

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**Figure 1. Borassus akeassii** *sp. nov.* a, habit, with scarring of the stem caused by wine extraction. Scale bar (1) = 1 m. b, unarmed petiole. Scale bar (2) = 10 cm. c, armed petiole from juvenile palm. Scale bar (2) = 10 cm. d, section of leaf segment. Scale bar (3) = 5 cm. e, leaf venation pattern (detail of section from d). Scale bar (4) = 1 cm. f, section of stamine inflorescence with one rachilla. Scale bar (5) = 10 cm. g, staminate rachilla with flowers emerging from pits. Scale bar (6) = 1 cm. h, multiple staminate flowers emerging from rachilla pit (detail of section from g). Scale bar (4) = 1 cm. j, partial pistillate inflorescence without flowers. Scale bar (2) = 10 cm. k, branched pistillate infructescence *in situ.* a & k, drawn from photographs at Kew; b & d–f, Bayton, 74; c, Bayton, 72; g–h, Bayton 73; j, Bayton 69. Drawn by Lucy T. Smith.

peduncular bracts bicarinate, to 30 cm long; rachis to 80 cm long; flower-bearing portion of axis 24–39 cm long, covered in densely crowded bracts; ±23 flowers, arranged in 3 spirals. **Pistillate flowers** ovoid and to 3 cm diameter; perianth segments 6, orbicular with an apiculate apex. Fruit glaucous green when ripe, ovoid to ellipsoid, with somewhat pointed apex, ±15 cm long and ± 12 cm wide, though variation owing to the number of pyrenes in the fruit; mesocarp yellow and fragrant, with longitudinal fibres in the pulp; pyrenes 6.8–9.3 × 5.4–7.5 cm, with 1–3 per fruit. **SEEDS** 1 in each pyrene, with hard white endosperm, seed almost filling endocarp; embryo apical, ±4 × 3 mm.

**Pollen.** Monosulcate and elliptical: the longest axis in polar view (L) is 51–72 µm long and the polar axis in equatorial view (h) is 49–61 µm long; aperture is almost as long as L at 47–61 µm; tectum reticulate, with dense covering of psilate gemmae; gemmae 1.8–2.7 µm diameter, though size decreasing towards the sulcus (see Figs 2–7).

**Additional note.** The dried leaves of *B. akeassii* exhibit a rather distinctive venation pattern compared with other *Borassus* species (see Figs 8–10). The spacing between the commissural veins is greater in *B. akeassii* (5–7 veins cm⁻¹) than in either *B. aethiopum* (10–15 veins cm⁻¹) or *B. flabellifer* (11–18 veins cm⁻¹). Consequently, less support is provided to the surface layers of the leaf, and upon drying they collapse into the lacunae, producing a characteristic pattern of rectangular sunken pits. In comparison, the dried leaves of both *B. aethiopum* and *B. flabellifer* have a smooth texture and the lacunae are barely visible.

**Distribution.** Restricted to West Africa (Fig. 11). Aké Assi & Guinko (1996) reported that the palm is present in Benin, Burkina Faso, Côte d’Ivoire, Mali, Niger and Nigeria. *Borassus* sp. aff. *flabellifer* described by Arbonnier (2004) can be assigned to *B. akeassii* based on the description and photographs. In addition to the previous countries, it was recorded in Senegal and the Central African Republic. The range of *B. akeassii* may be much wider than suggested owing to misidentification of the palm as *B. aethiopum*. A fragmentary specimen at K that includes only a single mature leaflet (*Liben* 2822) has the same venation pattern as leaves of *B. akeassii*, but this specimen was collected in south-eastern Congo (Zaire), a considerable distance from the known localities for *B. akeassii*. In Burkina Faso, the major populations are in Comoé and Léraba Provinces in the south-west. However, a few specimens are found outside this area, including in the major cities of Ouagadougou and Bobo-Dioulasso.

**Habitat and ecology.** Sudanian and Sudano-Guinean savannas with 800–1100 mm annual precipitation, often in close proximity to human settlements. In Burkina Faso it is the common palm in the western provinces. Vast areas of land are populated with *B. akeassii*, with food and cash crops (particularly cotton) growing beneath the palms. *Borassus akeassii* is exploited in several ways, though wine production is the most significant of these. The apical bud is hollowed out and the resulting sap is collected and fermented. Endosperm from the seeds of immature fruits is harvested and consumed, and the leaves are collected for thatch and basketry. *Borassus akeassii* shows a preference for well-drained soils and is fire-resistant (Arbonnier, 2004). Little is known about its ecology outside the sphere of human influence.

