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Revisiting taxonomic circumscriptions in *Hydnocarpus* Gaertn. and *Ryparosa* Blume for the Achariaceae of Thailand

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ABSTRACT. The split of the Flacourtiaceae into Achariaceae and Salicaceae has necessitated an updated treatment of these families for regional floras. In revising the Achariaceae for the Flora of Thailand, new insights on taxon circumscriptions in the family were generated based on a robust interrogation of delimiting characters and historical taxonomic decisions. Justifications for accepting certain taxa and synonymising others are here presented, along with recommendations for guiding future taxonomic work.

KEY WORDS: Achariaceae, delimiting characters, Flacourtiaceae, *Hydnocarpus*, *Ryparosa*, Hermann Sleumer, Thailand.

INTRODUCTION

Revisions for Thailand of the genera now included in Achariaceae have often lagged behind current circumscriptions at both the family and species levels. The most recent regional revision covering the 11 genera that were once placed in Flacourtiaceae is now 30 years old (Sleumer, 1985). Since then, Chase *et al.* (2002) concluded that there was no justification for maintaining Flacourtiaceae, and placed the majority of genera in either Salicaceae or Achariaceae. Of the 13 genera occurring in Thailand, four (*Gynocardia* R.Br., *Hydnocarpus* Gaertn., *Ryparosa* Blume and *Scaphocalyx* Ridl.), were transferred to Achariaceae and the remaining nine were placed in Salicaceae. Chase *et al.* (2002) recognised four tribes in Achariaceae: Acharieae, Pangieae, Lindackerieae and Erythrospermeae. The four genera occurring in Thailand belong to Pangieae and two are monotypic (*Gynocardia* and *Scaphocalyx*).

There is an emerging pattern of uncertainty around species level delimitation of certain genera in the Achariaceae (Webber & Woodrow, 2006). Some characters used by Hermann Sleumer, one of the experts on these genera, to synonymise certain species (e.g. *Ryparosa wrayi* King with *Ryparosa javanica* Koord. & Valeton), maintain other species (e.g. *Ryparosa fasciculata* King and *Ryparosa scortechinii* King), and characterise important morphological differences between species (Sleumer, 1954), do not appear to hold when subjected to closer scrutiny, particularly when applying field-based knowledge of the species in question. To complement the revision of Achariaceae for the Flora of Thailand (Harwood & Webber, 2015), here we revisit species from two of the four genera in Thailand – *Hydnocarpus* and *Ryparosa* – providing detailed notes on the justification behind our taxonomic treatment.

***Hydnocarpus anthelminthicus* Pierre ex Laness., *H. castaneus* Hook.f. & Thomson and *H. castaneus* ssp. *pseudoverrucosus* Sleumer**

Previous authors have treated *H. castaneus* and *H. anthelminthicus* as separate species, and further detailed investigation with new evidence may support this hypothesis. However, *H. anthelminthicus* is synonymised here because specimen and field studies failed to find any reliable characters to separate it from *H. castaneus*. Kerr (1930), discussing *H. castaneus* said: ‘This is a large tree, not unlike *H. anthelminthicus*, but with larger leaves’. In his key (Kerr, 1930), he separated the two species as follows:

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Breadth of leaves less than 1/3 length. Ovary with short brown tomentum. *H. anthelminthicus*

Breadth of leaves 1/3 the length or more. Ovary with rather long straw-coloured tomentum. *H. castaneus*

Leaf shape and size vary considerably on any one *H. castaneus* tree, and even on individual herbarium specimens. There are specimens at BKF that could be identified as either *H. castaneus* or *H. anthelminthicus*, using Kerr's leaf characters, depending on which leaf of the specimen is selected. Ovary tomentum also proves to be unreliable as a discriminating character. None of the specimens examined had 'short brown tomentum', all being straw-coloured to orange, even on the same ovary. The length of the tomentum is quite variable, but never short, even though the indumentum on mature fruits is always short. Sleumer (1985) separates the two species in his key as follows:

Leaves ovate-lanceolate or ovate-oblong, base markedly inequilateral, olivaceous when dry above, nerves 8–10 pairs. Fruit globose (8–) 10–12 cm diam. *H. anthelminthicus*

Leaves elliptic-oblong or oblong, base ± equilateral, red-brown when dry, nerves 6–7(–8) pairs. Fruit globose or depressedly so, (4–)5–6.5 cm diam. *H. castaneus*

Again, leaf characters are unreliable, including number of veins and colour, and fruit size is also variable. In his description of *H. castaneus* following the key, Sleumer (1985) gives fruit size as (4–)6–8 cm diam., so species characteristics even vary between key and description!

