A Species of *Rhizophora* New to New Guinea and Queensland, with Notes Relevant to the Genus

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Abstract


Recent field work in Papua New Guinea and Queensland has revealed the presence of *Rhizophora lamarckii*, previously thought to be endemic to New Caledonia. Attention is drawn to these observations since they reveal that *R. lamarckii* has a much wider distribution than previously realized. The present article describes our observations in relation to other *Rhizophora* species in eastern Malesia, with a discussion of the evidence for the possible hybrid origin of *R. lamarckii*. Detailed diagnostic illustrations are provided in order to emphasize the status of *R. lamarckii* and assist the field worker. Some general discussion of the taxonomy of *Rhizophora* is also provided.

TAXONOMY OF RHIZOPHORA

Our current taxonomic understanding of *Rhizophora* is provided in its revision by Salvoza (1936), most recently extended by Ding Hou (1960). These accounts do not diverge much except in a few details of nomenclature and interpretation, which suggests a stable and relatively satisfactory taxonomy, although it is remarkable how recently this has been achieved in view of the long historical familiarity of botanists with *Rhizophora*. The taxonomic situation in the Caribbean area was only clarified as late as 1908, by Leechman when he recognized *R. harrisonii*; the fact that the same taxon occurred in West Africa was recorded only as recently as 1953 by Keay. This demonstrates that *Rhizophora* species are not strikingly different from each other. More recently Breteler (1969) has raised doubts about this segregation, suggesting that *R. harrisonii* is no more than a hybrid between *R. mangle* and *R. racemosa*.

From this, it becomes clear that Ding Hou’s revision is still provisional and this he states explicitly at several points (see also Ding Hou 1958). One can understand these tentative statements if one works with *Rhizophora* in the field. Systematics has been based mainly on a knowledge of collections in herbaria. Many proposed diagnostic features, notably of leaf shape, size and texture, and of seedling size and shape, are of little value to the field worker confronted with a wide range of variation. Salvoza had limited opportunity to visit only American populations, Ding Hou’s revision was based solely on a study of herbarium material; no one botanist has studied the genus in the field throughout its range. Elementary botanical knowledge about the genus is still deficient and precise morphological statements about many characters which are diagnostically useful have never been made. Biologically
orientated field work on Rhizophora has concentrated on the dispersal and establishment of viviparous seedlings. With few exceptions (e.g. Guppy 1906) there has been no concern for floral biology; mechanisms for reproductive isolation and population diversity have been little discussed. Speculation about evolutionary pathways in Rhizophora has proceeded without any knowledge of possible mechanisms of speciation (e.g. van Steenis, in Ding Hou 1958).

Four species of Rhizophora, i.e. R. apiculata, lamarckii, mucronata and stylosa, may be recognized in eastern Malesia out of a total of a possible eight for the genus (Ding Hou 1958, 1960). In order to understand the morphological relationship between the four species in the Australasian area in relation to other species, the following diagnostic key is offered, based on the examination of mainly living material, supplemented by either fluid-preserved material or the examination of dried specimens in A, BRI, GH, LAE, K and SUVA. The key is based primarily on features of the flower and inflorescence, which prove to be more constant and reliable than commonly used vegetative characters.

**DIAGNOSTIC KEY TO RHIZOPHORA SPECIES**

1a. Stamens (9–11)–12–(13) (rarely some aborted), sessile. Leaf apex mucronate. Flowers usually in 2's (sometimes 4's), on peduncles shorter than the petiole, peduncles of mature flowers in the axils of leaf scars; each flower sessile, with massive corky bracteoles. Petals glabrous. Stigmas sessile. Fruits always borne well below the leafy rosette. *Rhizophora* section *Aerope* Bl. .............................. one species, *R. apiculata* Bl. (Indo-Malaya)

b. Stamens either 8 or about 16 (sometimes some aborted) with a short filament. Leaf apex mucronate or rounded. Flowers in 2's but usually more (potentially up to 128), peduncle equaling or usually longer than the petiole, usually in the axil of a persistent leaf, i.e. within the leafy rosette; each flower pedicellate, the bracteoles never corky. Petals hairy. Stigmas sessile or the ovary narrowed above into a distinct style. Fruits borne below the leafy rosette. *Rhizophora* section *Rhizophora* ............................................................................................................. 2