**Conservation status.** *Borassus akeassii* exists in close proximity to human settlements, and provides a large number of useful products. Therefore, there is a risk of over-exploitation, although in Burkina Faso the species is abundant. Populations of *B. aethiopum* (?) are threatened by over-exploitation in Senegal (Sambou, Lawesson & Barfod, 1992) and Guinea (Sambou et al., 2002). There is a lack of accurate information regarding the population size and geographical range of *B. akeassii*. Therefore, the Red List Category of Data Deficient (DD) is selected. With the identification of *B. akeassii* as a new species, it is hoped that more information on its distribution and frequency will be collected, allowing a re-assessment.

**Etymology.** This species is named in honour of Professor Laurent Aké Assi of the Université d’Abidjan in Côte d’Ivoire. Professor Aké Assi (together with SG) provided the first description of the palm which is named here (Aké Assi & Guinko, 1996). In addition, his overall contribution to West African botany cannot be overstated.

**Other specimens examined.** BURKINA FASO: Comé Province: Département de Banfora: 1 km west of Siniana village, 20.1.2004 (♂), Bayton et al. 68 (AAU, K, OUA); 500 m north of Lake Tengrela, 22.1.2004 (juc.), Bayton et al. 72 (K, OUA); 3 km north of Banfora, 22.1.2004 (♀), Bayton et al. 73 (AAU, K, OUA); (♂), Bayton et al. 74 (AAU, K, OUA); village of Wolonkoto, 29.vii.1998, Ouédraogo & Boussim 9 (OUA); Houet Province: Département de Bobo-Dioulasso: village of Dinderesso, 28.vii.1998, Ouédraogo & Boussim 8 (OUA); Kadiogo Province: Ouagadougou, Centre-ville, 4.vii.1998, Ouédraogo 4 (OUA); Somgandé, 18.vi.1998, Ouédraogo & Guinck 2 & 3 (OUA); Forêt classée de Ouagadougou, 5.vii.1998, Ouédraogo 5 (OUA). SENEGAL: Région de Louga: Département de Linguere: Vellingara in Ferlo, east of village, 30.x.1989 (♂),

DISCUSSION

*Borassus akeassii* (Fig. 1) most closely resembles the Asian *B. flabellifer*, and has been likened to this species by previous authors (Aké Assi & Guinko, 1996; Lawesson 5444 (AAU); Région de Thiès; Département de Mbour: village of Ndianda near Joal, 7.xii.1997 (juv.), Ervik & Sambou 307 (AAU); ♀, Ervik & Sambou 308 (AAU); ♂, Ervik & Sambou 309 (AAU); Senegambia, 1840, Brunner s.n. (K).

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Ouédraogo et al., 2002). However, *B. flabellifer* is absent from Africa. Both taxa appear to be rather smaller in overall stature than *B. aethiopum*. In West Africa, this difference in stature has been attributed to the intensive harvesting of sap for wine production (Portères, 1964). Palm wine production in Burkina Faso entails hollowing out the apical bud, which causes massive damage to the palm. The petiole spines of both *B. flabellifer* and *B. akeassii* are small. However, the petiole of *B. akeassii* is variable and can have an unarmed margin (in older trees) or large spines (in juvenile trees).

The petioles of *B. akeassii* are green whereas those of *B. flabellifer* are yellow, and the mature fruits of *B. flabellifer* have a dark black skin whereas those of *B. akeassii* are green at maturity. The pistillate inflorescence of *B. akeassii* has a long rachis and a short flower-bearing portion, and the pistillate flowers are arranged in three spirals. In *B. flabellifer*, the proportions are different, with a short rachis and a long...
flower-bearing portion. The flowers are arranged in two spirals. Branching in the pistillate inflorescence is common in populations of B. akeassii. In a sample of 100 pistillate trees in western Burkina Faso, 47% of trees and 31% of inflorescences showed some degree of inflorescence branching, whereas in eastern Burkina Faso, inflorescence branching was not detected in B. aethiopum. This character has been cited as being of taxonomic significance (Ouedraogo et al., 2002). However, given the destructive nature of the tapping procedure used in Burkina Faso, it is possible that the branching occurs due to damage of the apical bud, and so this character should be treated with caution. It is worth noting that the illustration selected as lectotype for B. flabellifer (see Moore & Dransfield, 1979) shows a branched pistillate inflorescence, and branching also occurs rarely in pistillate inflorescences of B. aethiopum (Dransfield, 1986a).

