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Floribunda

Floribunda merupakan organ resmi Penggalang Taksonomi Tumbuhan Indonesia, diterbitkan dua kali setahun dan menerbitkan makalah dalam bahasa Indonesia dan Inggris mengenai pelbagai gatra sistematika keanekaragaman flora Malesia pada umumnya dan Indonesia pada khususnya yang berasal dari hasil penelitian, pengamatan lapangan, pengalaman pribadi, telaahan bergagasan, dan tinjauan kritis.

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PHENETIC ANALYSIS AND DISTRIBUTION OF CLAOXYLON IN THE LESSER SUNDA ISLANDS

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Adhy Widya Setiawan & Tatik Chikmawati. 2020. Analisa Fenetik dan Persebaran *Claoxylon* di Kepulauan Sunda Kecil. *Floribunda* 6(5): 167–174. — Marga *Claoxlon* A. Juss. di Kepulauan Sunda Kecil telah direvisi. Sebelas jenis tercatat terdapat di Kepulauan Sunda Kecil. Catatan *C. capillipes* dan *C. fulvescens* diperluas sampai Pulau Bali. Berdasarkan distribusi *Claoxylon* di Kepulauan Sunda Kecil, Bali memiliki nilai keanekaragaman tertinggi (7 jenis), sementara Wetar menunjukkan keanekaragaman terendah (hanya 1 jenis). Analisis fenetik menggunakan Sistem Analisis Taksonomi Numerik dan Multivariat (NTSYS-pc) versi 2.11a dan Pemetaan distribusi menggunakan Quantum GIS versi 2.4. Berdasarkan 14 karakter morfologi mengelompokkan *Claoxylon* ke dalam 3 kelompok. Seluruh *Claoxylon* di Kepulauan Sunda Kecil termasuk ke dalam seksi *Indica* dan *Affinia.*
Kata kunci: *C. capilipes, C. fulvescens*, fenetik, pola fitogeografi, UPGMA.

Adhy Widya Setiawan & Tatik Chikmawati. 2020. Phenetic Analysis and Distribution of *Claoxylon* in the Lesser Sunda Islands. *Floribunda* 6(5): 167–174. — The genus *Claoxylon* A.Juss. in the Lesser Sunda Islands (LSI) was reviewed. Eleven species were recognized in Lesser Sunda Islands. Records of *C. capillipes* and *C. fulvescens* were extended to the Bali Island. Based on distribution of *Claoxylon* in LSI, Bali has the highest number of species (7 species), while Wetar shows the least number of species (only 1 species). A phenetic analysis was using Numerical Taxonomy and Multivariate Analysis System (NTSYS-pc) version 2.11a and distribution mapping using Quantum GIS version 2.4. Based on 14 morphological characters grouped *Claoxylon* species in LSI into three groups. All *Claoxylon* in LSI belong to section *Indica* and *Affinia*.
Keywords: *C. capilipes, C. fulvescens*, phenetic, phytogeographical patterns, UPGMA.

Claoxylon was firstly published by de Jussieu (1824) based on the species of *C. parviflorum* A.Juss. The genus are characterized by dioecious shrubs to small trees, a lack of milk sap, presence of pellucid glands, and rough leaf blade surface when dry, due to protruding needle-like crystals (Kabouw *et al*. 2008). Besides it has petiole with glands, inflorescences axillary spikes or racemes with the flowers usually in glomerules, no petals and a pistillode. The genus has numerous stamens with separated thecae on top of the connective (resembling the face of Mickey Mouse), strap-like disc glands among the stamens with generally an apical tuft of hairs, 3-locular ovary of pistillate flowers with a single ovule per locule (Koorders 1910, Backer & Backhuizen 1963).

Claoxylon consists of 113 species distributed in the Palaeotropics, ranges from Madagascar and the Mascarenes throughout South and South East Asia to the West Pacific and Hawaii (Govaerts *et al*. 2000). Recently McPherson (2019) add two news species from Madagascar and Setiawan *et al*. (2020) add a new species from Moluccas. Some *Claoxylon* species are known for their uses as food ingredients and as medicine to treat eye sickness, cough (Bharati *et al*. 2015), arthritis (Chen *et al*. 2017), tumor/cancer (Rai & Lalramnghinglova 2010), and sinusitis (Suroowan & Mahomoodally 2016).

