Short Communication:
Note on the genus *Dorstenia* Plum. ex L. (Moraceae) in Java (Indonesia) and noteworthy information on the identity of *D. bahiensis* through ITS sequence

ARIFIN SURYA DWIPA IRSYAM1*, MUHAMMAD RIFQI HARIRI2, PENI WIDIYANTI1,2, RINA RATNA SITH IRWANTO4

1Herbarium Bandungense (FIPIA), School of Life Sciences and Technology, Institut Teknologi Bandung, Labtek VC Building, Jl. Letjen Purn. Dr. (HC) Mashudi No. 1, Jatinangor, Sumedang 45363, West Java, Indonesia. Tel.: +62-22-7798600. *email: arifin@sitb.itb.ac.id, muhammad.rifqi.hariri@lipi.go.id
2Research Center for Plant Conservation and Botanic Gardens, Indonesian Institute of Sciences. Jl. Ir. H. Juanda No. 13, Bogor 16022, West Java, Indonesia
3Department of Biology, Faculty of Mathematics and Natural Sciences, Institut Pertanian Bogor. Jl. Agatis, Kampus IPB Darmaga, Bogor 16680, West Java, Indonesia
4School of Life Sciences and Technology, Institut Teknologi Bandung, Labtek XI Building, Jl. Ganesha No. 10, Bandung 40132, West Java, Indonesia

Manuscript received: 20 January 2021. Revision accepted: 22 July 2021.

Abstract. Irsyam ASD, Hariri MR, Widiyanti P, Irwanto RR. 2021. Short Communication: Note on the genus Dorstenia Plum. ex L. (Moraceae) in Java (Indonesia) and noteworthy information on the identity of *D. bahiensis* through ITS sequence. Biodiversitas 22: 3358-3363. *Dorstenia* Plum. ex L. grouped within tribe Dorstenieae in the Moraceae. The genus comprises 105 species that are distributed in the African, Asian, and Neotropical regions. Previous studies showed that Java Island has only one species of *Dorstenia*, namely *D. contrajerva* L. This exotic species was introduced a long time ago and naturalized in Java. The field survey was carried out in Banten, Jakarta, West Java, and East Java. Herbarium study was also carried out in Herbarium Bogoriense and Herbarium Bandungense.

There are two additional species from Java, *D. bahiensis* Klotzsch ex Fisch. and C.A. Mey. and *D. foetida* (Forssk.) Schweinf. *Dorstenia bahiensis* originated from Eastern Brazil and was found naturalized in Mekarwangi Village, Lembang, Bandung Barat regency, Indonesia. *Dorstenia foetida* is native to Africa and is only found as a popular cultivated plant. A molecular approach was carried out to provide the right identity of *D. bahiensis* because it has been mistakenly labeled as *D. elata* by a Javanese horticulturist. The internal transcribed spacer (ITS) sequence separated and distinguished both *D. bahiensis* and *D. elata* into different clades, which makes the popular name for *D. elata* actually *D. bahiensis*. Based on this study, there are three species of exotic *Dorstenia* in Java. The descriptions, photographs, and further discussions are provided.

Keywords: Alien, *Dorstenia*, Java, Moraceae, *tusuk konde*

INTRODUCTION

*Dorstenia* Plum. ex L. is the second largest genus in the Moraceae after *Ficus* L. It consists of 105 species that are distributed in Africa, Asia (Arabia, Sri Lanka, and India), and Neotropics (Fiiri 1983; Berg et al. 2006; Misiewicz and Zerega 2012; Chase et al. 2013; de Oliveira Boeni and Singer 2015). Morphologically, *Dorstenia* has unique characteristics, and it can be easily distinguished from the other genera within Moraceae. This genus includes herbs, shrubs, and succulent species, whereas the woody species are only found in Africa (Berg 2001). The inflorescences of *Dorstenia* are bisexual, borne solitarily from the axil of leaves, and vary in shape (discoid, turbinate, orbicular, elliptic, quadrangular, stellate, or lingulate). The receptacle is centrally or eccentrically attached to the peduncle and it has an entire dentate, crenate, appendiculate, or lobed margin (Berg 2001; Berg et al. 2006). Based on its inflorescence characteristics, the genus is presumed to be the intermediate form between an open inflorescence in *Morus* and the specialized syconium of *Ficus* (Misiewicz and Zerega 2012).

