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Notes on the monotypic genus *Hexapora* (Lauraceae), endemic to Peninsular Malaysia

R.P.J. de Kok[1]

[1]Honorary Research Associate, Singapore Botanic Gardens,
National Parks Board, 1 Cluny Road, Singapore 259569
dekokrogier@gmail.com

ABSTRACT. An account of the genus *Hexapora* (Lauraceae) is presented. It comprises morphological descriptions of the genus and species, a provisional IUCN conservation assessment, ecological information and taxonomic notes. The morphology of the genus is compared to that of a number of possible close relatives, leading to the conclusion that it most likely belongs within the *Beilschmiedia* clade, and is likely closely related to *Sinopora.*

Keywords. *Beilschmiedia* clade, Penang, *Sinopora*, taxonomy

Introduction

The genus *Hexapora* Hook.f. was first described by J.D. Hooker in his *Flora of British India* in August 1886 (Hooker, 1886a). It was based on material sent to him by Charles Curtis, a plant collector and Superintendent of the Gardens and Forests of Penang, in what is now Peninsular Malaysia. The specimens arrived at Kew just before the pages of the Flora were sent to the printers, with the result that Hooker only briefly mentioned the genus at the end of the family account. The generic name, according to Hooker, alludes to the pore-like openings at the apices of the cells of the six anthers, and the specific epithet, "*curtisii*", is in honour of Charles Curtis. However, in November of the same year, Hooker (1886b: t.1547) decided to change the generic name to *Micropora* Hook.f. when he realised that although each flower has six stamens, each stamen has two pores, thus giving a total of 12 pores per flower, rather than six. However, this name change is superfluous and the original name is the nomenclaturally correct one.

The genus is monotypic and endemic to the island of Penang, but in the older literature there has been some confusion about its distribution. Ridley (1893: 341) cited a number of sterile specimens from Pahang as belonging to the genus. These collections were also labelled as *Hexapora* by Henderson in 1925. However, they were later identified as *Beilschmiedia glauca* by Kostermans in 1952, following Gamble (1912: 70–71) who had earlier already placed them in *Beilschmiedia* Nees. Gamble also cited a collection from Perak as belonging to *Hexapora curtisii* Hook.f. but the confusion regarding the locality was caused by the collection labels which are part of a series of King's Collector printed labels that have a standard locality: Perak, Larut. However, in the same hand as the rest of the written part of the label, the locality of Penang is given (see label of *King's Collector 5215*). This mistake was corrected by Ridley (1924: 90).

The classification and circumscription of the various genera in the Lauraceae have always been problematic. This is particularly true for *Hexapora* as only a few specimens are known of which none has fully mature fruits and only one of which has very immature fruits. Recently, molecular data have helped to elucidate relationships in the Lauraceae (Rohwer et al., 2014). In the case of *Hexapora*, given that all known specimens are old, generating molecular data is currently problematic.

Since it was described, *Hexapora* has been compared with a number of other genera, suggesting various possible relationships. It was placed in the Apollonieae by a number of authors (Pax, 1889; Von Dalla Torre & Harms, 1901; Uphof, 1910), together with genera such as *Beilschmiedia* and *Dehaasia* Blume, while other authors (Durand, 1888; Boerlage, 1900) placed it in the Perseeae, together with a large number of other genera of Lauraceae. More recently, Kostermans (1957) placed it in the subtribe *Beilschmiedineae*, comparing it with *Endiandra* R.Br. and *Beilschmiedia*, and Rohwer (1993: 378) put it in the *Beilschmiedia* group of the *Perseeae*, together with *Beilschmiedia*, *Endiandra*, *Brassiodendron* C.K.Allen and *Potameia* Thouars.

Rohwer (1993) also compared it with the Malagasy endemic *Aspidostemon* Rohwer & Richter. According to him, the massive cushion formed by the stamens and staminodes in the flowers of *Hexapora* is reminiscent of the flowers of *Aspidostemon*. The fruits of *Aspidostemon* are completely enclosed in an accrescent tube (Rohwer, 1993), and according to the *Tree Flora of Peninsular Malaysia*, the fruit in *Hexapora* is seated on the accrescent perianth and stamens (Kochummen, 1989). However, from my own observations on the one specimen of *Hexapora* with very immature fruits, it is clear that the fruit is free and situated above the remains of the perianth and stamens.