The LSI is a group of islands belonging to a

series of volcanic mountains extending from Sumatra, Java, Bali to Alor and Wetar. The LSI consists of an inner island arc comprising Lombok to Wetar, and an outer island arc comprising Sumba, Timor, and the Tanimbar Islands (Henderson & Pitopang 2018). Wallace's line runs through the LSI, between Bali and Lombok (Welzen & Raes 2011). Nusa Tenggara (LSI) and the Mollucas are a series of islands that are flanked by four continental plates, the Eurasian plate, the Indo-Australia plate, the Philippine plate and the Pacific plate. The islands themselves are flanked by the Sundanese shallows and Arafura basins (Monk *et al*. 2000). Many continental fragments, throughs and fast changes in the sea floor depth or mountain heights make this part of Malesian region very interesting for biogeographic studies in relation to speciation event.

This present study was aimed to revise *Claoxylon* in LSI and to describe species diversity as well as distribution for this area. The results from this study is expected to provide a valuable contribution to, e.g., conservation of the species. The study also provide data in revision of the genus for the Flora Malesia.

MATERIALS AND METHODS

This revision work has been carried out at Herbarium Bogoriense (BO) based on the study of 113 dried herbarium specimens (63 from LSI and 45 from Sulawesi and Moluccas), relevant literatures for the Lesser Sunda Islands and neighbouring regions, and 6 specimens collected during explorations in Lombok and Sumba. The term of botany followed the terminology of Harris & Harris (2001). The leaf architecture followed the Manual of Leaf Architectures (Ash *et al*. 1999). Morphological data were used to identify (Appendix 1), compiled in a matrix and used phenetic analysis based on simple matching (SM) coefficient and Unweighted Pair Group with Arithmetic Mean (UPGMA). Grouping 63 samples of Claoxylon based on 14 characters carried out used similarity for qualitative data (SIMQUAL). All analyses were performed using the *Numerical Taxonomy and Multivariate Analysis System* (NTSYS-pc) program version 2.11a (Rohlf 1997). A similarity index and clustering used UPGMA and distribution mapping using Quantum GIS version 2.4.

RESULTS AND DISCUSSION

This study identified 11 species (Table 1) based on leaf shape, leaf texture, venation, and size of leaf blades; petiole length; number of bracts, number of stamens, ratio inflorescence length with leaf length; fruit shape and seed surface. Our results showed that *C.* cf. *abreviatum* JJ.Sm, *C. capillipes* Airy Shaw, *C. fulvescens* Airy Shaw, and *C. rubescens* Miq. was confirmed live in LSI.

The highest number species of *Claoxylon* was found in Bali (7 species). Flores had 6 species, whereas Lombok, and Timor had the same number of species, 5 species. The lowest diversity was present in Wetar (only 1 species) (Fig. 1). Bali has wetter climate than other island (van Steenis 1979), it probably cause the diversity of *Claoxylon* on Bali higher than in the other areas. The LSI is very undercollected, and the likely islands as Wetar, harbour more species to be collected.

Table 1. Distribution of *Claoxylon* species in the Lesser Sunda Islands.

No	Species	A	B	L	**U**	S	**T**	F	W
1	*C. abbreviatum*	x						x	
2	*C. affine*	x	x	x					
3	*C. capillipes* *	x	x					x	
4	*C. colfsii*	*x*				x			
5	*C. erythrophyllum*	x	x	x		x		x	
6	*C. fulvescens* *	x	x						
7	*C. glabrifolium*	*x*		x	x		x		
8	*C. indicum*	x	x	x	x	x	x	x	
9	*C. longifolium*	x	x	x				x	
10	*C. rubescens*	*x*		x	x		x	x	
11	*C. tenerifolium*	*x*	x				x		x
	Total		7	5	4	2	5	6	1

A: species listed in the checklist by Airy Shaw (1982); B: Bali; L: Lombok; U: Sumba; S: Sumbawa; T: Timor; F: Flores; W: Wetar; * = new record; x = present.