2a. Stamens very variable, (8–15)–16 sometimes more (up to 22), often distorted, aborted, or represented by a filamentous staminode. Flowers in 2's or 4's. Petals with fine, inconspicuous marginal hairs. Styles variable, usually 2–3 mm long. Leaf apex mucronate ........................... .............................. R. lamarckii Montr. (New Caledonia, New Guinea and Queensland)

b. Stamens 8 (rarely with additional filamentous staminodes in R. harrisonii), petals with dense conspicuous hairs on the inner margins ............................................................................................ 3

3a. Inflorescences 2–5-flowered, often with an equal division into 3 at the first node (trifurcation). Flower buds angular, pointed, yellow at maturity. Leaf apex rounded .................................................. 4

b. Inflorescences 4–32 (up to 128–) flowered, branching entirely by bifurcation. Flower buds neither angular nor yellow. Leaf apex pointed or rounded ............................................. 5

4a. Bracteoles obscure, apex of ovary conical, narrowed to a stout blunt style 2–3 mm long ................................. *R. samoensis* (Hochr.) Salvoza (Fiji to Samoa, and possibly Tropical America)

b. Bracteoles conspicuous, forming a distinct 2-lobed cup, apex of ovary narrowed to a slender style 4–5 mm long ................................. *R. mangle* L. (Tropical America to West Africa)

5a. Leaf apex with a distinct mucro, flowers (4–)8–16–(32) per inflorescence, flower bud rounded. Distribution Indo-Malesian ................................................................. 6

b. Leaf apex rounded, without a mucro, flowers 8–128 per inflorescence, flower buds rounded or pointed. Distribution Atlantic ........................................................................................................... 7

6a. Stigmas sessile .......................... *R. mucronata* Lamk. (East Africa to New Guinea and Queensland)

b. Stigmas on a slender style, 4–5–(6) mm long ............................. *R. stylosa* Griff. (India to Fiji)

* This key excludes the sterile and putatively hybrid 'Rhizophora selala' from Fiji (Guppy 1906).
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7a. Bracteoles thin, long, pointed; flower buds pointed apically; flowers usually 8–32 per inflorescence ............................................................... *R. harrisonii* Leechm.

b. Bracteoles thicker, short, rounded; flower buds rounded, flowers often 32–64 per inflorescence ........................................... *R. racemosa* G. F. W. Meyer (Tropical America and West Africa)

The key shows that the genus can be split into two sections, the one monotypic and represented by the distinctive *R. apiculata*, the other including seven species which can be segregated readily on geographical and morphological grounds. *Rhizophora lamarckii* is morphologically very distinct in its variable number of stamens, commonly more than 12. The remaining species fall into the Atlantic group, i.e. *R. mangle, R. samoensis, R. harrisonii* and *R. racemosa* ranging from the eastern Pacific, the Caribbean to West Africa, and an Indo-Malesian group, i.e. *R. stylosa* and *R. mucronata* ranging from East Africa to the western Pacific. *Rhizophora apiculata* and *R. lamarckii* geographically belong to this last group. These two groups overlap in the Fiji-Samoa area where *R. samoensis* and *R. stylosa* are sympatric. No further discussion of the Atlantic group is included here.

**RHIZOPHORA IN PAPUA NEW GUINEA**

Collections of *Rhizophora* first made in the Port Moresby area in October 1974 revealed a distinct population in the vicinity of the village of Barune. This population was different from populations of *R. apiculata* and *R. stylosa*, which are otherwise common constituents of the mangrove communities of this coast. No material which could be referred to *R. mucronata* was found. Illustrations of these three taxa are included here (all drawn from fluid-preserved material as Figs 1-4.

The Barune collections correspond to *R. lamarckii*, previously considered to be endemic to New Caledonia, as is evident from descriptions of that species (Salvoza 1936; Ding Hou 1960) and comparison with the few herbarium collections available to us. The same entity occurs elsewhere in the Port Moresby area towards the village of Tubusereia, as established by Dr D. G. Frodin. Of interest is that *R. lamarckii* is intermediate between *R. apiculata* and *R. stylosa* in a number of characters.

