

## *Artocarpus bergii* (Moraceae), a New Species in the Breadfruit Clade from the Moluccas

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**Abstract**—*Artocarpus bergii*, named for the late C. C. Berg, is from Halmahera in the Moluccas, and is a close ally of breadfruit (*A. altilis*). The species resembles the Micronesian *A. mariannensis* but with generally smaller parts. Because it is known from only a small area and the type locality is a potential mining site, *A. bergii* is likely of conservation concern, particularly given its status as a crop wild relative.

**Keywords**—Crop wild relatives, Halmahera, Maluku.

*Artocarpus* J.R. Forst. and G. Forst. (Moraceae) contains about 70 species of trees, distributed from India to the Solomon Islands, with a center of diversity in Borneo (Williams et al. 2017). Among its species are several high-yield but underutilized crops that may help improve food security in tropical regions, in particular breadfruit (*A. altilis* (Parkinson) Fosberg) and jackfruit (*A. heterophyllus* Lam.) (Zerega et al. 2010; Jones et al. 2011). We present a new species of *Artocarpus* collected during a biodiversity inventory at a potential nickel mining site near Weda Bay, Halmahera, Maluku Utara (North Maluku), Indonesia.

A close ally of cultivated breadfruit (*A. altilis*) and breadnut (*A. camansi*), this is the first new species described in the breadfruit clade in more than 50 yr (Jarrett 1959). The type locality is rich in metal hyperaccumulating plants (Lopez et al. 2019). Additional research on this new crop wild relative would be of interest to determine whether it has natural stress resistance or is able to phytoremediate heavy metals. This type of information could be valuable in possible breeding programs to expand the environmental tolerance of breadfruit and breadnut. With its attractive foliage and potentially edible fruits (inferred from its phylogenetic allies), the new species may have horticultural or agronomic potential as well.

*Artocarpus bergii* E.M. Gardner, Arifiani, and Zerega, sp. nov. TYPE: INDONESIA. North Maluku Province, East Halmahera, Weda Bay, Doromesmesan, primary forest, 47 m, 24 Dec 2012, *Iska Gushilman* & al. 285 (holotype: BO!; isotypes (MO!, L).

Differs from *A. horridus* F.M. Jarrett in the subglabrous, entire leaves on mature trees and slenderer staminate inflorescences; from *A. mariannensis* Trécul in the entire leaves on mature trees (compared to up to 3–7 lobes on mature *A. mariannensis*); and from *A. teijsmannii* Miq. by the absence of both interfloral bracts and sterile filiform processes between perianths of adjacent flowers in *A. bergii*.

Trees, monoecious, height to at least 22 m; outer bark whitish grey to greenish brown, fairly smooth with shallow fissures, inner bark brownish red; latex white. **Young twigs**

3.5–6 mm thick, appearing smooth but minutely whitish appressed-puberulous; lenticels scattered in loose rings below the nodes, amplexicaul stipular scars ca. 1 mm broad, prominent. **Stipules** amplexicaul, 33–61 mm long, lanceolate, densely appressed whitish to rufous-puberulous (to sparsely patent pubescent), but rufous subsericeous toward the margins and the apex. **Leaves** spirally arranged, lamina subcoriaceous, elliptical to sub-ovate, 11–29 × 5–14.5 cm, apex short-acuminate, acute to nearly rounded, base acute to obtuse, attachment barely inequilateral; upper surface dark green, (sub)glabrous; lower surface pale green, minutely whitish appressed-puberulous in the areoles to sparsely to densely longer whitish or brownish puberulous on the veins, scabridulous; margin entire to repand; main veins flat above, prominent beneath; lateral veins 7–15 pairs, yellow-green, drying reddish, ascending, nearly straight, only occasionally forked or looping back at the margin, tertiary venation scalariform, indistinct above, slightly prominent below; petiole 21–40 × 1.5–3 mm, pale green, drying dark brown, striate, epidermis persistent, glabrous to sparsely and minutely whitish appressed-puberulous (to sparsely patent pubescent). Leaves on juvenile trees probably pinnatifid (see notes below). **Staminate inflorescence** (at anthesis) in leaf axil, solitary; peduncle 38–54 × 2 mm, pale green, drying dark brown, minutely whitish appressed-puberulous; head spicate, 70–150 × 7–13 mm, yellow, more or less smooth, covered by flowers; perianths tubular, ca. 0.8 mm long, bilobed above, minutely whitish hispidulous; stamens ca. 1 mm long, filament cylindrical, anther-cells ovate, ca. 0.4 mm long; interfloral bracts absent. **Pistillate inflorescence** (post-receptive) in leaf axil, solitary; peduncle 66–70 × 2.5 mm, pale green, drying dark brown, minutely whitish appressed-puberulous; head cylindrical, 50–58 × 18–23 mm green, densely but minutely whitish hispidulous; perianth apices cushion-shaped, ca. 1.5 mm wide and 1 mm long; bifid styles deflexed, exserted to ca. 0.5 mm; interfloral bracts absent. **Syncarp** cylindrical, 45–70 × 18–25 mm; surface yellow when ripe, covered with cushion-shaped