C. fulvescens Airy Shaw and *C. capillipes* Airy Shaw were extended to Bali Island (Fig. 2 & 3). These two species were previously reported to be endemic in New Guinea (Shaw 1980). The new records increased the diversity of *Claoxylon* on Bali from 6 species (van Balgooy & Widjaja 2014) to 7 species (one species switched names). This finding has also confirmed the doubtful species identified previously, *C.* cf. *capillipes* and *C.* cf. *fulvescens* (Shaw 1982).

Previous report on flora of Bali (van Balgooy & Widjaja 2014) reported that the 6 species distributed in Bali included *C. tenerifolium* and *C. glabrifolium*. However, these appear to be misidentifications because this study re-identified *C. tenerifolium* as *C. affine* due to the presence of the staminate flowers that have bracts on each raceme node and the leaves are chartaceous. *C. glabrifolium* actually resembles *C. fulvescens*, because *C. fulvescens* has a short petiole (<2 cm) and dense tomentose indumentum, while *C. glabrifolium* has a longer petiole (> 2 cm long) and is glabrous.

Distribution

In the LSI, *Claoxylon* grows in various habitats, ranging from primary mixed forest, to generally secondary lowland forests up to 2000 m above sea level. However, they was also found in coastal forests, river banks, roadsides, cliff edges, mountain forests, open areas and forest gaps.

C. tenerifolium was mainly known for Australia, but it has also been found in New Guinea; in LSI region, *C. tenerifolium* found on Wetar by Elbert (*Elbert 4377*). *C. rubescens* is distributed from Sumba, Sumbawa, Timor, and Flores, but it was absence in Bali.

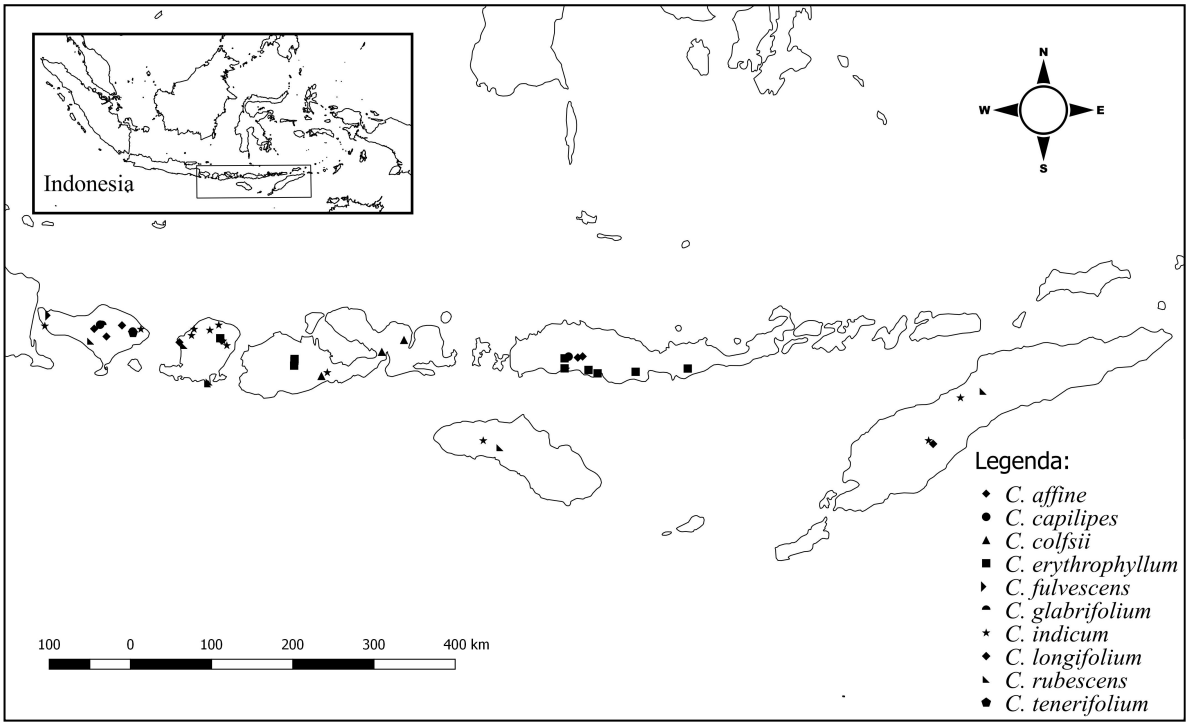

Figure 1. Distribution map of *Claoxylon* species in LSI

The high geodynamics of Sunda-Banda Plate in LSI are indicated by the significant of heterogeneous crust as a tertiary rifting process (Rangin *et al*. 2014, Honthaas *et al*. 1998). The amount of subduction and transition allows evolution to occur in the form of speciation, isolation and other process which affected *Claoxylon* distribution in LSI. In general, the number of species *Claoxylon* in LSI is higher than Java Island with the ratio of 11:5. Until now, Sumbawa is the only island in LSI that has an island endemic *Claoxylon* species.