Van der Werff (2001) compared *Hexapora* with *Brassiodendron* as both have six stamens per flower, each with two cells. However, the fruits of *Brassiodendron* are free on the pedicel, with no remains of the perianth and stamens present, and its stamens have glands, which are not present in *Hexapora.*

In 2008, a new genus of Lauraceae, *Sinopora* J.Li, N.H.Xia & H.W.Li was described from Hong Kong. It shares several characters with *Hexapora*, including some that were previously considered unique to this genus (Li et al., 2008). They include the presence in each flower of six stamens on short filaments, giving the whole complex a cushion-like appearance, and 2-celled anthers which open by pores. At the base of the young fruit in *Sinopora* are the remains of perianth lobes, stamens and staminodes. However, these are lost when the fruits mature and then they become very reminiscent of *Beilschmiedia* fruits.

Discussion of the taxonomic position of *Hexapora*

Ever since the discovery of this genus people have wondered where *Hexapora* fits in the classification of the Lauraceae. Its vegetative morphology is not distinctive and, apart from the presence of small terminal buds, which are in fact very common in the family, all of its vegetative characters are shared with almost all other genera of Asian Lauraceae. The main features of its flowers and fruits are shown in Table 1 to allow

comparison with selected other genera in the family.

Unfortunately, only very immature fruit is known for *Hexapora curtisii*. *Anonymous 3158*, housed at Kew, has two young fruits, one still attached to the infructescence and one unattached and in a packet. At the base of both fruits are the remains of broken off free perianth lobes, stamens and staminodes. This is in contrast to what has previously been reported (see Kochummen, 1989; Rohwer, 1993). Most genera to which *Hexapora* has been compared have a distinct type of fruit. In *Beilschmiedia, Brassiodendron* and *Endiandra* the mature fruit is on top of the pedicel without any remnants of the perianth or stamens (Van der Werff, 2001). In addition, in some species of *Beilschmiedia*, the apex of the fruit stalk can have a slight circular restriction just below the fruit. This was observed in some of the Bornean species by Nishida (2008: Fig 27K) and in some of the Peninsular Malaysian species by De Kok (in press). This is also found in very young fruit stalks in *Hexapora*.

In the Lauraceae the numbers of stamens and staminodes in a flower are among the main characters used to delimit genera. The androecium in this family is typically organised in four whorls, each composed of three stamens or staminodes. Most genera have a single diagnostic arrangement, but a small number of genera show some variation (Van der Werff, 2001, see also Table 1). It is, therefore, no surprise that all the genera thought to be closely related to *Hexapora* can have six stamens (see Table 1). In addition, the presence or absence of glands at the base of the stamens is also an important feature in these genera. The particular organisation of the stamens of *Hexapora* in a cushion-like structure is one of its most characteristic features and is shared with only a few other genera, most notably *Sinapora* and maybe with some species of *Endiandra*. In the latter, the glands at the base of the stamens can be greatly enlarged and are united, forming a disc that surrounds the androecium and gynoecium (Van der Werff, 2001).

One of the other main characters used in the classification of the Lauraceae is the number of cells per anther, and to a lesser extent the shape of the anthers and their type of opening. As with stamen number, most genera have a constant number of cells per anther, but variation does occur in some (Van der Werff & Richter 1996). All genera in Table 1 have 2-celled anthers, which are either introrse or extrorse. Whether there is really a difference in the shape of the openings is debatable. Both in *Sinopora* and *Hexapora* the openings are reported to be small and round, whereas in the other genera in Table 1 they are more or less oval.