Berg et al. (2006) and Backer and Bahkuizen van den Brink (1965) only recognized one species of *Dorstenia* in Java, namely *D. contrajerva* L. The species is native to Mexico and Tropical America. It was introduced to Java years ago and became a naturalized alien species on the island (Berg et al. 2006). Based on our recent botanical survey and specimen observation, there are two additional species of exotic *Dorstenia* on Java Island, *D. bahiensis* Klotzsch ex Fisch. and C.A. Mey. and *D. foetida* (Forssk.) Schweinf. Both species are commonly known as *tusuk konde* plants by Javanese people. The presence of both species on the island is reported here.

MATERIALS AND METHODS

Botanical exploration and specimen observation

The field survey was conducted in Jakarta, Banten (Tangerang), West Java (Bandung, Bogor, and Sumedang), and East Java (Surabaya, Madura) from August 2019 to
March 2020. The field exploration followed Rugayah et al. (2004). The materials from the field were collected following van Balgooy (1987). The data recorded includes collector name, collection number, locality, habitat, date, vernacular name, and morphological characteristics (i.e., the color of exudates, stem, leaves, inflorescences, and infructescences).

The materials were observed at Herbarium Bandungense (FIPIA), School of Life Sciences and Technology (SITH), Institut Teknologi Bandung, and Bogor Botanic Gardens (BBG). Specimen examination was also carried out at Herbarium Bogoriense (BO), Indonesian Institute of Sciences (LIPI), Cibinong, Bogor. As many as seven sheets of herbarium specimens were observed for this study.

**DNA extraction, amplification, and sequencing**

Molecular analysis was carried out to confirm the identity of *D. bahiensis* as well as to compare it to the sequences of *D. elata* using the internal transcribed spacer (ITS) sequence following Sun et al. (1994). The DNA extraction and PCR process were conducted at Treub Laboratory, Bogor Botanic Gardens. The DNA was extracted using Tiangen Plant Genomic DNA Kit (Tiangen Biotech Co., Ltd.), following the manufacturer’s protocol. The polymerase chain reaction was carried out in a total volume of 50 μL, consisting of a 5 μL DNA sample, 1.5 μL each of ITS forward (5’-ACGAATCATGGTCCGGTG AAGTGTTCG-3’) and reverse (5’-TGAATTTCCCC GTTTCGCTCGCGGTAC-3’) primer, 25 μL MyTaq PCR mix, and 17 μL ddH₂O through the following reaction [95°C 3 min, (95°C, 30 s, 58°C for 45 s, 72°C for 45 s) × 35 cycles]. 72°C for 5 min. The PCR products were sent to be sequenced at 1st Base, Singapore.

**Sequence editing, alignment, and phylogenetic tree reconstruction**

The contig sequence was aligned to the homologous sequences and analyzed using MEGA X software using the Kimura 2-parameter model (Kimura 1980; Kumar et al. 2018). The reconstruction of a phylogenetic tree was achieved through the neighbor-joining (NJ) method with 1000 replicate bootstraps (Saitou and Nei 1987; Felsentein 1985). The evolutionary distances were computed using the Kimura 2-parameter method (Kimura 1980). The rate variation among sites was modeled with a gamma distribution (shape parameter = 5). All ambiguous positions were removed for each sequence pair (pairwise deletion option).

**RESULTS AND DISCUSSION**

**Taxonomic Treatment of Dorstenia in Java**

Updated key to the *Dorstenia* of Java

1. A. Acaulescent, leaves shallowly to deeply lobed ............ 1
   B. Caulescent, leaves unlobed .................................. 2

2. A. Stem terete, sap milky yellow, leaf blade oblong, margin entire or dentate, receptacle irregularly lobed to angular in outline, unappendaged .................................. *D. bahiensis*
   B. Stem tuberous, sap milky white, leaf blade oblong, obovate, to elliptic, margin crisped, receptacle circular in outline, linear appendages present .................................. *D. foetida*
Berg, Corner & Jarrett, Fl. Males. Ser. I, 17(1): 145-146 2006. — *Dorstenia quadrangularis* Stokes, Bot. Mat. Med., 4, 338 1812. Type: *Habitat in nova Hispania, Mexico, Peru, Vera Cruce, insula Vicentii, "Dorstenia" in Plumier, Nov. Pl. Amer., 29, t. 8, 1703* (lecto).

*Dorstenia contrajerva* L. var. *Houstonii* L., Sp. Pl. ed. 2. 176 1762–1763. — *Dorstenia quadrangularis* Stokes var. *Integripolia* Stokes, Bot. Mat. Med., 4, 339 1812.

*Dorstenia alexteria* L., Syst. Nat., Ed. 10: 889 1759.

*Dorstenia quadrangularis* Stokes var. *pinmatifida* Stokes, Bot. Mat. Med., 4, 341 1812.