C. erytrophyllum is recorded as the species with the widest distribution after *C. indicum* and *C. longifolium*, but *C. erytrophyllum* was still not found in Sumba and Timor Island. The differences in geological processes involving the establishment of each island were probably very influential on the distribution of *C. erytrophyllum.* Both Sumba and Timor arrived late at their present geological position, the arc-continent collision was marked by rapid uplift which moved sedimentary rocks

deposited at depths of several kilometres below sea level to their present position of more one kilometre above sea level (Hall 2013). Another problem, there is very limited collection in LSI, thus, *C. erytrophyllum* could be present on more islands. The amount of subductions and transitions, often on a short geological time scale, probably evoked speciation, isolation and other processes that affected the distribution of *Claoxylon* over LSI.

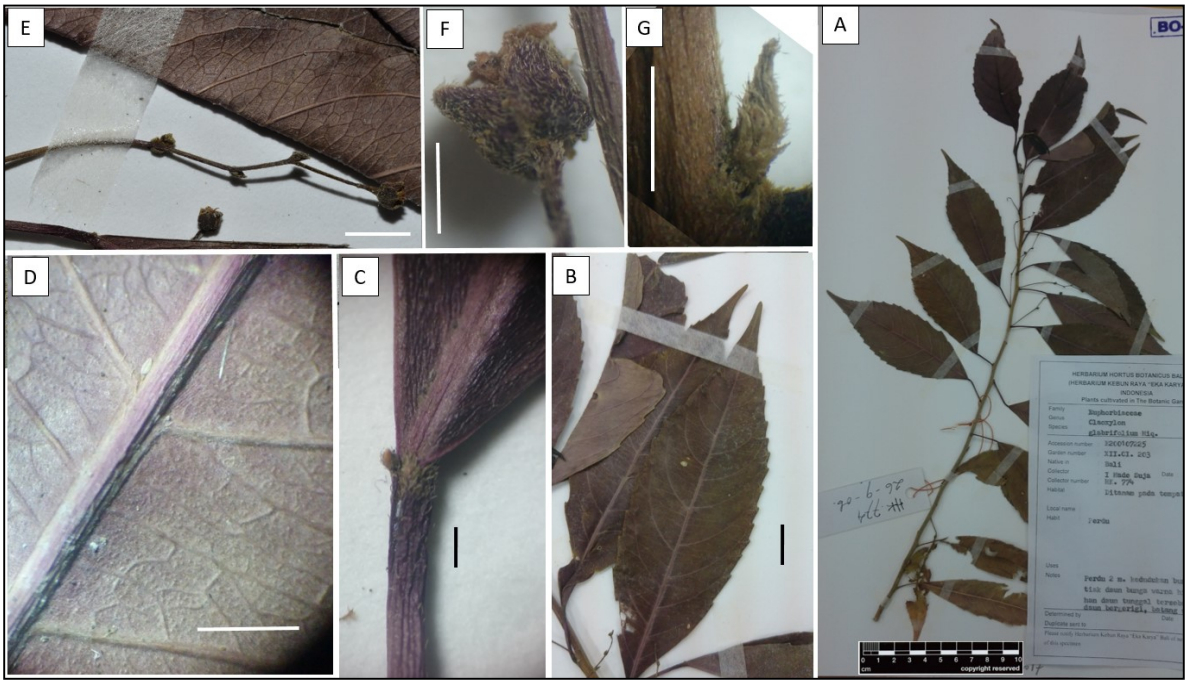

Figure 2. *C. capillipes* A. Twig (scale 10 cm). B. Leaves (scale 1 cm), C. Petiole glands (scale 2 mm). D. Lower leaf surface with raised venation and purple colouring (scale 5 mm). E. Inflorescences (scale 5 mm). F. Pistillate flower (scale 2 mm), G. Stipules (scale:2 mm). (*I Made Suja* 774 (BO).