processes, ca. 1.5–2.5 mm wide, minutely whitish hispidulous; flesh not seen; interfloral bracts absent; subtended by a ring of sterile processes; wall ca. 2 mm thick; core ca. 7 mm across; fruiting perianths numerous; proximal regions of adjacent perianth tissue free, middle regions fused, and apical regions slightly raised, "seeds" (endocarps) (immature) ellipsoid, ca. 6 × 4 mm, style attachment sub-apical; peduncle 66–70 × 2.5 mm, minutely whitish

appressed-puberulous (to sparsely patent pubescent). Figures 1 and 2.

#### DISTRIBUTION AND HABITAT

The species is found in the Maluku Islands, North Maluku Province: Halmahera (Fig. 3), in primary to degraded forest, from open places near the shoreline at 14 m to at least 300 m in altitude.

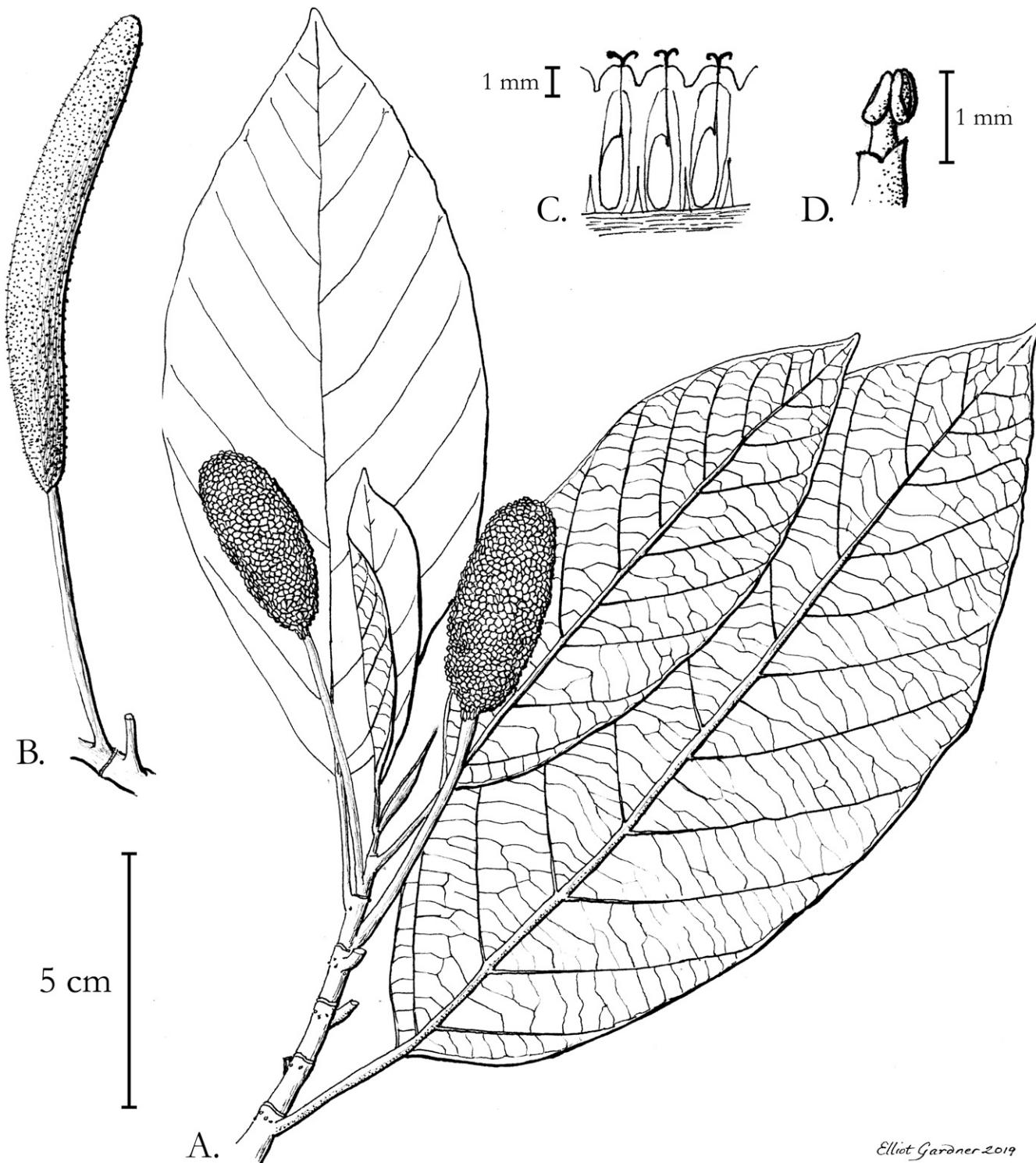


FIG. 1. *Artocarpus bergii*. A. Leafy twig with immature syncarp. B. Staminate inflorescence. C. Pistillate flowers. D. Staminate flower. (Drawn by EMG from R. Mahroji 160 and I. Gushilman 285).



FIG. 2. Field images of *Artocarpus bergii*. A. Underside of spirally arranged leaves. B. Stipule scars. C. Stamineate inflorescence and stipule. D. Stamineate inflorescence at anthesis. E. Syncarp with white exudate. F. Syncarp and upper side of spirally arranged leaves. Scale bars are estimated based on herbarium specimens of these collections. All images are available under a Creative Commons Attribution Licence 3.0: (A, B, C, D: Idris Haris 26; photo credit I. A. Haris at <http://www.tropicos.org/Specimen/100547538?tab=images>), and (E, F: Roji Mahroji 160; photo credit T. J. F. Bangun at <http://www.tropicos.org/Specimen/100560823?tab=images>).