No molecular studies have yet been undertaken on *Hexapora*, although *Sinopora* was included in a study of the *Cryptocarya* group (Rohwer et al., 2014). This genus was well supported as sister to a group of Central American *Beilschmiedia* species in the Bayesian analysis, the ITS analysis and in the combined analysis, but received less than 50% bootstrap support in the parsimony analysis

Sinapora and *Hexapora* are likely to be closely related and they may even be congeneric. Taking these two genera together, their closest relatives are most likely to be either *Beilschmiedia* and/or *Endiandra* in the *Beilschmiedia* clade. This conclusion is mainly based on the possession of similar types of fruit, which is free when mature and in which the fruit stalk has a slight circular restriction at its apex (common in

Beilschmiedia) and present in at least *Hexapora,* not yet observed in *Sinapora*. Suggestions of their close relationship are further supported by the numbers of stamens and anther cells in these genera and their geographical distributions.

Material and Methods

The generic and specific descriptions in this study are based on observations of herbarium specimens from BM, K and SING. In the following descriptions:

i) all measurements and colour descriptions are from mature material;
ii) all measurements and statements about the position of the veins relative to the remainder of the leaves are taken from dried material;
iii) all collections of *Hexapora* seen by the author are cited;
iv) all synonyms of *Hexapora* are included;
v) for the provisional IUCN conservation assessment, the extent of occurrence (EOO) and area of occupancy (AOO) were calculated using http://geocat.kew.org on 3 December 2015.

Taxonomic treatment

Hexapora Hook.f.
Fl. Brit. India 5: 189 (1886); Kosterm., Commun. For. Res. Inst. Bogor 57: 38 (1957); Kosterm., Bibliogr. Laurac. 540 (1964); Kochummen, Tree Fl. Malaya 4: 114 (1989); Rohwer, Fam. Gen. Vasc. Pl. 2: 385 (1993); Van der Werff, Blumea 46: 137 (2001). – TYPE SPECIES: *Hexapora curtisii* Hook.f.

Micropora Hook.f., Hooker's Icon. Pl. 16: t. 1547 (1886b), nom. superfl.; Hook.f., Fl. Brit. India 5: 862 (1890); Gamble, J. Asiatic Soc. Bengal. 75: 70–71 (1912); Ridl., Fl. Malay Pen. 3: 90 (1924). – TYPE SPECIES: *Micropora curtisii* Hook.f. (= *Hexapora curtisii* Hook.f.)

Trees. ***Terminal buds*** not perulate. ***Leaves*** alternate, somewhat clustered at twig apex, penninerved, not glaucous below. ***Inflorescences*** formed of panicles (type 3 in Van der Werff (2001)), involucral bracts absent. ***Flowers*** trimerous, bisexual; perianth tube not distinct; perianth lobes 6, equal, erect at anthesis, shorter than stamens. Stamens 6, in 2 whorls, without glands; filaments slightly longer than anthers; 3rd and 4th rows of androecium consisting of thick staminodes as large as the fertile stamens, together with the stamens forming a massive cushion in the flower; anthers 2-celled, each cell opening by a circular apical pore. Ovary glabrous, narrowing into a short style, stigma minute. ***Young fruit*** with persistent perianth and stamens/staminodes at the base, mature fruit unknown.

Distribution. Only known from the Malaysian island of Penang.

Notes. In his discussion of the inflorescence of *Hexapora*, Van der Werff (2001) says that it has a 'type 3' inflorescence which is paniculate and in which the lateral flowers of the ultimate cymes are somewhat alternate rather than strictly opposite. This can be confirmed in this study as the short central axis has cymes coming off at irregular intervals. Most of these cymes are reduced to single flowered ones although occasionally there are also two or three flowered ones (see Fig. 1).

Hexapora curtisii Hook.f., Fl. Brit. India 5: 189 (1886); Kosterm., Bibliogr. Laurac. 540 (1964); Kochummen, Tree Fl. Malaya 4: 114 (1989). – *Micropora curtisii* Hook.f., Hooker's Icon. Pl. 16: t. 1547 (1886), nom. superfl.; Hook.f., Fl. Brit. India 5: 862 (1890); Gamble, Asiatic Soc. Bengal. 75: 70–71 (1912); Ridl., Fl. Malay Pen. 3: 90 (1924). – TYPE: Peninsular Malaysia, Penang, close to Chalet, December 1885, *Curtis 524* (holotype K [K000778553]). (Fig. 1)