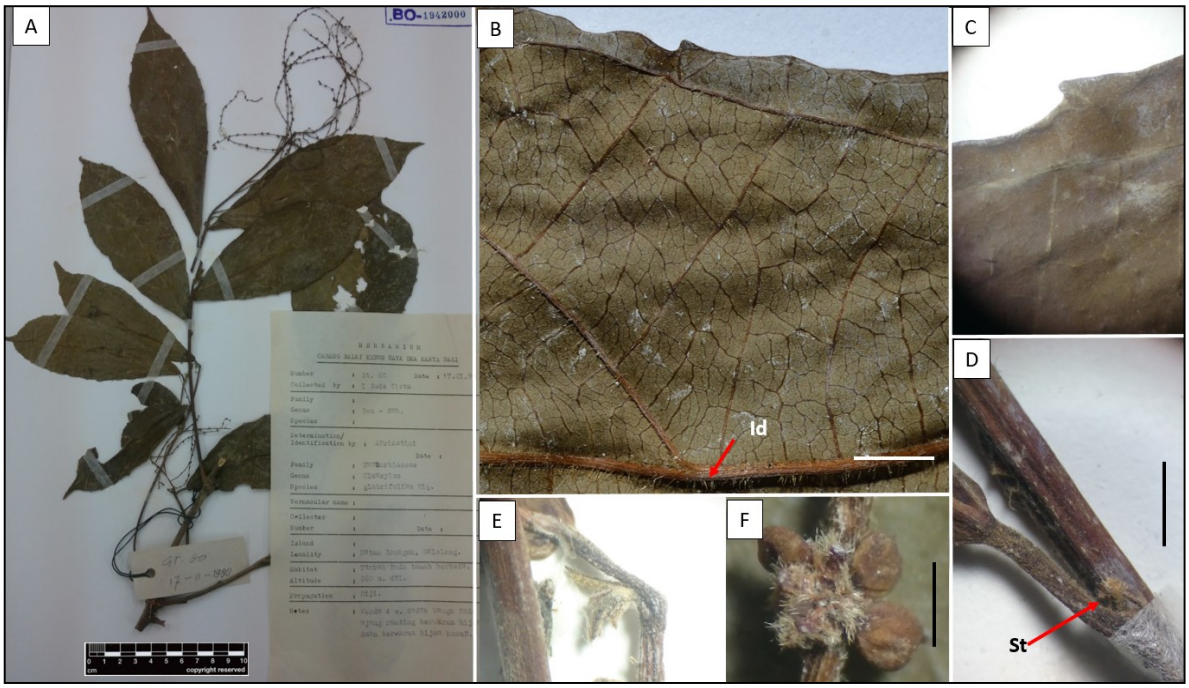

Figure 3. *C. fulvescens* A. Twig (scale 10 cm), B. Lower leaf surface, id = indumentum pilose (scale 5 mm), C. Marginal gland, D. Petiole, st= stipule (scale 1 cm), E. Young shoots, F. Buds in tomentose glomerule. (*I Gede Tirta* Gt. 60. (BO)).

The biogeography of a taxon can be influenced by many factors, such as biotic factors including adaptation, speciation and extinction; or ecological factors like pollination, predation, seed dispersal and competition (Spence *et al*. 2006). Abiotic factors include tectonic plate movements, changes in sea level, climate change and ocean circulation, fires, precipitation, El Niño, drought stress, hurricanes and volcanic eruptions (Spence *et al*. 2006). Different plate tectonic movements in LSI might be the most important factor that influenced the distribution of *Claoxylon* (Wallace's line is a result of it). Then ecological factors like predation, seed dispersal, followed by competition below forest canopy fine-tune the geographic patterns of *Claoxylon*. The distribution of *Claoxylon* in LSI, as shown in this study, agrees with van Welzen *et al.* (van Welzen *et al*. 2011), that placed Bali as part of the Southern Malesian Flora.

