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MORPHOLOGY AND PHYTOGEOGRAPHY OF *GLUTA* (L.) DING HOU- A REVIEW

***Namitha L.H. and Suhara Beevy S.**

Department of Botany, University of Kerala, Kariyavattom, Thiruvananthapuram-695581 (Kerala), India.

Abstract

This review encompasses a detailed analysis of the morphology and phytogeography of the different species of the genus *Gluta*. The genus is widely distributed around Southeast Asian region especially outside the eastern regions of the Indian peninsula and it has a sparse distribution with one species each from the Madagascar, South India and Papua New Guinea respectively. The species' under this genus show distinct morphologic and genetic variation, which is evident in their morphologic characters. The genus includes about 35 species of which the morphology of 27 species are documented and tabulated here.

Introduction

The plants in the genus *Gluta* (L.) Ding Hou belongs to the family Anacardiaceae and are commonly known as 'Rengas' (Stadelman, 1966). The name *Gluta* comes from the Latin word 'gluten' or 'glutus', which is an allusion to the petals being glued to the stipe-formed torus (Craig J., 1849). 'Rengas' is a name derived by the indigenous people in Southeast Asia where the plants flourish. It consists of four genera *viz*., *Gluta, Melanochyla, Melanorrhoea, Semecarpus a*nd *Swintonia*, all belonging to the same family. Injured bark of these plants secretes a toxic resinous sap that blackens when exposed to air and turns into a resin that causes allergic dermatitis. (Lachapelle, 2014). In spite of which they are widely exploited for its hard, durable crimson heartwood. Reduction of many species in the genus *Melanorrhea* to *Gluta* has resulted in the 35 species distributed mainly in the Myanmar-Malaysia region and one species each identified from Madagascar, South India and New Guinea (Hou, 1978). For this review the authors have selected the accepted species in the genus *Gluta* described in the Plant List. They are mainly trees and rarely of shrubby nature. The trunk shows a gradient of greyish to reddish brown colour. Leaves are evergreen or deciduous, arranged spirally, sometimes aggregated into pseudo whorls and are alternate, simple, entire, petiolate, rarely subsessile or sessile, mostly coriaceous. Inflorescence is a panicle in all species and can be axillary or terminal. Flowers are bisexual, pedicellate, articulate or non-articulate and corolla show imbricate and/or contorted, rarely valvate aestivation. Petals (4) 5 (8) are white often creamish white or red at base or changing to pink, can be caducous and if persistent they are enlarged in fruits. Sepals are circumscissile, tubular and toothed. Stamens ranging from a minimum of 4 to a maximum or approximately 100 sometimes inserted on conical torus, filaments may be glabrous or pubescent, anthers dorsifixed. Gynoecium is monocarpellary, sessile or supported by gynophore atop the torus, obovoid, ellipsoid or subglobose, glabrous or pubescent, pseudonumerous, style filiform, lateral or sublateral, stigma punctiform, ovule shows basal placentation. Fruit is a monolocular drupe glabrous to wrinkled, stalked or sessile, globose to reniform. Some species have wind dispersal adaptation due to the presence of persistent, accrescent, winged-like petals. Fruit coat can be brown to purplish red to black. Seed cotyledons sometimes incompletely fused, embryo straight and sometimes slightly curved. (Kubitzki, 2010).

Many species now classified in the genus *Gluta,* was placed under *Melanorrhea* by earlier taxonomists. They were initially separated based on number of stamens (Wilkinson, 1983). The genus *Gluta* was established by Linnaeus (1771) for G. *renghas* from Java with 5 stamens and the genus *Melanorrhoea* by Wallich (1829) for M.

***Author for correspondence :** E-mail: namithahelen@gmail.com

usitata from Burma with 20-30 stamens. *Gluta* has a gamosepalous calyx, 5 petals, 5 stamens and a stipitate ovary (cf. Linnaeus and de Villers, 1789).

Most *Gluta* species are not included in the CITES appendices and are in the Least Concern category in the IUCN Red List, therefore exploited for its deep red heartwood with darker streaks. With an exception of G. *papuana* from New Guinea in Vulnerable category and G. *travancorica* from South India in the Near Threatened category (IUCN *ver*. 2.3, 1994). Heartwood is highly durable and the colour darken on exposure to sun and wind. Sapwood is a light pinkish-brown to almost white and causes severe irritation in some individuals. Due to the striped pattern in the hardwood they are called by the trade name Tiger Rengas (Wood-Database). The potential of the trees saw wood waste as a source of natural dye in the shades of brown with color fastness and long shelf life was found in a study on the species G. *aptera* (Ahmad W.W. *et al.,* 2011). Like most trees in family Anacardiaceae, *Gluta* species also contain dermatitis causing compounds like pentadecyl (C-15) and heptadecyl catechol (C-17) urushiols (Kubitzki, 2010). The compound isolated from different species of *Gluta viz*., thitsiol from G. *usitata*, moreacol from G. *laccifera* (Ward, 2008) and renghol from G. *renghas* (Lin, 1960, cf. Backer, 1941).

Speciation is one of the most fascinating phenomena in life forms which is a result of geographic as well as reproductive isolation. This interspecific variability is actually vital for the survivability of organisms and it has greatly helped them to adapt in various challenging climatic conditions. The genus *Gluta* is observed to be showing remarkable variation in morphology based on its current geographic location. Since the genus is mostly confined to dense virgin forest ranges and due to lack of sufficient data a review has not been done till date. But considering the importance of the genus and its economic value, especially timber and resin, a detailed record is to be maintained for future utilization and conservation studies.