Trees 12–18 m tall, dbh up to 40 cm. ***Twigs*** slender, 1.8–2.3 mm diameter, velutinous to densely hairy when young, smooth; terminal buds lanceolate, 2.9–4 mm long, velutinous. ***Leaves*** alternate, elliptic, 6–13 × 3–6 cm, apex acute to rounded, base cuneate, slightly asymmetric, margins straight to slightly recurved when dried, blades thinly leathery, dark green; secondary veins 7–9 pairs, curved towards the margins and merging with the tertiary venation; tertiary veins reticulate; upper surface of blades glabrous apart from a densely hairy main vein, main vein sunken at base, secondary veins raised, tertiary venation distinct; lower surface of blades glabrous, main vein and secondary veins raised, tertiary venation distinct. Petioles 9.5–13 mm long, half terete, slightly swollen at base, velutinous when young, densely hairy when older. ***Inflorescences*** 12–31 mm long, not enclosed by bracts, densely hairy; bracteoles lanceolate, 0.5–1.4 mm long, with acute apex, caducous. ***Flowers*** pale yellow; perianth lobes 6, equal, orbicular, 0.75–0.9 × 0.75–0.9 mm, apex rounded, sparsely to densely hairy, margin not ciliate. Stamens 6, in 2 rows of 3, orbicular, 1 × 0.8 mm, apex rounded to emarginate, without glands. Ovary 1–1.2 mm diam., ovoid, glabrous; style c. 0.5 mm long. ***Fruit*** (only immature fruit known) globose, 3.2–3.4 × 2.8–3.2 mm, smooth, glabrous, free, with remains of perianth, stamens and staminodes present below the base. Fruit stalk not to slightly swollen, circular restriction at apex of stalk present.

Distribution. Endemic to Penang Island, Malaysia.

Ecology. Growing in open forest at 240–830 m altitude. Flowering from March to December; fruiting time unknown.

IUCN Conservation Assessment. Data Deficient (DD). This species has been collected 10 times, all between 1883 and 1901, on the hills of the northern part of the island of Penang. A fieldtrip in May 2015 failed to locate the species. The Extent of Occurrence (EOO) suggests a status of Critically Endangered, while the Area of Occupancy (AOO) gives an assessment of Endangered. However, this part of Penang Island still has much