Phenetic Analysis of *Claoxylon* in LSI

A dendrogram was constructed based on 14 morphological characters (Fig. 4). Some important characters that could be used for distinguishing the *Claoxylon* species are the ratio of petiole and blade length, glands and indumentum; texture and vein patterns of leaves; ratio inflorescences and leaf length, number of flowers in glomerule and number of stamens (Appendix 1). The number of flowers in glomerule and number of stamens was used by Pax & Hoffman (1914) to distinguished section in *Claoxylon*. All observed species were grouped in three major groups, A, B and C, (Fig. 4) at a similarity coefficient of 0.42.

A phenetic analysis in *Claoxylon* has never been done before. Pax & Hoffman (1914) split all *Claoxylon* which used in this research into *Affinia* and *Indica* sections. The distinction between *Indica* section and *Affinia* section is the *Indica* section has bract with 1–12 flower, stamens 20–30, rare pauciflora, until 30–40, rare to 50–60 stamen. While in *Affinia* section, it has dioecious rarely monoecious flowers, male bract with few flowers, stamens 2–20 (Pax & Hoffman 1914).

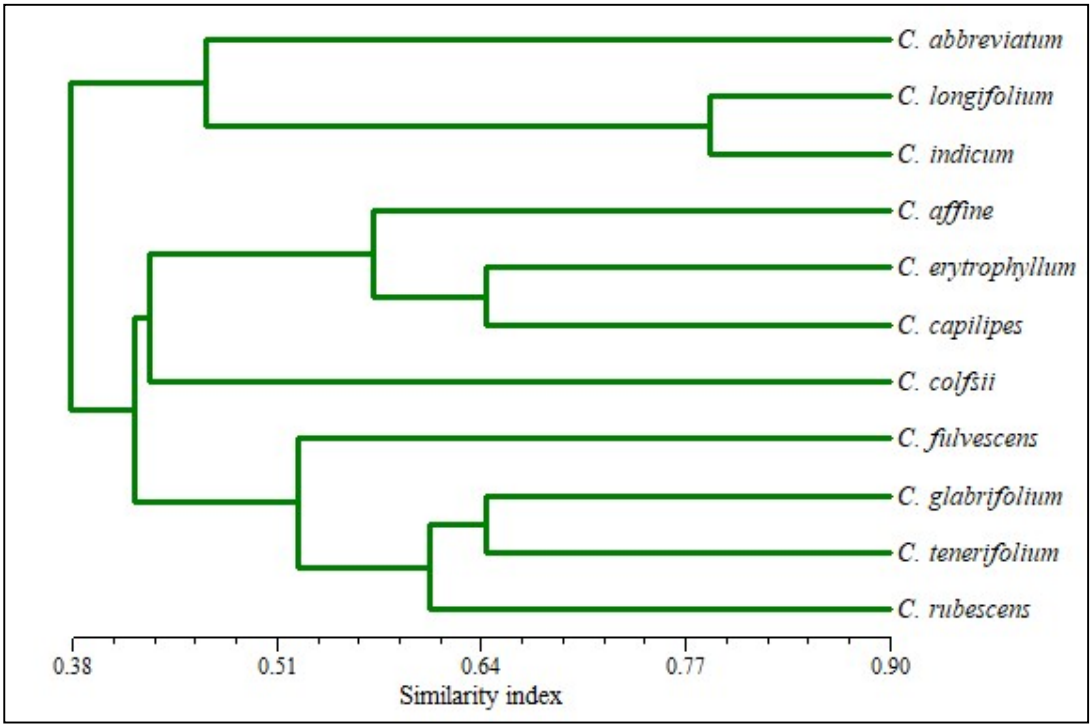

Figure 4. *A UPGMA* Dendrogram of *Claoxylon* in Lesser Sunda Islands based on 14 morphological characters using SM similarity index.

The result of this phenetic analysis is different from the classification of Pax & Hoffman (1914), which separated *Claoxylon* based on the number of stamens and number of flower in each glomerule. This phenetic analysis was based on mostly sterile characters, while Pax & Hoffman (1914) used dominantly fertile characters.

The species in LSI, fall into two of their sections, section *Affinia* (stamens < 20), and *Indica* (stamens ≥ 20). Species in section *Affinia* are related in group B consisted of *C. erythrophyllum, C. affine, C. colfsii,* and *C. capillipes.* Whereas the

section *Indica* are related with group A and C which consists of *C. indicum, C. fulvesens, C. longifolium, C. glabrifolium, C. abbreviatum, C. rubescens, C. tenerifolium* (Pax & Hoffman 1914).