Inexplicably, Sleumer (1985) described *H. castaneus* and *H. anthelminthicus* as dioecious, even though he correctly stated in his 1954 Flora of Malesiana treatment that *H. castaneus* (and *H. curtisii* King), were monoecious (*H. anthelminthicus* wasn't in that treatment). Kerr (1930) had previously pointed out that both *H. castaneus* and *H. anthelminthicus* are monoecious. This is not the first time where there has been confusion between monoecy and dioecy in the Pangieae (van Slooten, 1925; Webber *et al.*, 2008). As staminate and carpellate flowering periods can be temporally distinct in monoecious Pangieae species (e.g. *Ryparosa kurrangii*; Webber *et al.*, 2008), monoecy could easily be missed in single sampling trips. Further investigation would be advisable to explore flowering states and phenology in these species, and other Pangieae species in general.

There are 41 specimens that are either *H. castaneus* or *H. anthelminthicus* at BKF, and considerable time was spent trying to distinguish the two species. Stipule size seemed to vary too much to be one species, from 2 mm to 7 mm, but couldn't be co-related with any other character consistently. There is a large amount of variation in flower and fruit pedicel size. *Gardner ST123* from Trang was exceptional, having slender flower pedicels to 60 mm long. More common on other specimens were slender pedicels ca. 20 mm, but *Phengkhlai 2135* from Krabi has an ovary just starting to develop into a fruit with a stout pedicel only 9 mm long. The length of the fruiting pedicels also varied considerably.

If *H. castaneus* and *H. anthelminthicus* are to remain synonymised as we have treated them here, *H. castaneus* is the older name and takes priority. However, we acknowledge that there may be a case for conserving *H. anthelminthicus* because the name has been widely used medicinally, but we are not at that point yet. That is, we have only examined specimens collected in Thailand and neither of the types have been examined (*H. anthelminthicus* from Vietnam, *H. castaneus* from Malaysia), so the treatment presented here provides a working hypothesis that would benefit from further detailed investigation.

Hydnocarpus castaneus ssp. *pseudoverrucosus* also cannot be maintained. Sleumer described it from Myanmar, and said it differed from the type by the number of lateral veins 9–11 versus 7–8(9), fruit size (7.5–8.5 mm versus 5–6.5 mm), fruit apex slightly conical versus not, and fruit indumentum (densely brown velutinous versus fulvous tomentose). As shown for *H. anthelminthicus*, none of these characters are enough to justify a separate taxon.

Kerr (1930) discusses some of the medicinal uses for *H. castaneus* (as *H. anthelminthicus*) in The Record, stating that extracts from the seeds were principally used for the treatment of leprosy and other skin diseases. Between 1925 and 1930, an average of 225 tons of seed were exported each year, mainly to China. Kerr (1930) provided some other interesting statistics, including that the fruits on one tree were counted, and the total was 643. He states that some trees would have more than this, but also many with less, and estimated 200 fruits per tree as an average. The seeds of 22 fruits were counted, with the number varying from 8 to 115, with a mean of 60.

Hydnocarpus ilicifolius King and *Hydnocarpus serratus* Warb.