#### PROVISIONAL CONSERVATION ASSESSMENT

**Vulnerable.** *Artocarpus bergii* is recorded only from the Indonesian province of North Maluku (Maluku Utara). Within the province, all collections are from Halmahera, and were made in either the 1920s and 1930s, or in 2012/2013. Among the more recent collections, they are all known only from a biodiversity inventory that was conducted ahead of a potential mining operation. Thus, the only known populations from recent collections may be considered at risk of severe disturbance.

#### ETYMOLOGY

*Artocarpus bergii* is named in memory of the late C. C. Berg, in recognition of his lifetime of work on the Moraceae in general, including *Artocarpus*.

#### NOTES

Recent phylogenetic analysis of *Artocarpus* included near complete taxon sampling (96%) across the genus, using 517

nuclear loci (exons and flanking non-coding sequences). Taking into account the impact of paralogs, codon partitions, noncoding sequences, and analysis methods (i.e. species tree versus concatenated supermatrix) on phylogenetic reconstruction, *A. bergii* is placed with strong support in the breadfruit clade (along with *A. altilis* (Parkinson) Fosberg, *A. camansi* Blanco, *A. mariannensis*, and *A. horridus* F.M. Jarrett) (Gardner et al. 2020) (Fig. 4).

In her notes following the protologue to *A. horridus*, Jarrett (1959) noted the existence of subglabrous material (here assigned to *A. bergii*) whose entire leaves and slender stamineate inflorescences did not match the *A. horridus* type, which has pinnatifid leaves, proportionally wider stamineate inflorescences, and abundant sharp, hispid hairs. Jarrett (1959) suggested that perhaps the type came from a juvenile tree and that mature *A. horridus* trees may have entire leaves. However, material with pubescent pinnatifid leaves matching the *A. horridus* type has been collected from trees over 25 m tall (e.g. (exp. Kostermans) Tangkilisan 178, bb33864 (L)). Mature trees of *A. bergii* seem clearly to have entire leaves. A specimen of *A. bergii* with pinnatifid leaves (e.g. Beguin 2223 (L)) may come from a juvenile tree. Notably, the lobes of that specimen are