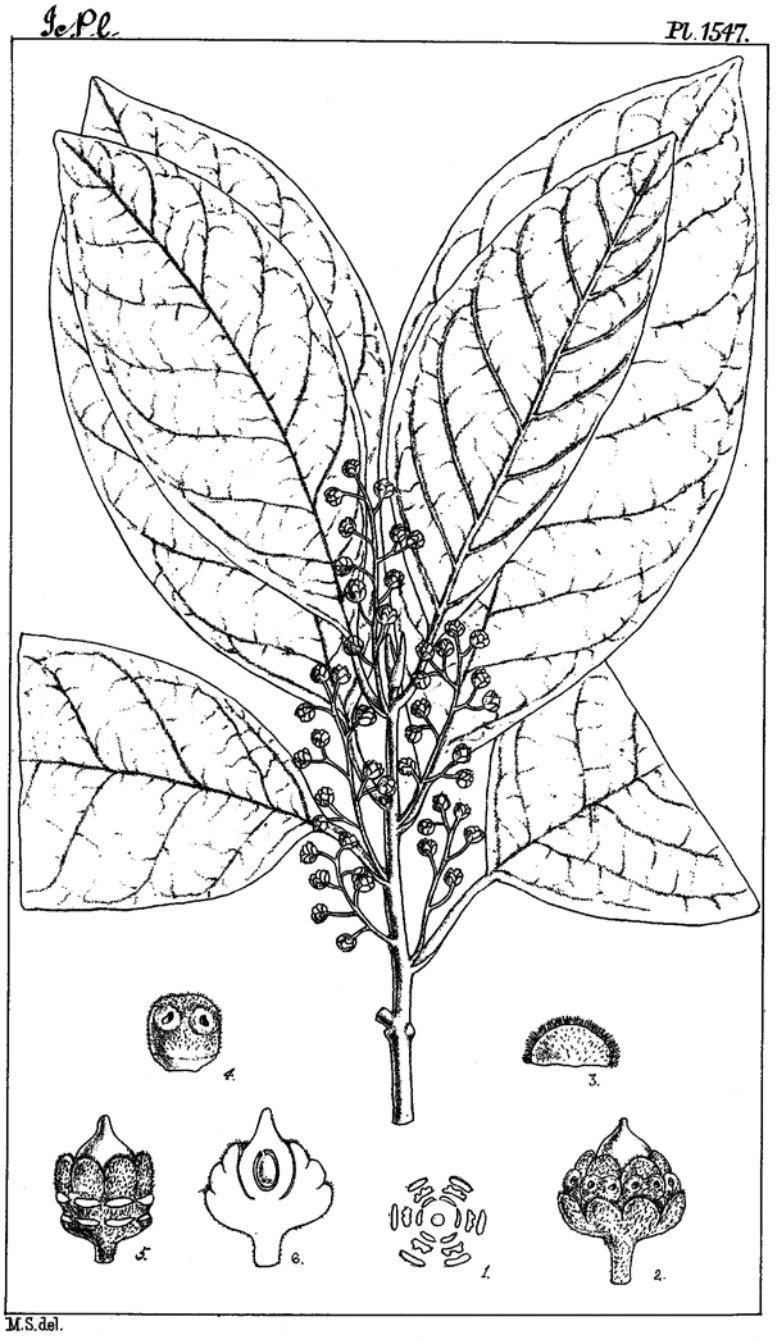

Fig. 1. Original plate of Hooker (November 1886b) of *Micropora curtisii* Hook.*f.* (= *Hexapora curtisii* Hook.*f.*). 1 = floral diagram; 2 = flower; 3 = apex of perianth lobes; 4= anther; 5 = ovary with staminodes; 6 = longitudinal section of flower. Reproduced with the kind permission of the Director and the Board of Trustees, Royal Botanic Gardens, Kew.

Table 1. Morphological comparison between *Hexapora* and other genera of Lauraceae with which it is usually compared.

Genus	Stamen number	Anther opening	Stamens short and thick	Glands on stamens	Fruit	Perianth persistent	Distribution
Anaueria	6	Valves, near apex	Outer whorl short	Absent	Free or enclosed at base	Yes	South America
Aspidostemon	3 or 6	Apical valves	Yes, only the 3th whorl	Present	Completely enclosed	Yes	Madagascar
Beilschmiedia	6 or 9	Valves	No	Present	Free	No	Pan tropical
Brassiodendron	4, 5 or 6	Valves	Yes	Present	Free	No	Australia to New Guinea
Endiandra	2 or 3	Valves	Yes	Usually present	Free	No	Asia
Hexapora	6	Pores at apex	Yes	Absent	Free	Yes	Peninsular Malaysia
Sinopora	6	Pores at apex	Yes	Absent	Free	Yes, when young	China

of its original forest surviving in good condition and it is well protected. Given the lack of recent data concerning this species and its population status, it is listed here as Data deficient, until more data becomes available.

Notes. Several specimens collected by Curtis are present at K, SING and one at BM; most have the same number (or give no number). However, these numbers were added later and are not collection numbers (Van Steenis-Kruseman, 1950). Only one specimen with the number 524 has the collection locality and date mentioned in the original description, and this sheet [K000778553] is accepted here as the holotype.

Additional specimens examined. PENINSULAR MALAYSIA: **Penang:** 'Perak, Larut', [Penang]: Nov 1883, *King's Collector 5215* (K [4 sheets]); 'Perak' [Penang in hand written notes on label], *Cantley's Collector s.n*. (SING [2 sheets]); s.d., *Anonymous 3158* (K); Jul 1890, *Curtis s.n*. (BM); 1885, *Curtis 524* (K [2 sheets]); West Hill, Sep 1887, *Curtis 1214* (K); ibidem, Sep 1887, *Cantley's Collector 1214* (SING); Government Hill, Mar 1890, *Curtis 1214* (SING [2 sheets]); ibidem, Oct 1892, *Curtis 524* (SING [3 sheets]); ibidem, 1901, *Curtis 524* (K).

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