Variability which is as a result of genetic and environmental or geographic factors and the combination of both has enhanced the adaptability of the genus to survive in variable habitats ranging from terrestrial to coastal and swampy areas. Characters like vivipary which is a prominent adaptation of plants, to circumvent the marshy and highly saline environmental conditions in some *Gluta* species clearly substantiates their high survivability and establishment (Jose, 2013), (Kessler, 1996). The compiled morphological data is as a result of extensive field surveys conducted by research groups in different parts of the world, which shows that vast updation is needed in this genus to fill up the gaps in the information database of the genus.

The morphological and phytogeographic data was obtained from extensive literature survey (Tagane *et al.*, 2019, Quattrocchi, 2016, Chayamarit, 2010, Kochummen, 1997, Kochummen, 1996, Soepadmo and Wong, 1995, Adema *et al.*, 1994, Yoshimoto, 1989, Wilkinson, 1983, Halim *et al.,* 1980, Hou, 1978, Smythies, 1965, Tardieu, 1962, Pierre, 1898, Kirtikar and Basu, 1918). Data was also collected from online databases like JSTOR herbaria, TROPICOS (Missouri Botanical Garden), GBIF (Global Biodiversity Information Facility) and Flora Malesiana.

Morphological and phytogeographical data of 27 species of the genus are tabulated in table 1.

A comprehensive description and characteristics of the 27 species studied from literature review are as given below.

1. *Gluta aptera* (King) Ding Hou: (Syn: *Melanorrhoea aptera* King) Distributed in Borneo, Malaysia and Sumatra. The tree grows upto 40 m high and has a girth of 60 cm. Have a smooth brown bark, leaves are coriaceous, obovate to obovate-oblong or elliptic. Petals are white, then changing to red from base upwards, aestivation is imbricate, oblancolate, puberulous outside, sparsely hairy and slightly papillose near the base inside, sometimes glabrescent. Stamens (100), 8-11mm, panicles grow upto 3.2 cm long, pubescent especially when young, glabrescent, sometimes glabrous. Ovary broadly ellipsoid, obovoid or obliquely subglobose and glabrous. (Smythies, 1965). Fruit is a subglobose to globose brown coloured drupe (Adema *et al.*, 1994). Plant is poisonous, used for criminal poisoning, cause allergies, chemical irritation of skin, sap can cause dermatitis. A resinous exudate from the wood can cause severe skin irritation. Smoke of the burning wood can cause severe irritation of the eyes. The resin obtained from the plant is a source of long lasting black ink (Flora Malesiana). The wood is highly resistant to termite attack and is used for making fine furniture, turnery and cabinet work (Martin, 1984).

2. *Gluta beccarii* (Engl.) Ding Hou: (Syn: *Melanorrhoea beccarii* King) Distributed in the fresh water peat swamps of Borneo and Peninsular Malaysia. The tree grows upto 33 m tall and a girth of 72 cm. The trunk has a reddish grey to brownish smooth finish bark. Leaves are coriaceous, obovate or elliptic, glabrous, sometimes puberulous beneath, especially on the midrib and nerves. Petals are white, changing to dark pink, contorted and narrowly elliptic, puberulous outside, glabrous inside. Stamens (70), 5-10mm long. Inflorescence

Table 1: List of *Gluta* species studied.

S. No.	Plant	Habitat & elevation	Distribution & height of tree	Flower color (no. of petals)	Sepal	Stamen	Fruit (Drupe)	Cotyledon
1.	*G.aptera*	Low land, peat swamp, lower montane forest	Borneo, Malaysia, Sumatra (40m)	White-red	Calyptriform Glabrous except for tuft of hair at the apex	100	Globose or sub globose Brown smooth	Free
2.	*G.beccari*	Fresh water swamp, peat swamp, ridge forest(300m)	Asia tropical Borneo Peninsular Malaya(33m)	White turingto Dark pink	Calyptriform, Hairy outside	70	Bright purplish red Subglobous Wings 5-6 cm	Free
3.	*G.capituliflora*	Lowland, submontane forest found upon ridges, sometimes along river banks	Malaya Peninsula Kelantan (24m)	-	Irregularly torn, spathaceous, hairy outside (outwardly puberulus)	5	Drupe nodding in horizontal position, scurfy, buff	Imperfectly connate (incompletely united)
4.	*G.curtisii*	Lowland and hill forest (1200m)	Southeast Asia, Malyasia (30m)	White or pale lilac	Circumsessile	8-10	With wing-like enlarged	Free
5.	*G.elegans*	Low land forest	Peninsular Malaysia, Thailand, Myanmar (3-10m)	White	Red or pink glabrous	5	petals Oblong, flattened, gibbous drupe	Incompletely fused, freeon one side
6.	*G.laccifera*	Deciduous tree	Vietnam, Cambodia, Thailand, Laos(18m)	5	Caly ptriformis	c.60	Globose, small enlarged persistent petals	-
7.	*G.lanceolata*	Mixed rain-forest	Penang, Balik Pulau (30m)	-	Irregularly, puberulous outside	5	Globose, glabarous, black	Incompletely fused, freeon one side
8.	*G.laosensis*	Semi evergreen hill forest (200-310m)	Laos(15m)	Whitish to Pinkish 5(6)	Reddish purple, pubescent outside, irregularly splitting into 2	5(6)	Smooth reniform	-
9.	*G.laxiflora*	Low land mixed diptercarp forest	Endemic to Borneo (20m)	Hairy outside	Bursting irregularly	5(6)	Obliquely or broadly ellipsoid Brown to reddish brown, scurfy	Incompletely fused, free on one side

Table 1 Continue ...