*Dorstenia quadrangularis* Stokes var. *sinuata* Stokes, Bot. Mat. Med., 4, 339 1812.

*Dorstenia palmata* Willd. ex Schult., Mant. 3: 317 1827.

*Dorstenia maculata* Lem., Ill. Hort. 10: t. 362 1863. — *Dorstenia contrajerva* L. var. *maculata* (Lem.) Bureau in DC., Prodr. 17: 260 1873.

*Dorstenia contrajerva* L. subsp. *tenauloba* Blake, Contr. U.S. Natl. Herb. 24: 2, t. 1. 1922 — *Dorstenia contrajerva* L. var. *tenauloba* (Blake) Standl. and Steyerm., Publ. Field Mus. Nat. Hist., Bot. Ser. 23: 40 1944.

Herb, acaulescent with milky sap; internodes short. *Stipules* subulate, 3–6 × 2.5–5 mm, fleshy, green, puberulous. *Leaves* spirally arranged; petiole 13–23 cm long, green, slender; leaf blade lobed to parted or cordate to hastate, 7–22 × 7–26.5 cm, base cordate or hastate, apex acuminate; adaxial surface yellowish green to dark green, hirtellous to subhirsute or scabrous, abaxial surface glaucous, puberulous to hispidulous; veins prominent beneath. *Inflorescence* bisexual, axillary, discoid, green; peduncle 22.5–31.5 cm long, slender, scabrous, green; receptacle eccentrically attached, irregularly lobed to quadrangular in outline, 2.5–3 cm wide, margin lobed, green. *Staminate flowers* numerous; tepals connate; stamens 2; filament white; anthers yellow. *Pistillate flowers* numerous; tepals tubular, membranous, yellowish-white; ovary free, compressed ovoid, cream; stigmas 2, filiform, white. *Fruits* drupelet, ovoid, up to 2 mm wide, tuberculate, exocarp white.

---

**Figure 1.** Morphology of *Dorstenia bahiensis*: A. Living plant. B. A small wild population in Mekarwangi Village, Bandung (arrows). C. Abaxial surface of the leaf. D. Adaxial surface of the leaf. E. Upperside of inflorescence. F. Lower side of inflorescence. G. Male flowers. H. Female flowers. Photo A taken from MR Hariri 45 and photos B–H taken from ASD Irsyam 282.
**Distribution.** Mexico to Panama, West Indies, Colombia, northern Venezuela, western Ecuador, northern Amazonian Peru. The species was introduced to Malesia (Java) (Berg 2001; Berg et al. 2006).

**Specimen examined.** Jakarta: Parapat, Weltevreden, Batavia, 18 March 1903, C.A. Backer 33665 (BO); Parapat, Weltevreden, Batavia, 19 June 1903, C.A. Backer 33666 (BO); West Java Cult. in Hort. Bog., Leg ign s.n. (BO); Cult. in Hort. Bog., 12 May 1893, Hallier D573a (BO); Cult. in Hort. Bog., 10 April 1893, Hallier D573b (BO); in front of Treub Laboratory, BBG, Bogor, 12 August 2019, MR Hariri 44 (FIPIA); Schoolweg, 22 November 1922, C.A. Wisse 973 (BO).

**Vernacular name.** Tusuk konde (Bahasa Indonesia).

**Etymology.** The epithet ‘contrajerva’ means counter herb in Spanish, because the root of *D. contrajerva* is used as an antidote to snakebite (Cassidy and Le Page 2002).

**Status.** Naturalized.

**Dorstenia foetida** (Forssk.) Schweinf., Bull. Herb. Boissier 4 (App. 2): 120 1896; Friis, Nord J Bot 3(5): 536 1983. — *Cosaria foetida* Forssk., Fl. Aegypt.-Arab. Cxiii 1775. Type: Hadie, Yemen, Forsskål s.n. (Holo C). — Fig. 2

Dorstenia obovata J.F. Gmel., Syst. Nat. 2(1): 22, 71 1791.

Dorstenia arabica Hemsl., Hooker’s Icon. Pl. 26: t. 2503 1899.

Dorstenia crispa Engl., Monogr. Afrik. Pflanzen-Fam. 1: 27 1898.

Dorstenia foetida subsp. lancifolia (Rendle) Friis, Nordic J. Bot. 3: 538 1983. — Dorstenia crispa var. lancifolia Rendle, J. Bot. 53: 302 1915.

Dorstenia crispa var. pachypoda Chiov., Result. Sci. Miss. Stefanini-Paoli 1. 1916.