We agree with Sleumer (1938) that *H. serratus* is a synonym of *H. ilicifolius*, but provide a few details here on the variation found in *H. ilicifolius*. Kerr(1930) says *H. serratus* was only known from Phrae and Prachuap Khiri Khan (type location), and separates it from *H. ilicifolius* by *H. serratus* having free petals. *Williams 1633* is from Prachuap Khiri Khan, and the first bud dissected had a petal on one side, and the rest combined into a tube with one side open, with no hint at all of where the petals making up the tube started or finished. The one petal was suborbicular, with both margins overlapping and outside the two margins of the incomplete tube. A second bud revealed two more or less equal sized petals, each occupying about half the circumference. Each had one margin inside and one margin outside the other petal. A third bud had only one petal forming a tube, but overlapping where the two margins of the tube joined. In all cases, the scales formed an entire tube. *Geesink 6802* (Saraburi) appeared to be a continuous tube in the two buds examined, but it is hard to be sure because of the membranous nature of the tube. *Phengklai 15864* (Surat Thani) had 4 petals in both buds examined, although there size varied considerably. In one bud, the petals were all approximately the same size, while the other had two broad and two narrow. One had 24 stamens, the other 25. Many fresh male flowers were examined at Soi Dao and the tube was always complete and seamless. Stamens were also counted, varying between 26 and 37.

Hydnocarpus kurzii (King) Warb. and *H. kurzii* ssp. *australis* Sleumer

When he described *H. kurzii* ssp. *australis*, Sleumer (1938) separated ssp. *australis* from *H. kurzii* by the thicker exocarp: 3–4(–6) versus 1–2 mm, less lateral veins: (6–)7 versus 7–8(–9), fruits rugose and blotched, and tertiary venation more distinct. He also noted that he had not seen any flowers. The thickness of the mesocarp of all *Hydnocarpus* species varies too much to be a useful taxonomic character, the vein numbers Sleumer uses above overlap, all species have somewhat blotched fruits due to variation in the presence and density of indumentum (there is some indication that this is due to damage rather than natural variation), and the distinctness of the tertiary venation is somewhat subjective. Whether fruits are rugose or not may depend on maturity or it may depend on the drying process, but there are specimens of other *Hydnocarpus* species at BKF that have both rugose and non rugose fruits on the same branch. Based on the above, *H. kurzii* ssp. *australis* is treated as a synonym of *H. kurzii*.

Hydnocarpus macrocarpus (Bedd.) Warb. ssp. *malabaricus* Sleumer and *H. macrocarpus* ssp. *burmanicus* Sleumer

In his monograph of *Hydnocarpus*, Sleumer (1938) described two new subspecies of *H. macrocarpus* (ssp. *malabaricus* and ssp. *burmanicus*). He describes ssp. *malabaricus* in detail, but for ssp. *burmanicus* simply states that it differs from ssp. *malabaricus* by the number of lateral veins: 8–9(–10) for ssp. *burmanicus*, (6–)7 for ssp. *malabaricus*. Sleumer (1938) appears to have regarded ssp. *malabaricus* as the type of *H. macrocarpus*, as it is from the type location (Travancore, on the Malabar Coast of India), and he describes it fully in his monograph, and doesn't describe *H. macrocarpus* at all (nor make any mention of a subspecies *macrocarpus*). He describes every other *Hydnocarpus* species fully in his monograph, and only uses a short diagnosis for all new subspecies described other than ssp. *malabaricus*. In his Thai Flacourtiaceae revision, Sleumer (1985) said that ssp. *burmanicus* was the only subspecies occurring in Thailand, yet two specimens cited by him mostly have only six lateral veins, one leaf only having five. The subspecies are consequently treated as synonyms.

Ryparosa inconstans Craib, *R. scortechinii* King and *R. fasciculata* King

Ryparosa inconstans and *Ryparosa scortechinii* are tentatively treated as synonyms of *Ryparosa fasciculata* for the following five reasons. Firstly, in his *Ryparosa* treatment for Flora Malesiana, Sleumer (1954) noted how similar *R. fasciculata* and *R. scortechinii* were, his description of *R.*