Table 1 Continue ...

10.	*G.macrocarpa*	Hill forest 400-900 m	Peninsular Malaysia, Borneo (52m)	White creamish	Calyptriform hairy outside persistent	20(28) With few stami-nodes	Purple black fruit with short wings	Free
11.	*G.malayana*	Forest	Sumatra Malaya (45m)	-	Circum-sessile, puberulous outside	5	Globous 5 enlarged wing like rose and red colored petals	Free
12.	*G.oba*	Low land mixed Dipterocarp forest	Endemic to Borneo (30m)	White	Caly ptriform	10	Sub globose Dark brown smooth	Free
13.	*G.papuana*	Fresh water swamps (10m)	New Guinea (31m)	White	Ruptured irregularly	5-6	Globose, lightly attached	Incompletely connate
14.	*G.pubescens*	Dry land and swamp forest at low altitude, sometimes found up to 600 m	Sumatra, Malaysian peninsula (25-45 m)	White	Circum-scissile, puberulous outside	C60	Drupe on a centric stalk transverse -oblong, smooth	Free
15.	*G.renghas*	Coastal regions, in peat-swamps, occasionally inundated areas, river-banks, at low altitude, inland forest (250-800m)	Borneo, Java, Malaya, Sumatra (50m)	White	Bursting irregularly, glabrous	5	Irregularly crested	Incompletely fused, free on one side
16.	*G.rostrata*	Lowland and marshy forests (60m)	Sumatra (20m)	-	Base circumsessile, calyptriformis	>100	Globose, slightly depressed	Free
17.	*G.rugulosa*	Low land forest(150m)	Endemic to Borneo (30m)	-	Base circumsessile, calyptriformis	c.40	Globose, light brown, scurfy, with wings	Free
18.	*G.sabahanas*	Lowland forest, swamp forest (90m)	Borneo, Sabha (30m)	Whitish to pale yellow	Bursting (rupturing) Irregularly Hairy outside	5(7)	Broaldly ellipsoidal Brownish scurfy	Imperfectly connate, side free
19.	*G.speciosa*	Lowland forest, swamp, Hill forest (600m)	Endemic to Borneo (40m)	White red at the base	Calyptriform Densly hairy outside	>100	Sub globose smooth	Free
20.	*G.tavoyana*	Coastal forest and degraded forest dominated by *Pinus merkusii* (500 m)	China, Myanmar, Thailand, Laos (15m)	White	Scarlet puberulous outside	4-5	Drupe Globose During ripening	Imperfectly fused, free on one side

Table 1 Continue ...

Table 1 Continue ...

21.	*G.torquata*	Lowland forest	Malesia: Sumatra and Malay Peninsula (30m)	White	Bursting irregularly, puberulous outside	5	Sub Globose, brown, smooth	Free
22.	*G.tourtour*	Lowland rainforest	Madagascar (7m)	Greenish white	Brown	-	-	-
23.	*G.travancorica*	Hill forest region (300-1100m)	Endemic to Southern Western Ghats(35m)	Cream (4-6)	Spathaceous, splitting irregularly, deciduous	4-6	Globose rarely furrowed	Fused at region of embryo
24.	*G.usitata*	Open forests and rarely dry forests (100-1000m)	Myanmar, Thailand, Northeast India(25m)	Pinkish white (5-7)	-	30	Red coloured winged (modified petal) fruit	-
25.	*G.velutina*	Tidal river forming dense thickets	Sumatra, Borneo, Tenasserim, Thailand, Vietnam Peninsular Malaysia, Java(10m)	White	Bilobed 2 inch tomentose	5	Light brown drupe, subglobous Slightly compressed, tubercled	Free
26.	*G.wallichii*	Swampy or dryland forest	Sumatra, Malay Peninsula and Borneo (45m)	White wooly	Red puberulous outside	5	Ovoid or ellipsoid	Free
27.	*G.wrayi*	Lowland forest, granite ridges	Peninsular Malaysia, Vietnam, Thailand	White 5	Half as long as petal, pinkcalyx	5 (longer)	Oblong laterite red elliptic	Incompletely fused, free on one side

is a panicle 9-15 cm long, puberulous, ovary is 1mm long, subglobose and glabrous. (Smythies, 1965), (Davies and Becker, 1996). The tree sap is an irritant, but according to Halim *et al.,* (1980) urushiols could not be detected in the bark extract of *Melanorrhoea beccarii.*

3. *Gluta capituliflora* Ding Hou: This lowland and submontaneous forest tree, commonly found upon ridges and sometimes along river banks at an elevation of 300m, is endemic to Peninsular Malaysia. It grows to a height of 24m and girth of 19cm. The trunk possess short buttresses and the bark is brown with a smooth finish. The leaves are subcoriacious, elliptic to narrowly elliptic or lanceolate. Inflorescecne is a panicle 8-10.5 cm long, puberulous, petals show imbricate aestivation, narrowly elliptic or lanceolate. Timber of this tree, when dried and exposed to weathering for several years, can be used for making fine furniture, turnery, cabinet work and speciality items (Adema *et al.*, 1994).