Dorstenia foetida var. obovata (A. Rich.) Engl., Monogr. Afrik. Pflanzen-Fam. 1: 27 1898. — Dorstenia obovata A. Rich., Tent. Fl. Abyss. 2: 1851.

Dorstenia phillipsiae Hook. f., Bot. Mag. 125: t. 7676 1899.

Dorstenia radiata Lam., Encycl. 2: 318 1786.

Herb, succulent with milky white latex; internodes short. *Stipules* fleshy, subulate from a broad base, 1–2 mm, very minute, white. *Leaves* spirally arranged; petiole 17–23 mm long, green, slender; leaf blade obovate, oblong, to elliptic, 43–60 × 20–25 mm, base cuneate, margin crisped, apex acute to obtuse; adaxial surface dark green, scabridulous, abaxial surface glaucous, sparsely puberulous; veins prominent beneath; leaves foetid when bruised. *Inflorescence* bisexual, axillary, discoid, green; peduncle 6–20 mm long, slender, green; receptacle green, circular in outline, 9–14 mm wide; appendages 8–10, linear-triangular, 1–6 mm long, green. *Staminate flowers* numerous; tepals connate; stamens 2; filament white; anthers white. *Pistillate flowers* numerous; tepals tubular, membranous, greenish-white; ovary free, ovoid, trigonous, cream; stigma simple, unbranched, white. *Fruits* drupelet, ovoid, trigonous, up to 1 mm wide, tuberculate, exocarp pale brown.

**Distribution.** Yemen, Somalia, Ethiopia, Sudan, Kenya, and Tanzania (Friis 1983).

**Habitat.** Limestone, dry woodland, and deciduous bushland at elevation 100–2100 m alt (Friis 1983).

**Specimen examined.** Banten: culta, Tangerang Selatan, 3 November 2019, MR Hariri 62 (FIPIA); Jakarta: Culta, Jakarta Utara, 11 August 2019, MR Hariri 43 (FIPIA); East Java: Culta, Surabaya, 3 November 2019, MR Hariri 63 (FIPIA).

**Vernacular name.** Tusuk konde hias (Bahasa Indonesia).

**Etymology.** The epithet ‘foetida’ refers to the foul-smelling of this species (Gledhill 2008).

**Status.** Cultivated.

**Molecular analysis of Dorstenia bahiensis in Java**

*Dorstenia bahiensis* is commonly and mistakenly identified as *D. elata* by Javanese horticulturists. Both *D. bahiensis* and *D. elata* are native to Eastern Brazil. However, their morphological characteristics are different and can be easily distinguished, as listed in Table 1. The morphological characteristics of *D. elata* used as a comparison to *D. bahiensis* are taken from dos Santos et al. (2016) because *D. elata* presence, currently, is not known in Indonesia.

The molecular approach using ITS sequence was carried out to ensure the species delimitation between *D. bahiensis* and *D. elata*. The reconstructed phylogenetic tree generated through the NJ method and the Kimura 2-parameter model with gamma distribution showed that both samples of *D. bahiensis* are clustered together with *D. arifolia* HQ214101. Those three are in a different cluster than *D. elata* HQ214087.1, as shown in Figure 3, which clearly states that *D. bahiensis* in Java is a different species from *D. elata*.

Table 1. Distinguishable morphological characteristics between *Dorstenia bahiensis* and *D. elata*

| Distinguishable characteristics | *D. bahiensis* | *D. elata* (dos Santos et al. 2016) |
|--------------------------------|---------------|----------------------------------|
| Shape of stipule               | Subulate      | Foliateous                       |
| Leaf blade                     | Oblong        | Elliptic-obovate                 |
| Leaf apex                      | Acuminate     | Acute to obtuse-rounded          |
| Abaxial surface                | Glabrous      | Puberulous to pubescent          |
| Indument on peduncle           | Glabrous      | Puberulous to pubescent          |
| Appendages on receptacle       | Present       | Absent                           |
| Shape of fruit                 | Ovoid         | Globose                          |

Note on the genus *Moraceae* in Java

The molecular approach using ITS sequence was carried out to ensure the species delimitation between *D. bahiensis* and *D. elata*. The reconstructed phylogenetic tree generated through the NJ method and the Kimura 2-parameter model with gamma distribution showed that both samples of *D. bahiensis* are clustered together with *D. arifolia* HQ214101. Those three are in a different cluster than *D. elata* HQ214087.1, as shown in Figure 3, which clearly states that *D. bahiensis* in Java is a different species from *D. elata*. **Table 1.** Distinguishable morphological characteristics between *Dorstenia bahiensis* and *D. elata*
Figure 2. Morphology of *Dorstenia foetida*: A. Living plant. B. Abaxial surface (left) and adaxial surface (right) of the leaf. C. The whole inflorescence. D. Zoom in of inflorescence shows female and male flowers. All photos taken from *MR Hariri* 63.