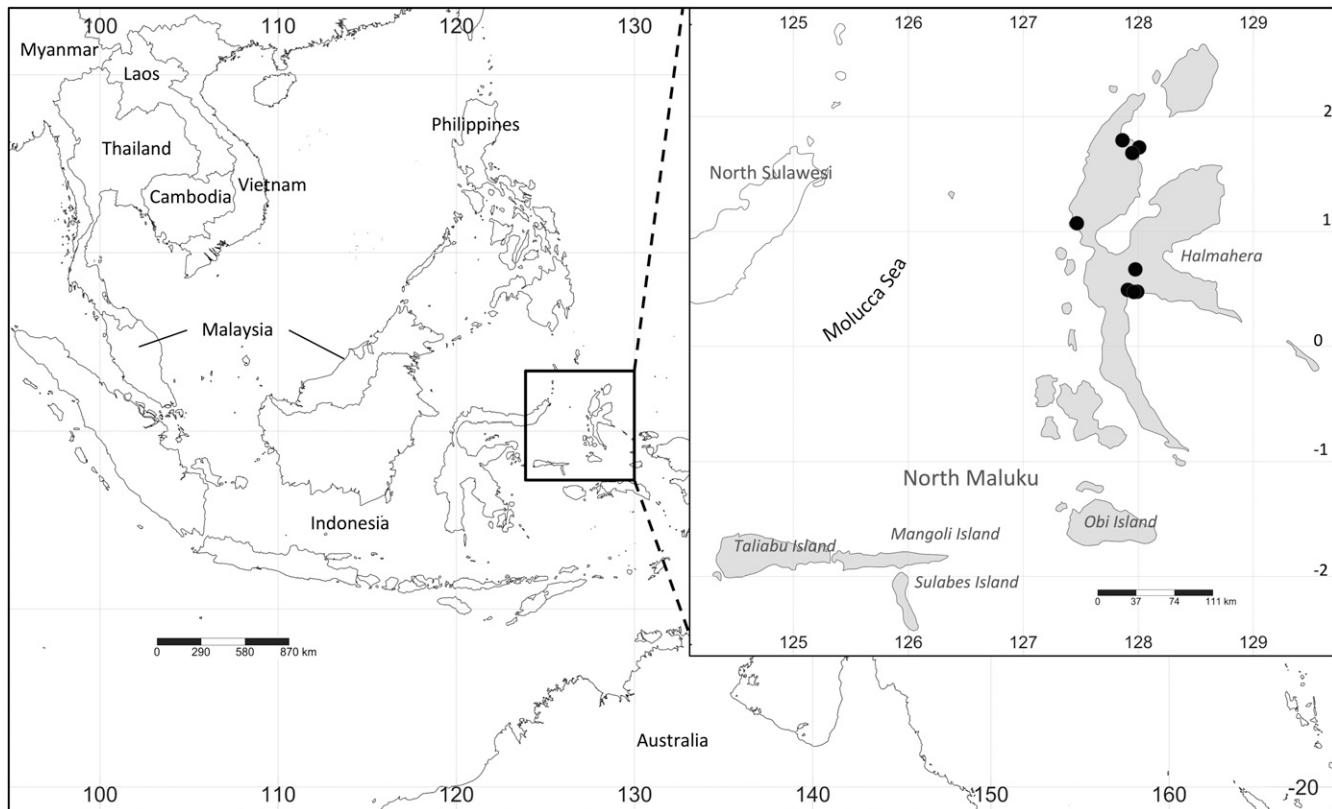


FIG. 3. Map showing the distribution of *Artocarpus bergii*. The boxed area in the main map shows the region of focus in the inset map. The province of North Maluku is highlighted in gray. Locations of *A. bergii* specimens are indicated with black circles.

much shallower and fewer in number than in *A. horridus*. Pinnatifid leaves in juveniles is not uncommon in the clade to which *A. bergii* belongs. Finally, if the subglabrous, entire leaved specimens that Jarrett (1959) assigned to *A. horridus* (and that we assign here to *A. bergii*) were indeed just the mature version of *A. horridus*, the marked difference in the

staminate inflorescences between juvenile and mature trees would be highly unusual within *Artocarpus*. We note another entity sister to *A. horridus*, from Buru island in the Maluku province of Indonesia, designated “*Artocarpus* sp. 1” in Fig. 4. Although it was consistently sister to *A. horridus* in phylogenetic analyses and is a mature tree with pinnately lobed leaves, it differs notably in its almost completely glabrous vegetative parts and much larger syncarps. This putative species deserves further investigation. Rumphius recognized two species within *Soccus silvestris*, the first corresponding to *A. horridus* and the second probably corresponding to the entity from Bulu or perhaps less likely to *A. bergii* (Rumphius 1741).