4. *Gluta curtisii* (Oliv.) Ding Hou: This tree has a mixed forest habitat, from lowland forests to hill forests of 1200m altitude, grows to a height of 30 m and girth of 80cm. It is endemic to the Malayan Peninsula. Bark is brown and flaky, leaves are coriaceous, elliptic-oblong, rarely oblanceolate and glabrous, petals are white or pale lilac, contorted or imbricate, narrowly lanceolate or linear, densely puberulous outside, papillose at the central part inside. Inflorescence is a panicle 6-17cm long, stamens 8(-10), ovary subglobose, 0.5mm diameter and is glabrous. This tree yields a hard red wood, logs are left in the forest for weathering before extraction (Adema *et al.*, 1994).

5. *Gluta elegans* (Wall.) Kurz: (Syn: *Syndesmis elegans* Wall.) Commonly known as 'Rengas Ayam'. Distributed in lowland forests up to 300 m altitude above sea level in peninsular Thailand and Malesia. The young

foliage is intensely violet. Tree up to 20 m high and 26 cm wide. Bark grey, smooth. Young foliage intensely violet. Leaves subcoriaceous or coriaceous, elliptic to elliptic-lanceolate, glabrous, base attenuate or acute, apex acuminate, nerves 7-14 pairs. Inflorescence is a panicles 4-7 cm long, sparsely puberulous, pedicels 4-7 mm. Calyx red or pink, bursting irregularly, glabrous, very rarely sparsely puberulous outside. Petals white, with imbricate aestivation, narrowly lanceolate or oblanceolate, glabrous. Stamens 5, filaments glabrous, anthers oblong. Ovary subglobose or obliquely ovoid, glabrous, stipe 1 mm, style lateral, 5-9 mm. Fruit is a drupe, born on a lateral stalk, obliquely ovoid or broadly ellipsoid, rather flat, blackish, without enlarged petals. (Adema *et al.*, 1994).

6. *Gluta laccifera* (Pierre) Ding Hou: Is a deciduous tree native to Vietnam, Cambodiaa, Thailand, Lao growing to a height of 18 m. Leaves are oblong to ovoid shaped and is coriaceous. Inflorescence is a panicle, petals are puberulous and 5 in number, stamens are more than 60 in number. Petals are persistent in fruits (Pierre, 1898). The milky sap of this tree is caustic, the acrid juice of *Alocasia macrorrhizos* is used to counter this effect (Quattrocchi, 2016).

7. *Gluta lanceolata* Ridl.: This evergreen tree is endemic to Peninsular Malaysia, especially in Penang and Balik Pulau province. Growing upto 30 m high, having buttressed trunk and leaves flaky brown bark. Leaves are narrow, laneolate blunt, narrowed to a long petiole, coriaceous, nerved 12 pairs, faint, 6 inches long and 2 inches wide, petioles 1.5-3 in long. Dense flowered axillary or terminal panicle which are, around 4 inches long. Calyx is half as long as corolla, tubular, split on one side and is pubescent. Petals are linear oblong, obtuse, pubescent and hairy on the inner face. Stamens extend out of the flower and ovary is glabrous and subglobose. Fruit is globose, glabrous and black. (Adema *et al.*, 1994).

8. *Gluta laosensis* Tagane and Kameda: It is a new species discovered from the mixed deciduous and disturbed semi-evergreen forest on hills of Vientiane, Central Laos in 2019. This species is similar to *Gluta velutina* Blume, in appearance, but have distinct features like short petioles less than 4 mm long, obovate-oblong or oblong-elliptic leaf blade with rounded to slightly cordate base and 18-24 pairs of secondary veins, unlike other related *Gluta* species. They are trees growing to a height of 15m. The bole is grayish to reddish brown in colour. Tender twigs are covered with dense brown velvety hairs, older twigs are glabrescent, with sap which slowly turns reddish brown when exposure. Leaves alternate, clustered near end of twigs, blade obovate-oblong, thinly leathery, densely brown hairy when young and glabrous when mature, midrib prominent on both surfaces, secondary veins 18-24 pairs, petioles short 4mm long, densely brown hairy. Inflorescences axillary branched panicle and rachis densely brown hairy. Pedicels 3-4 mm long, pubescent, calyx 7.5 mm long, reddish purple, pubescent outside, irregularly splitting into 2 parts, caducous, petals 5 (or 6), obovate, 11×2.6mm, whitish to pinkish, apex obtuse, pubescent on both surfaces, margin ciliate. Stamens 5(-6), 4-5.5 mm long, separated from the distinct stalk (torus), glabrous, anther oblong, 1-1.2 mm long, torus cylindrical, 4mm long. Ovary is obliquely ellipsoid, glabrous, shortly stalked, with style on one side. Fruit is a olicve green reniform, glabrous, wingless drupe which is blackish when dry. (Tagane *et al.*, 2019).