Figure 3. The evolutionary tree of *Dorstenia* generated from internal transcribed spacer sequence using the neighbor-joining method and Kimura 2-parameter.
ACKNOWLEDGEMENTS

We thank the Director of Herbarium Bogoriense (BO) and the curator for permitting us to use the specimens. Gratitude is also due to the Director of Bogor Botanic Gardens and the Head of Treub Laboratory, Bogor for their permission and support during the research.

REFERENCES

Backer CA, Bakhuizen van den Brink RC. 1965. Flora of Java. NVP Noordhoff, Groningen, The Netherlands.
Berg CC. 2001. Moreae, Artocarpeae, and Dorstenia (Moraceae): With Introductions to the Family and Ficus and With Additions and Corrections to Flora Neotropical Monograph 7. New York Botanical Garden Press, New York.
Berg CC, Corner EJH, Jarrett FM. 2006. Moraceae – genera other than Ficus. Fl. Males. – Ser. 1. Spermatophyta 17 (2): 1-702.
Cassidy FG, Le Page RB. 2002. Dictionary of Jamaican English. (2nd ed). The University of The West Indies Press, Jamaica.
Chase MW, Thajs KW, Kamau P, Fay MF. 2013. Dorstenia christenhuszii (Moraceae), a new species from the Taita Hills, Kenya. Phytotaxa. 81 (2):45-48. DOI: 10.11646/phytotaxa.81.2.1.
de Castro RM. 2006. Flora da Bahia – Moraceae [Dissertation]. Universidade Estadual de Feira de Santana, Feira de Santana, Bahia.
Boeni BDO, Singer RB. 2015. Synopsis of Dorstenia (Moraceae) in Rio Grande do Sul, Southern Brazil. Anais da Academia Brasileira de Ciências. 87 (2): 925-942. DOI: 10.1590/0001-3765201520140369.
dos Santos A, de São José PA, Filho MDMV, Neto SR. 2016. Dorstenia (Moraceae) da região da Serra da Mantiqueira, Brasil. Rodriguesia 67 (1):237-250.
Felsenstein J. 1985. Confidence limits on phylogenies: An approach using the bootstrap. Evolution. 39:783-791. DOI: 10.2307/2408678.
Friis L. 1983. The acaulescent and succulent species of Dorstenia sect. Rosaria (Moraceae) from NE tropical Africa and Arabia. Nordic J Bot 3 (5): 533-538. DOI: 10.1111/j.1756-1051.1983.tb01463.x.
Gledhill D. 2008. The Names of Plants. 4th ed. Cambridge University Press, Cambridge.
Kimura M. 1980. A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. J Mol Evol 16: 111-120. DOI: 10.1007/BF01731581.
Kumar S, Stecher G, Li M, Knyaz C, Tamura K. 2018. MEGA X: Molecular Evolutionary Genetics Analysis across computing platforms. Mol Biol Evol 35: 1547-1549. DOI: 10.1093/molbev/msy096.
Missewicz TM, Zerega NC. 2012. Phylogeny, biogeography and character evolution of Dorstenia (Moraceae). Edinburgh J Bot 69 (3): 413-440. DOI: 10.1017/S096042861200025X.
Rugayah, Retnowati A, Windadri FI, Hidayat A. 2004. Pengumpulan Data Taksonomi. In: Rugayah, Widjaja EA, Praptiwi (eds.). Pedoman Pengumpulan Data Keanekarakaman Flora. Pusat Penelitian Biologi-LIPI, Bogor. [Indonesian]
Saitou N, Nei M. 1987. The neighbor-joining method: A new method for reconstructing phylogenetic trees. Mol Biol Evol 4: 406-425. DOI: 10.1093/oxfordjournals.molbev.a040454.
Sun Y, Skinner DZ, Liang GH, Hulbert SH. 1994. Phylogenetic analysis of Sorghum and related taxa using internal transcribed spacers of nuclear ribosomal DNA. Theor Appl Genet 89 (1): 26-32. DOI: 10.1007/BF00226978.
Upadhyay GK, Ansari AA, Dalai AK. 2008. Dorstenia bahiensis Klotzsch Ex Fisch. and C.A. Mey. (Moraceae)-first naturalised record for India. Indian J For 31:479-482.
van Balgooy MMJ. 1987. Collecting. In: de Vogel EF (ed.). Manual of Herbarium Taxonomy Theory and Practice. UNESCO for Southeast Asia, Jakarta.