Borassus aethiopum is a common species in West Africa including Burkina Faso, where it is found in the eastern part of the country. It differs from B. akeassii in that its petioles are yellow, with large spines on the margins, even in mature plants. The lamina of B. akeassii can be distinguished from that of B. aethiopum even in herbarium material, as the dried leaves have a characteristic pattern of large sunken lacunae (see Figs 8–10). This character is found in all material of B. akeassii, but has also been found in one immature specimen of B. aethiopum collected in Kenya (Dransfield 4810). It seems unlikely that B. akeassii is present in East Africa, and mature leaves collected at the same locality can be readily assigned to B. aethiopum.

The fruits of B. aethiopum are large, yellow–orange at maturity and with a flattened apex. As in B. flabellifer, the pistillate inflorescence has a short rachis, and the flower-bearing portion is long. The pistillate flowers are arranged in two spirals. The staminate flowers of all Borassus species are arranged in cincinni, which are sunken in pits on the rachillae formed from imbricate rachilla bracts. When the staminate rachillae of B. akeassii were examined in the field, it appeared as though several male flowers were emerging from their pits simultaneously. This differs from the situation in other Borassus species where flowers emerge singly. However, this character is difficult to examine in herbarium material as the staminate flowers detach rapidly upon collection of the rachillae.

Aké Assi & Guinko (1996) noted that the stem of B. akeassii is more slender, and there are fewer leaves in the crown, when compared with B. aethiopum. Examination of living material has shown that the stems of both species become ventricose. However, most specimens of B. akeassii have a stem pitted with scars, revealing a long-term history of exploitation for wine production (Fig. 1). The overall appearance of the crown of leaves in B. akeassii is different to that in B. aethiopum, and indeed many of the herbarium specimens include mature leaves of rather small dimensions. However, with the harvesting of both leaves and sap widespread within populations of B. akeassii, these characters may be anthropogenic.

The pollen of tribe Borasseae was reviewed in 1986 but only two species of Borassus (B. aethiopum and B. flabellifer) were included (Ferguson, Havard & Dransfeld, 1986). Although there appeared to be some slight differences in overall size and in the size of the gemmae, the small sample size made it impossible to assess the extent of variation within the two species. The present study demonstrates that pollen of both B. aethiopum and B. flabellifer (Figs 2, 3, respectively) are rather similar, in terms of both size and ornamentation. However, B. akeassii (Figs 4–7) has distinctive pollen. The covering of gemmae on the tectum is so dense as to make the tectum itself almost invisible, whereas in the other two species, the gemmae are widely spaced. Close examination reveals that the tectum is reticulate in B. akeassii rather than finely perforate as in B. aethiopum and B. flabellifer. The diagnostic characters of B. akeassii are contrasted with those of B. aethiopum and B. flabellifer in Table 1.

The specimens used to typify the names of several Borassus species are missing. The type of B. aethiopum (Thonnin 258) was collected in modern-day Ghana, but is now lost (Hepper, 1976). This absence of type material could create a nomenclatural dilemma in the light of the recognition of two Borassus species in West Africa. However, modern herbarium material collected close to the type locality of B. aethiopum can be confidently assigned to that species.

The varieties of B. aethiopum (var. bagamojensis Becc. and var. senegalensis Becc.) were not recognized by Dransfield (1986a), on the basis that the pyrene characters which were used to define them vary considerably within the pyrenes from an individual tree. Numerous fruits develop on each infructescence, and each fruit may contain between one and three pyrenes. The number of pyrenes in a fruit and the position on the infructescence has a formative effect on the size and shape of the pyrenes, so these characters are insufficient to delimit taxa. In the absence of vegetative material, it is impossible to identify African Borassus pyrenes to species with confidence, and although it is appropriate that the varieties should be reduced to synonymy, the diagnostic characters are not sufficient to determine with which species they should be placed in synonymy (either B. akeassii or B. aethiopum). A third variety was described by Chevalier (in Chevalier & Dubois, 1938), although the
absence of a Latin diagnosis renders the name invalid. This variety (var. domestica) had yellow–green fruits at maturity and could conceivably be synonymous with *B. akeassii*. The designated type was collected in Mali and comprises pyrenes only. Without leaf material, it is impossible to determine the true identity of this specimen.

Species delimitation in *Borassus* is problematic in large part owing to the difficulties associated with collecting material of these massive palms. In addition, many characters of taxonomic significance in the genus (and in palms in general) are of greater value in the field when examining living material than when restricted to herbarium specimens. The combination of pollen and gross morphological characters presented in Table 1 is sufficient to distinguish the *Borassus* species in West Africa. Molecular data not presented here also confirm the distinctiveness of this species and suggest affinities with species other than *B. aethiopum* or *B. flabellifer* (R. P. Bayton, W. J. Baker & C. E. Lewis, unpubl. data). The recognition of *B. akeassii* may stimulate future research, which could explore the distribution and conservation status of this extremely useful palm.

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