9. *Gluta laxiflora* Ridl.: A lowland mixed dipterocarp forest tree growing up to 24 m high and 60 cm wide, endemic to Borneo. Bole may be buttressed and bark is flaky and rust brown in colour with light grey mottled pattern. Leaves are coriaceous, elliptic-lanceolate, rarely oblanceolate, glabrous, base cuneate, apex acuminate, nerves 11-17 pairs, prominent beneath, slightly elevated or flat above, venation is reticulate, usually distinct beneath, petiole 2-5 cm. Inflorescence is a hairy panicle, growing up to 12 cm long, pedicels 4-6 mm in length. Calyx 5 mm long, bursting irregularly, puberulous outside. Petals are hairy with imbricate aestivation and is narrowly elliptic. Stamens 5 (or 6) in number, filaments are glabrous, anthers oblong. Ovary is obovoid and puberulous, style is lateral and 4mm in length. Fruit is an obliquely ellipsoid, scurfy, reddish brown drupe, on an obscure, excentric stalk (Soepadmo and Wong, 1995).

10. *Gluta macrocarpa* (Engl.) Ding Hou: (Syn: *Melanorrhoea macrocarpa* Engl.) Tree growing upto 52 m tall and a girth of 91cm, at an altitude of 1200m above the sea level. Its distribution range is Malaysia and the islands of Borneo. The bark is greyish to rusty coloured and has smooth or scaly texture. Leaves are sub coriaceous, elliptic-oblong to lanceolate or obovate-oblong and is glabrous. Petals are white, yellow at the base, almost valvate except at the apical part, lanceolate and linear, puberulous outside, sparsely hairy and papillose at the lower half inside. Stamens are 20 (rarely 28) in number with a few filamentous staminodes. Inflorescence is a panicle (15 cm long), pubescent. Ovary is broadly ellipsoid, glabrous and 1mm in diameter. Fruit is a sub-globose, brown, reddish brown, or purplish black, smooth drupe on a centric stalk. Rarely the fruits have wing-like enlarged petals, narrowly elliptic or oblanceolate. (Adema *et al.,* 1994).

11. *Gluta malayana* (Corner) Ding Hou: (Syn: *Melanorrhoea malayana* Corner) Commonly known

as 'Rengas', 'Korbau Jalang', 'Malayan Rengas' and growing upto 45 m high. This evergreen tree is distributed in the evergreed forests of Sumatra and Malaya. The canopy of the tree forms a dome like crown and trunk exudes black sap. The leaves are spirally arranged and oval shaped (16cm-30cm long and 8-15cm wide) young leaves are hairy on both sides, old leaves are mostly smooth, except for hairs on midrib. Veins are raised below and looping near the margin. Inflorescence is a panicle bearing bisexual flowers, each flower has a cap like calyx, sepals 5, overlapping the petals, stamens 5. Fruit is globose with 5 enlarged wing like petal (1-2 cm long) which is pinkish to red coloured when fresh. All plant part is known to have irritant property and vesicant latex. (Hou, 1978, Kochummen, 1997).

12. *Gluta oba* (Merr.) Ding Hou: (Syn: *Melanorrhoea oba* Merr.) It is also a lowland mixed dipterocarp forest tree endemic to Borneo, growing up to 30m high and 60cm wide. Bark is bright grey or brown in colour and is scaly. Leaves are glabrous coriaceous, elliptic or broadly elliptic, base is cuneate or attenuate, apex obtuse, sometimes slightly acute, nerves 9-11 pairs, slightly elevated beneath, distinct above, venation is reticulate, distinct beneath, sometimes faint above. Inflorescence is a panicles up to 20 cm long. Flower-buds are lanceolate and acuminate. Calyx is circumscissile, calyptriform and glabrous, but hairy at the apical part on both surfaces. Petals are white in colour, showing valvate aestivation, puberulous outside. Stamens 10 in number and is 3-5 mm long, filaments are sparsely hairy and anthers oblong. Ovary is subglobose and glabrous, style is terminal. Fruit is a dark brown smooth drupe set on a centric stalk, without enlarged wing like petals. (Smythies, 1965, Adema *et al.*, 1994).

13. *Gluta papuana* Ding Hou: This 31m tall tree is endemic to New Guinea and grows in seasonally inundated forest along rivers, in freshwater swamps and on well-drained soil at an elevation of upto 50m from sealevel. The bark of the tree is greyish brown to dark red, smooth and peeling off in small round scales. Leaves are coriaceous, elliptic, broadly elliptic or obovate-oblong, glabrous. Petals are white, with imbricate aestivation and elliptic or obovate-oblong shape. Stamens are 5 to 6 in number. Inflorescence is a panicle which is around 30 cm long, puberulous when young, glabrescent or glabrous. The reddish brown grained heartwood of the tree is moderately hard and has been used especially for keels of canoes and for carving and is also suitable for corbels and sleepers. The resinous sap of this species has irritant properties and was used as criminal poisoning (Adema *et al.*, 1994).

14. *Gluta pubescens* (Ridl.) Ding Hou: (Syn: *Melanorrhoea pubescens* Ridl.) Deciduous tree growing upto 45m high, distributed in Sumatra and Malaysian Peninsula. The tree is characterized by its peculiar bark shedding property. The bark of the tree is deep brown. The leaves are skin-like elliptic or obovate, abaxially pubescent, adaxially glabrous with the exception of pubescent mid ribs and wedge shaped base. Calyx 11-13 mm long, petals are white, elliptical or lanceolate, large, outwardly pubescent, anthers elongated or broadly ellipsoid, ovary is subglobose, sparsely hairy, style terminal or slightly excentric. Fruit is a drupe, on a centric stalk, transverse-oblong and smooth (Flora Malesiana).