In *Rhizophora apiculata* (Figs 1 and 2), the flowers are in pairs (sometimes 4's) in each leaf axil. They originate within the terminal bud, as is usual for flowering branches in *Rhizophora*, but have a subsequent long period of development outside the terminal bud, so that a flowering shoot includes a long series of stages of inflorescence development within the leafy crown (Figs 1C and 1D). Consequently, open flowers appear only below the leafy crown (Fig. 1E, which shows a shoot with the leaf blades cut off) and the seedling develops relatively remote from the leafy crown (Fig. 1A). This is the most distinctive biological feature of *R. apiculata*; viviparous seedlings develop as in other *Rhizophora* species (Fig. 1B) but, because of their long period of exposure, bracteoles and calyx lobes become quite corky with age. Flowers in this species are exclusively in pairs (Figs 1D and 1F) and are further distinguished by the presence of about 12 (sometimes fewer, rarely more) stamens (Figs 2A, 2B, 2C, 2G) while the petals are essentially glabrous, although a few marginal hairs have been seen in some samples (Fig. 2E). Stigmas are almost sessile (Fig. 2D) so that they are exceeded by the flap of the dehisced stamen (Fig. 2F) as is shown diagrammatically in Fig. 2D. As in other *Rhizophora* species, the stamens dehisce before the flower buds open and wind pollination is likely.
Fig. 1. *Rhizophora apiculata* (collector P. B. Tomlinson, 18.x.1974A, Singaua, Lae, Papua New Guinea). Shoot and fruit morphology.  
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Rhizophora stylosa (Fig. 3) shows numerous contrasted features, most of which are representative of the section Rhizophora. Flowering branches complete their development wholly within the leafy crown (Fig. 3L), the individual branches bearing numerous flowers (Figs 3K–M) based on a repeated bifurcating pattern of up to 5 orders with a theoretical maximum of 32 flowers (e.g. Fig. 3N, showing 4 orders of bifurcation). The usual number of flowers is about 8 since many potentially flowering axes abort. Individual flowers (Figs 3A–C) have 8 stamens (Fig. 3J), each with a distinct filament and the petals are conspicuously hairy on the inner margins (Fig. 3H). The style is long (Fig. 3F) so that the flap of the dehisced stamen (Figs 3D and 3E) does not exceed the stigma (Fig. 3G).
Fig. 3. *Rhizophora stylosa* (collector P. B. Tomlinson, 30.x.1974C, Bootless Bay, Port Moresby, Papua New Guinea). Shoot, inflorescence and flower morphology.  

A–C, Flower:  
A, from side;  
B, in L.S.;  
C, from above;  
D, undehisced stamen;  
E, dehisced stamen;  
F, style and stigmas;  
G, relation between style and dehisced stamen;  
H, single petal;  
I, floral diagram;  
J, leafy shoot with inset detail of leaf apex;  
K, leafy shoot with leaf blades cut off to show mature inflorescences subtended by existing leaves;  
L, theoretical 2⁵ or 32-flowered inflorescence with an actual 14 flowers;  
M, theoretical 2⁴ or 16-flowered inflorescence with an actual 10 flowers, two of which are detached;  
N, diagram of inflorescence construction, branching shown in one plane.  

(A–H, all same magnification;  
K–M, all same magnification.)
Rhizophora lamarckii (Fig. 4) is intermediate between these species in some respects. The flowering branches occur wholly within the leafy crown (Fig. 4J) and are 2- to 4-flowered, since the axis may bifurcate either once or twice (Figs 4H, 4I, 4L). Three-flowered inflorescences may occur by abortion. Individual flowers

(Figs 4A-C) are somewhat larger than those of R. stylosa, but not as large as in R. apiculata, and they lack the corky bracteoles of the latter species. The petals are fringed with fine hairs (Fig. 4G), i.e. neither almost glabrous as in R. apiculata nor as densely villous as in R. stylosa. The stamens have a short filament and the
anther flap exceeds the stigmas (Fig. 4E). Stamen number is very variable but seems based on 16, and so is distinctive for the whole genus. There is frequent abortion of several stamens which may be represented by a slender filamentous structure. In addition, stamens are frequently distorted or represented by irregular structures with few locellae. This taxon is, therefore, quite clearly circumscribed from other Rhizophora species and of interest because in many morphological features it spans the two sections of Rhizophora which otherwise would remain very distinct.