fasciculata including 'flowers light yellowish-brown, exactly as in *R. scortechinii*, but ovary more attenuate at base and with 3 stigmas'. Secondly, in his notes following the description of *R. fasciculata* he states 'in the sterile state to be distinguished from the very similar *R. scortechinii* by the numerous, elongate linear lenticels on the branchlets, which are in *R. scortechinii* very few in number and short orbicular-elliptic in shape'. These 'lenticels' are now thought to be food body scars and their size and density most likely driven by ant-related harvesting (Webber *et al.*, 2007). Thirdly, the two stigmas of *R. scortechinii* against the three of *R. fasciculata* appear to be Sleumer's best way of distinguishing the two species, but stigma numbers are not consistent within the majority of *Ryparosa* species (B.L. Webber unpublished data; Webber & Woodrow, 2006). Fourthly, when Craib (1926) described *R. inconstans*, he stated 'stigmas 2, occasionally 3'. That species supposedly differs from *R. scortechinii* and *R. fasciculata* by the more numerous lateral veins on the leaves, but the type specimen does not have the 10–12 pairs of lateral veins the type description says it has! Lastly, all three species are restricted to Peninsular Malaysia and southern Thailand, and all have been recorded near the border of Malaysia and Thailand. The type of *R. inconstans* is from Pattani, and the other Thai specimens are from Narathiwat and Yala, those two provinces bordering Malaysia to the south and Pattani to the north. The type specimens for both *R. fasciculata* and *R. scortechinii* were collected in Perak, a Malaysian State on the Thai border.

The several immature fruits on one of the Thai specimens all have three stigmas, so the name *R. fasciculata* was chosen for this treatment ahead of *R. scortechinii*, which is described as having two stigmas (both species were described in King, 1890). More work, however, needs to be done to confirm if the taxa treated here together under *R. fasciculata* represent a single species. In particular, the possible differences in reproductive material, including inflexed petals and more numerous seeds in *R. fasciculata* (King, 1890), warrant further attention. Unfortunately, the availability of specimens with these features to make observations on is limited, and this applies to the full range of material that we have examined across more than 10 herbaria globally. It is suspected that apparent differences between the three taxa may be explained by the poor condition of type material, altitudinally related morphological plasticity and collection bias to sample or avoid ant-plant characters.

***Ryparosa wallichii* Ridl.**

In this treatment, the decision was made to reinstate *Ryparosa wallichii* as a valid species. Sleumer (1985) synonymised *R. wallichii* with *Ryparosa acuminata* Merr. without explanation, but citing a number of specimens now determined as *Ryparosa wrayi* (as part of a recent revision of *R. javanica sensu lato*; Webber & Woodrow, 2006). It appears that Sleumer had difficulty in recognizing useful characters to assign specimens between *R. acuminata*, *R. wallichii*, *Ryparosa javanica* and *R. wrayi*. Furthermore, he synonymised the latter two taxa in his generic revision of the Flacourtiaceae (Sleumer, 1954). As such, many collections of *R. wallichii* and *R. wrayi* (reinstated by Webber & Woodrow, 2006) may be incorrectly determined as either *R. acuminata* or *R. javanica*. Based on current circumscriptions, it is extremely unlikely that *R. acuminata* occurs on the Thai-Malay Peninsula and most likely occupies a restricted range in Borneo (B.L. Webber, unpublished data). *Ryparosa wallichii* differs from most other *Ryparosa* species by the sessile flowers, also by only having 4 anthers (generally *Ryparosa* have pedicelled flowers and mostly 5 anthers).

CONCLUSIONS

In revising the four genera for the Achariaceae treatment in Flora of Thailand (Harwood & Webber, 2015), both *Hydnocarpus* and *Ryparosa* presented challenges for resolving clear taxonomic delimitation between species. It was not possible to justify maintaining a number of species, and synonymy has been proposed for these. In contrast, for other species, previous synonymy was viewed as unjustified, and we have reinstated these species. At the heart of these decisions lies a general trend towards a choice of defining character states for species that are either considerably variable within and between specimens and taxa, or not representative of the taxa concerned, particularly when field observations are taken into account. Both genera have been most recently revised by Sleumer (1938, 1954, 1985), whose work was largely conducted in Europe on dried herbarium material, with little opportunity to examine fresh material or for observations of species in the field. With a better knowledge of the field ecology of these species and better collections of more representative material, we envisage taxonomic revisions of the future making better use of more informative and appropriate characters. Moreover, given the historical interest in both *Hydnocarpus* and *Ryparosa* for pharmacological purposes (Sahoo *et al.*, 2014) and plant-animal mutualisms (Webber *et al.*, 2007), respectively, there is also a clear need for molecular studies on these two genera to support these morphometric insights and resolve further taxonomic uncertainties.

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