15. *Gluta renghas* L.: Distributed in Sumatra, Malay Peninsula, Java, Borneo and Sulawesi. This tree groing to a height of 50m high and 115cm wide, is one of the important constituents of the 'rapak' type of swamp forest, which is swamp forest without peat formation. G. *renghas* is often found associated with other tree species like *Coccoceras, Alstonia*, other *Gluta* spp., *Ficus retusa, Mangifera gedebe* and *Lagerstroemia*. Bark of the tree is fawn brown to greyish when old scaly with small flakes. Leaves are coriaceous, elliptic-oblong, narrowly elliptic or oblanceolate, glabrous. Petals white, contorted, elliptic-lanceolate, or linear, 2-3 mm, glabrous outside, papillose inside. Stamens 5, filaments glabrous, anthers oblong, ovary subglobose and glabrous, style is lateral. Fruit is a subglobose drupe on a centric stalk, pinkish brown, with irregular crests and protuberances, without enlarged petals. In deep marshy places the stem-base of this tree is often conically thickened. The timber is very strong, durable and characteristically red (Adema *et al.*, 1994). An early work conducted by Lin and Whittow in 1960 showed that the leaves of *Gluta renghas* contain an anticholinesterase substance and a heart-stimulating substance. Its toxic lacquer and wood exudates are used as dart posion (Yoshimoto, 1989).

16. *Gluta rostrata* Ding Hou: Lowland forest and marshland dwelling tree endemic to the island of Sumatra, growing to a height of 20m and a girth of 65cm, with buttresses 2m high, 6cm thick. Bark is greyish red-brown and rough. Leaves are coriaceous obovate-oblong, oblanceolate, sometimes elliptic,glabrous, base attenuate, apex obtuse,rounded or emarginate, nerves 9-14 pairs, slightly elevated beneath, flat and distinct above, veins reticulate, usually distinct on both surfaces. Inflorescence is a panicle and is puberulous. Petals are elliptic-oblong, sometimes lanceolate, densely hairy outside, sparsely hairy and papillose at the base inside. Stamens more than 100 (Wilkinson, 1983), ovary is subglobose and glabrous with diameter ranging from 0.5-0.75mm. Fruit is a sessile,

brown, spherical drupe with a slight depression (Adema *et. al.*, 1994).

17. *Gluta rugulosa* Ding Hou: It is a species of *Gluta* endemic to Borneo, growing to a height of 30 m high, in low land forests and forest edges. Leaves are coriaceous obovate to oblanceolate, glabrous on both surfaces, sometimes the lower surface is slightly puberulous when young, base is decurrent, with rounded apex, sometimes slightly emarginate, nerves 11-21 pairs, venation is commonly reticulate or could be transverse or parallel, petiole is round 0-1 cm long. Inflorescene is a puberulous panicle, around 5-20 cm long, pedicels 5-7mm. Flower-buds are ovoid or ellipsoid, calyx 7-8mm long, circumscissile, densely puberulous outside. Petals show imbricate aestivation, is elliptic-oblong or ovate-oblong in shape and is densely puberulous outside, the lower part is papillose. Stamens approximately 40 in number, filaments are hairy, anthers are around 1mm long and is oblong. The 1mm long ovary is scurfy and broadly ellipsoid, style is terminal (3-4 mm). Fruit is a light brown, scurfy, wrinkled, enlarged, sessile, globose drupe with modified lanceolate wing-like petals.

18. *Gluta sabahana* Ding Hou: This species of *Gluta*, is endemic to Borneo, especially Sabah. They are adapted to lowland forest, including swamps, below an altitude of 30m (Kochummen, 1997). The tree grows up to a height of 30m and girth of 60cm. Buttresses are present in older trees. The bark is smooth and dark brown in colour. Leaves are coriaceous, oblanceolate, obovate-oblong, elliptic-lanceolate or narrowly elliptic, glabrous and is pseudo-whorled, apex maybe acuminate or acute, veins reticulate, often faint on both surfaces. Here also inflorescence is a panicles 7-15cm long, puberulous and the pedicel is 3-6mm long. Flower-buds are ellipsoid, calyx bursting irregularly and is puberulous outside. Petals are whitish or pale yellow, puberulous outside, densely papillose usually at the lower half inside, stamens 5(-7) and is 5-6 mm in length, filaments are glabrous and anthers oblong. Ovary is obovoid 0.5-1 mm long, puberulous, stipe obscure and style is lateral. Fruit is a brownish scurfy drupe on an obscure, excentric stalk, embryo is subreniform, cotyledons incompletely fused, free on one side (Adema *et al.*, 1994).

19. *Gluta speciosa (Ridl.)* Ding Hou: (Syn: *Melanorrhoea speciosa* Ridl.) This tree is endemic to Borneo, adapted to dry lowland and swamp forests, have dark rich brown bark and grows to a height of 40m and girth of 80 cm (Smythies, 1965). Leaves are coriaceous, elliptic or obovate and pubescent beneath, apex rounded or emarginate. Inflorescence is a panicles, flower-buds ovoid-oblong, calyx 11-13mm long, puberulous outside, sparsely puberulous circumscissile, densely puberulous outside. Stamens, white more than 100 in number, 3-7 mm long, red at the base, filaments sparsely hairy, anthers oblong. Ovary subglobose, densely slightly excentric. Fruit is a drupe on a centric hairy stipe, terminal style without wing-like petals (Adema *et al.*, 1994).