The following herbarium record establishes a likely population of R. lamarckii at Buiku, north coast of New Hanover, New Ireland District – NGF 7967 (J. S. Womersley and A. C. Richardson x.1955) and its existence in the Solomon Islands is suggested by BSIP 16836 (I. Gafui et al. 26.vii.1969) from west of Nata Village, Big Nggela.

RHIZOPHORA IN QUEENSLAND

More recently (March 1976), Dr John S. Bunt has drawn our attention to anomalous populations of Rhizophora on Hinchinbrook Island, Queensland. Field study of these populations confirms that they are also referable to R. lamarckii, but with some minor quantitative variation in floral morphology, chiefly expressed by lower stamen number. Such populations occur intermixed with R. apiculata and R. stylosa, which form the dominant species of much of the mangroves of this area. In addition to these three species, R. mucronata occurs in Queensland, as recorded by Jones (1971) and confirmed by us on the basis of herbarium study. However, it is less widely distributed than R. apiculata and R. stylosa and has not always been distinguished from the latter species.

It is likely that further study will reveal the presence of other populations of R. lamarckii in Queensland, and indeed herbarium specimens suggest that it occurs at the mouth of the Proserpine River. However, we have not checked this locality at first hand.

HYBRID ORIGIN OF R. LAMARCKII

A notable feature of populations of R. lamarckii in the Port Moresby area is the complete absence of seedlings from all trees. This immediately suggests that this population represents a hybrid between R. apiculata and R. stylosa, since both putative parents form extensive stands along this coast and frequently grow together. Female sterility, intermediate floral morphology and aberrations in stamen morphology support the idea. However, R. lamarckii in New Caledonia is said to set good seed. Preliminary observations give no indication of pollen sterility. The Barune populations form a fairly extensive even-age pure stand of several acres, consisting of sizeable trees with a low spreading habit, the branches frequently twisted and broken. The population is being kept under observation. To the seaward side, it merges with a stand of R. apiculata.

The Hinchinbrook population in Queensland also is closely intermixed with its putative parents, but is not entirely sterile, since occasional seedlings were observed on several trees.

DISCUSSION

The fact that this distinct entity remained overlooked, especially in at least one accessible locality, indicates our present limited knowledge of the distribution of
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*Rhizophora* species. This in part is a consequence of the very uniform architecture of the genus (Aubréville's model, Halle and Oldeman 1970) and the constant pattern of shoot morphology (Gill and Tomlinson 1969, 1971), such that different species can be separated only by careful examination of flowers, although flower number per flowering axis and the position of these axes in relation to the leafy crown provide readily accessible diagnostic features. With emphasis given to precise characters, this situation should change.

In this respect, the status of *R. mucronata* in Malesia, the Australian area and the western Pacific needs further clarification. The only consistent morphological character which distinguishes it from *R. stylosa* is the sessile stigmas (i.e. in this character it resembles *R. apiculata* as illustrated in Fig. 2D) rather than having a long style (cf. Fig. 3F). The similarity between *R. mucronata* and *R. stylosa* has been indicated by many authors, e.g. Schimper (1891), who treated *stylosa* as a variety of *mucronata*. Other characters used by Ding Hou (1960) in separating the two do not seem very reliable. Records of *R. mucronata* in Fiji (e.g. Guppy 1906) may represent errors of identification (Mrs Thelma Richmond, personal communication and our own observation).

Hybrids within *Rhizophora* are suspected in other areas. *Rhizophora 'selala*', based on Fijian material which never sets seedlings, is possibly a hybrid between *R. stylosa* and *R. samoensis* (Guppy 1906; Richmond, personal communication). In the Atlantic group, *R. harrisonii* is suspect as a hybrid between *R. mangle* and *R. racemosa* (Breteler 1969), although records of its distribution suggest that it does not always grow with its putative parents.

The lack of any knowledge of sterility barriers between *Rhizophora* species, ignorance of breeding mechanisms and the uncertainty of the geographical limits of many taxa indicate the need for biologically orientated field work throughout the range of this economically important genus.

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