Almost all *Claoxylon* species in group A have the same tertiary vein category, alternate percurrent, while group B has four distinctive characters, which are stamens less than 20, alternate percurrent tertiary veins, presence of the apical glands on the petiole adaxially, glabrous lower leaf surface. Group C shares three characters, elongated inflorescences (longer than leaves), more than 20 stamens, and a glabrous surface.

C. indicum and *C. longifolium* have the highest similarity coefficient (0.72). Both species are different in width and surface of leaf blades, the petiole length and the seed surface. *C. longifolium* has a blade width or rarely twice its length; the blade surface is glabrous, but rough, and its petiole is longer than 12.5 cm long. Most leaf blades of *C. indicum* are twice as long as the wide, and the petiole is longer than 8 cm (Loo *et al*. 2018). A striking difference between both species is the smooth seed of *C. longifolium* versus the rugose-verrucose seed of *C. indicum*.

CONCLUSION

There are eleven species *Claoxylon* in Lesser Sunda Islands. The highest species diversity was found in Bali (7 species) and the lowest diversity in Wetar (only 1 species). The LSI is very under-collected and likely islands such Wetar Island only has one species. A phenetic analysis based on 14 morphological characters, grouped the LSI *Claoxylon* species into three major groups that was not correspond to the section classification by Pax & Hoffmann.

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Appendix 1 Matrix characterization

No.	Character	Character state	Species										
			A	B	C	D	E	F	G	H	I	J	K
1	Petiole Category(ratio)	0. very short, 1. short, 2. long, 3. very long	1	2	1	2	1	0	2	3	3	1	3
2	Petiole Indumentum	0. glabrous, 1. sericeous, 2. pilose, 3. pubescent. 4. tomentose. 5. sericeous	4	0	3	3	3	2	0	0	0	0	0
3	Apical glands petiole	0. absent, 1. present	1	1	1	0	1	0	0	2	1	1	1
4	Vein colour	0. purplish, 1. green, 3 rubra/red	0	1	1	1	2	1	0	0	0	1	0
5	2°vein angle	0. uniform, 1. one pair acute basal secondaries, 2. two pair acute basal, 3. smoothlys increasing toward base, 4. smoothly decreasing toward base, 5. abruptly increasing toward base	5	4	4	5	4	4	1	5	4	3	5
6	3°vein category	0. opposite percurrent, 1. alternate percurrent, 2. mix opp/alt, 3. random reticulate, 4. dichotomizing, 5. regular polygonal reticulate	2	2	2	2	2	0	1	2	2	1	0
7	Surface indumentum	0. glabrous, 1. villous, 2. pilose, 3. pubescent. 4. tomentose. 5. sericeous	3	0	0	3	0	0	0	3	3	0	0
8	Lower indumentum	0. glabrous, 1. villous, 2. pilose, 3. pubescent. 4. tomentose. 5. sericeous	5	0	0	3	0	0	2	3	3	0	0
9	Texture	0. chartaceous, 1. coriaceous	0	0	1	0	1	0	1	1	1	1	0
10	Inflorescences	0. loose/lax, 1. short lax, 2. short tight, 3. zig-zag raceme	1	0	3	0	0	0	0	0	0	0	0
11	Ratio inflorescence with leaves	0. < leaves long, 1. = leaves long, 2. > leaves long	0	0	0	2	2	2	2	2	0	2	2
12	Number of stamens	0. < 20,(sec. *Affinia*) 1. > 20(sect. *Indica*)	1	0	0	0	0	1	1	1	1	1	1
13	Number of florae in Flower male in glomerule	0. 1–3 florae, 1. 3–5 florae, 2. 5–12 florae, 3. more than 12	0	3	0	1	1	2	1	2	2	0	1
14	Number of locule	0. 1 locule, 1. 2 locule, 2. 3 locule, 4. 4 locule	2	2	1	2	2	2	0	2	2	2	2

Notes: A. *C. abbreviatum,* B. *C. affine,* C. *C. capillipes*, D. *C. colfiii,* E. *C. erytrophyllum,* F. *C. fulvescens,* G. *C. glabrifolium*, H. *C. indicum,* I. *C. longifolium,* J. *C. rubescens,* K. *C. tenerifolium*

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