*Artocarpus bergii* also resembles the Pacific *A. mariannensis*, in the shape of both its adult leaves (entire or shallowly lobed rather than pinnatifid as in *A. altilis* and *A. camansi*) and inflorescences. It may, however, be easily distinguished from *A. mariannensis* not only by its geographic range, but also by its generally more slender parts, both vegetative (leaves in *A. mariannensis* reach up to 21 cm wide vs. 14.5 cm in *A. bergii*) and reproductive (staminate inflorescences in *A. mariannensis* range up to 35 mm in diameter vs. up to 13 mm in *A. bergii*; syncarps in *A. mariannensis* range from 70–110(180) mm × 50–85(120) mm wide in *A. mariannensis* vs. 45–70 × 18–25 mm in *A. bergii*), and, based on available material, the total absence of lobed leaves on mature trees (*A. mariannensis* may have 3–7 lobes on the lower half of leaves) (Zerega et al. 2005).

Within the range of *A. bergii*, sterile material may be confused only with *A. teijsmannii*; however, the leaves on *A. bergii* appear nearly glabrous beneath to the naked eye, whereas those of *A. teijsmannii* are appressed puberulent on the main

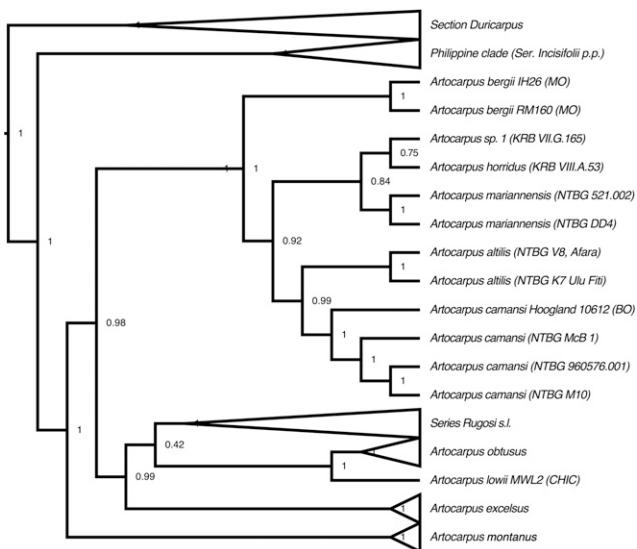


FIG. 4. ASTRAL species tree showing the position of *Artocarpus bergii* within subgenus *Artocarpus*, based on 517 nuclear loci plus flanking noncoding sequences, with node support as Local Posterior Probability; modified from Gardner et al. (2020).

veins. Fertile material may be readily distinguished by the absence of both interfloral bracts and sterile filiform processes between perianths of adjacent flowers in *A. bergii*, both of which are typically found in staminate and pistillate inflorescences of *A. teijsmannii*.

No material from beyond the Moluccas can be assigned to *A. bergii* with confidence. *J. Bourale & al. BSIP 9301*, 9 May 1968, from East Guadalcanal (L, SING), cited in the protologue of *A. teijsmannii* subsp. *subglabrus* C.C. Berg (Berg 2005), is morphologically similar to *A. bergii*, differing only in its narrower, pyramidate pistillate apices, simple rather than bifid styles, and occasional subulate sterile processes (likely sterile pistillate flowers). However, phylogenetic analyses have so far placed *BSIP 9301* not with *A. bergii* but near ser. *Rugosi* F.M.Jarrett (Gardner et al. 2020). We have not yet encountered other similar material from the Solomon Islands.

**Specimens Examined—Indonesia.**—NORTH MALUKU PROV.: Central Halmahera, Weda Bay. Doromesmesan: *Iska Gushilman & al.* 285, 24 Dec 2012 (MO&!, BO&?!, L); Central Halmahera, Weda Bay. Sake South: *Roji Mahroji & al.* 160, 6 Jan 2013 (MO&!, BO&!, L); Central Halmahera, Weda Bay. Tanjung Ulie: *Idris Haris & al.* 26, 14 Nov 2012 (MO&!, BO&!, L); Halmahera, Weda Bay. Kao Rahai: *Iska Gushilman & al.* 224, 8 Dec 2012 (MO&!, BO&?!, L); Halmahera, Galela, Soa Tobaroe, V.M.A. Béguin 1908, 16 Dec 1921 (L?!, BO); Halmahera, W. Pitoe (Pitu): *Béguin* 2223, 20 Oct 1922 (L&!); Halmahera, Djailolo (Jailolo), Toegoair eil: *bb.23731*, 6 Oct 1937 (L!); Halmahera, W. Tobelo: *Béguin* 2295, 10 Dec 1922 (L?!, BO&?!, L).

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#### AUTHOR CONTRIBUTIONS

All authors collaboratively drafted the manuscript. EMG prepared Figs. 1 and 4 and examined specimens. DA participated in fieldwork in Halmahera and examined the specimens at BO. NJCZ prepared Figs. 2 and 3 and examined specimens.

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