20. *Gluta tavoyana* Hook. f.: Evergreen tree growing upto 15 m tall and having a widespread distribution in Cambodia, China, Malaysia, Myanmar, Thailand, Vietnam and Laos. This tree species mostly inhabit coastal and degraded forests dominated by *Pinus merkusii*. The tree grows up to 30 m high and a girth of 30 cm. Leaves are subcoriaceous, obovate-oblong, or -lanceolate, base is cuneate, apex obtuse, acute, rarely acuminate, nerves 7-20 pairs, slightly elevated, sometimes hardly distinguishable from the fine, distinct, reticulate veins on both surface. Inflorescence is terminal or axillary panicle and is puberulous. The flower buds are ellipsoid and acuminate. Calyx is scarlet, bursting irregularly, puberulous outside. Petals are white, with imbricate aestivation, oblanceolate or narrowly elliptic and is puberulous. Stamens 4-5 in number, filaments glabrous and anthers oblong. Fruit is a globose drupe, with a centric stalk and is greenish-yellow when young (Adema *et al.*, 1994). Seasoned timber is used as cabinet wood. Furniture made from dried timber could be still toxic to people who are vulnerable (Tardieu, 1962).

21. *Gluta torquata* (King) Tardieu: (Syn: *Gluta elegans* var. *curtisii* Burkill, *Gluta elegans* var. *helferi* Hook.f., *Syndesmis tavoyana* Wall.) Lowland forest dwelling tree, having its distribution in Sumatra and the Malay Peninsula, growing up to a height of 30 meters. Bole is light brown in colour and steep buttresses upto 3m high maybe present occasionally. Leaves are pseudo-whorled, coriaceous, obovate, obovate-oblong, or broadly elliptic, glabrous, sometimes puberulous, apex round or slightly emarginate, nerves 16-29 pairs, prominent beneath, slightly elevated above, venation is usually reticulate. Inflorescence is a tomentose panicle which is 17-30cm in length. Calyx is 2-3mm long, bursting irregularly (sometimes it found hanging around the pedicel, like a loose collar) and puberulous outside. Petals are white, shows imbricate aestivation, oblanceolate, lanceolate, or narrow-oblong and is densely puberulous on both surfaces. Stamens 5 in number, filaments pilose and anthers oblong. Ovary is subglobose and style is terminal. Fruit is a smooth, globose, wingless drupe, set on a centric stalk.

22. *Gluta tourtour* Marchand: (Syn*: Gluta benghas* var. *tourtour* (Marchand) Engl.) This subhumid evergreen mangrove forest tree is endemic to Madagascar, especially in swampy areas. It is a small tree growing to a height of 20-25m and a girth of 50cm. The bark is blackish grey in

colour and the heartwood is bright yellow-orange in colour. Leaves are alternate, simple, with resinous and corrosive sap (Bois précieux de Madagascar, 1981). The inflorescence is a panicle, calyx is fused, calyptriformis and 5 lobed, petals 4 or 5 with imbricate aestivation. Stamens fused into a narrowly cylindrical, long staminal coloumn, entire or terminated by simple of bifid refleced appendages, anthers 8-10 and is inserted on the margin, alternating or opposite to the appendages. Ovary is unilocular, stigma sessile and is (2-) 3-lobed (Schatz, 2001) Fruit is a kidney shaped drupe, which has the appearance of a raw elongated mango. The fruit is consumed by pigs (Quattrocchi, 2016).

23. *Gluta travancorica* Bedd.: Evergreen tree endemic to the southern Western Ghats of the Indian subcontinent, growing at altitude of 1200m. This tree grows to a height of 35-40m tall and the diameter of the bole my go upto 150 cm. The trunk is smooth and pinkish grey, often with a lot of lichen growing on the surface. Leaves are alternate, simple, entire, coriaceous and arranged in whorls towards the end of each branch. Inflorescence is a terminal or axillary panicle, flower buds have a pinkish cream colour, petals are cream coloured 4-6 in number, inserted in a disk and shows imbricate aestivation. Stamens are usually found alternating with the petals and the same number as them, filaments are capillary. Ovary is sessile on the disk and is oblique, style is lateral and filiform and stigma is simple. Fruit is a brown, slightly scurfy drupe, seeds are exalbuminous and cotyledonous, are conform to the pericarp, testa sticks to the thick pericarp

24. *Gluta usitata* (Wall.) Ding Hou: (Syn: *Melanorrhoea usitata* Wall.) Open forest dwelling tree, at an altitude of 100-1000m above the sea level, distributed in Myanmar, Thailand and Southeast Asia. It grows to a height of 5-25m. Leaves are, coriaceous, slightly pubescent, oval-shaped or oblong and is 12-36 cm long. Inflorescence is a panicle, which is puberulous and grows upto 35cm long. Petals 5-7 in number and is pinkish white, which turns into red elongated wing like structures on fruits. Stamens around 30 in number and fruit is a red, globular drupe with elongated modified winged petals (Kirtikar and Basu, 1918, Chayamarit, 2010). A naturally black lacquer, commonly known as Burmese lacquer or *thit-si* is extracted from the sap of this species of *Gluta*. This lacquer is very strong and is used for strengthening cooking utensil, especially bamboo and wooden items. In the ethnic communities of Myanmar, they still use it to decorate temples and make ornaments (Asian-Urushi).

25. *Gluta velutina* Blume: (Syn: *Gluta coarctata* (Griff.) Hook. f., *Syndesmis coarctatus* Griff.) Distributed along the banks of tidal rivers of Sumatra, Borneo, Tenasserim, Thailand, Vietnam, Peninsular Malaysia and Java. This small tree is conspicuous by its bright red young leaves and have stilt roots and mangrove adaptation (Kochummen, 1996, Chayamarit, 2010). It is a large branching shrub, all parts are glabrous, except for the puberulous inflorescence. Leaves are stiffly coriaceous, oblong or oblanceolate, obtuse or subacute, narrowed to the blunt often cordate base, dark green (red when young), nerves 13-20 pairs, faint 5-9 in long, petioles are thick and 0.1-0.2 inch long. Inflorescence is an axillary panicle, branches are short and few. Flowers are white, 0.4 in long, calyx is 0.2 in long, bilobed and tomentose, petals 5 in number, oblanceolate, puberulous. There are 5 short stamens. Fruit is a light brown, subglobose, slightly compressed, tubercled drupe (Ridley, 1912). All parts of the plant are poisonous and the tree sap causes contact dermatitis (Quattrocchi, 2016). The associates of *Gluta velutina* are *Barringtonia conoidea* and *Pandanus helicopus* (Soepadmo and Wong, 1995).

26. *Gluta wallichii* (Hook.f.) Ding Hou: (Syn: *Melanorrhoea wallichii* Hook.f.) It is a large evergreen tree, widely distributed in the swampy dryland and peat swamps forests of Sumatra, Malay Peninsula and Borneo. The tree grows up to a height of 45m high and girth of 70cm, bark is greyish brown, flaky and distinctly rugose-fissured. Leaves are coriaceous, obovate-oblong, glabrous, sometimes tomentose and glabrescent beneath, base is cuneate, apex obtuse, acuminate, sometimes slightly emarginate, nerves 9-24 pairs, venation is reticulato-scalariform, which is distinct on both surfaces, petiole 2-6 cm. Inflorescence is a pubescent, sometimes glabrescent panicle. Flower buds are ovoid, calyx red, bursting irregularly, puberulous outside. Petals are white with yellow centre, which turns red, 5 in number, shows imbricate aestivation, is ovate-oblong, lanceolate or elliptic in shape and is villose on both surfaces. Stamens 5 is number, filaments pilose, glabrescent, anthers are oblong. Ovary is subglobose and style is lateral. Fruit is an ovoid or ellipsoid, smooth, brownish drupe, set on an obscure, centric stalk. The 5 red petals are modified to form elongated wings on the fruits (Soepadmo and Wong, 1995, Adema *et al.*, 1994). The heartwood yields a superior quality timber, which need to be weathered before using, otherwise it causes contact dermatitis. The resin is also used as dart poison (Adema *et al.*, 1994).

27. *Gluta wrayi* King: (Syn: *Gluta virosa* Ridl.) The tree is distributed in Thailand, Vietnam and the Malayan Peninsula, grows up to 30m in height and 85cm wide, occasionally with steep plank buttresses up to 3m high. The tree is adapted to dwelling in low land forests and sometimes on granite ridges. Bark is green to orangish-

brown, rugose or shallowly dippled. Leaves are subcoriaceous, elliptic to elliptic-lanceolate, rarely oblanceolate, base is cuneate or attenuate, apex acuminate, nerves 9-14 pairs, slightly elevated beneath, faint above, veins often distinct on both surfaces. Inflorescence is a puberulous panicle which can grow up to 8cm long. Flower-buds are ellipsoid, calyx 8-9 mm long, bursting irregularly, puberulous outside, petals are white, 5 (or 6) in number, narrowly oblanceolate with imbricate aestivation. Petals are, puberulous outside, papillose on the inside. Stamens 7 mm long, 5 (or 6) in number, filaments are glabrous, anthers oblong. Ovary is broadly obovoid, 2 mm long, densely puberulous and style is lateral. Fruit is a scurfy, ellipsoid, light brown drupe set on an obscure, centric stalk. The heartwood of the tree is deep red with black concentric bands sometimes called 'Straits mahogani' (Ridley, 1907). It is the most virulent among all the *Gluta* species (Quattrocchi, 2016).

Information regarding the morphological and phytogeographical data of the 34 'accepted' species in Plant List is limited. After extensive literature survey, details of 26 species as reposted in the Plant List database and a new species discovered from Vietnam in 2019 *viz*. *Gluta laosensis* was consolidated and is tabulated in table 1. That too is incomplete, due to insufficient data. Which again points at the need for exploring more on this underutilized tropical trees which show a high degree of vicariance and have evolved based on their new environment after the Gondwana split. Among the 27 species studied, 6 species namely *Gluta aptera, Gluta beccari, Gluta renghas, Gluta tourtour, Gluta velutina* and *Gluta wallichii* show marsh land and coastal adaptation, *Gluta travancorica*. *Gluta curtisii and Gluta macrocarpa* are highland varieties and most of the other species thrive well in lowland forests.

Conclusion

The vast diversity of the genus *Gluta* in its distribution and habitats appears to be remarkable which justifies the adaptive nature of the plant and its survivability. The morphological variations in the species' of *Gluta* (L.) Ding Hou is closely linked to the habitats in which they exist. The members confined to islands show significant variation as compared to the main land species. The relevance of this unexplored and unexploited genus is very well highlighted and it will help in generating interest among scientific communities to carry out more scientific explorations and clear the existing disputes in the genus. This will further trigger interest in proposing propagation and conservation strategies of the members of this valuable genus.

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