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Research Article

Morphological variability of *Indigofera cordifolia* (Fabaceae) from different habitats in India and its two new synonyms

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Abstract: Morphological variability in *Indigofera cordifolia* B. Heyne ex Roth over a range of habitats in India is provided and discussed. Recently described *I. jaisalmerica* C.S.Purohit & Kulloli and *I. jodhpurensis* Bhellum, Dhar & Magotra are synonymized with *I. cordifolia.* We also clarified the typification of the name *I. cordifolia* B.Heyne ex Roth.

Keywords: Heterotypic synonym, *Indigofera jaisalmerica, Indigofera jodhpurensis,* lectotype, Leguminaceae, variation

Introduction

The genus *Indigofera* L. consists of about 750 species (Schrire et al., 2009; POWO, 2024), distributed throughout the tropical and subtropical regions of the world. In India, the genus is represented by 63 species and 11 varieties (Sanjappa, 2020). *I. cordifolia* is common herb and grows in the wide range of habitats, forming gregarious colonies in moist open rocky gravel areas, grasslands, fallow lands and rocky crevices in dry deciduous forests of Andhra Pradesh, Bihar, Chhattisgarh, Delhi, Goa, Jharkhand, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Odisha, Rajasthan, Tamil Nadu, Telangana and Uttar Pradesh and shows high degree of polymorphism.

A collaborative project between Botanical Survey of India and National Remote Sensing Centre, Indian Space Research Organization from 2008 to 2013 and other in-house projects, the live specimens of *Indigofera cordifolia* were collected and studied from different states of India along with other taxa

collected during plant explorations. We observed morphological variations in *I. cordifolia* from the above states. Photographs of live plants of *I. cordifolia* were taken by Panasonic Lumix DMC-FZ28 and Nikon D5300 cameras. Herbarium specimens were made according to the standard herbarium techniques and deposited at BSI and BSJO. Floral parts were examined in Olympus SZ61TR stereo-zoom microscope. The identity of the species was confirmed by using relevant literature, studying herbarium specimens deposited at BSA, BSI, BSID, BSJO, CAL and MH, and also with the digital images of type specimens housed at BM, K and L. The earlier type citations for the name *I. cordifolia* B.Heyne ex Roth is corrected and clarified here as the lectotype according to the guidelines of Article 9 in the International Code of Nomenclature for algae, fungi, and plants (Turland et al., 2018).

Ecological Notes

In Jaisalmer and Jodhpur districts of Rajasthan, three *Indigofera* species namely *I. hochstetteri* Baker, *I. linifolia* (L.f.) Retz. and *I. tsiangiana* Metcalf share the habitat with *I. cordifolia*. In peninsular India, the common cohabitant *Indigofera* species are *I. astragalina* DC., *I. linifolia* and *I. tsiangiana*. We observed high degree of morphological variations within and between different populations of *I. cordifolia* in the above states of India. Morphological features such as size of plant, leaf growth pattern, leaf shape, indumentum on leaves and other parts, number of flowers in inflorescence, colour of petals, number of pods in infructescence, pod size and number of seeds per pod have vary, according to soil moisture and temperature. Soon after the first monsoon rains in June, *I. cordifolia* germinate, blooming start in July and end up during January, fruiting between August and February, and fallen seeds from dehiscent fruits remain dormant till next monsoon rains between June and August. Generally, this plant grows as prostrate (Figure 1. A, D, E) and decumbent when they are growing in open areas to receive the direct sunlight, sometimes it grows erect (Figure 1.B) when they are growing along with the grasses and other herbaceous plants to get the sunlight, later prostrate due to the weight of the inflorescence and infructescence. Plants growing in rocky crevices shows decumbent and straggling growth pattern (Figure 1.C). The height of the plant varies from 10 cm to 80 cm long (Figure 2). Stem colour also will change from green to purplish in between July to December (Figure 3. A, G; Figure 5. F, G) due to the accumulation of anthocyanin pigment. Branches are obscurely pubescent in between July and August and they are densely pubescent in September to February to withstand in winter temperatures. Recently, this species is reported new to the flora of Saudi Arabia from Dumsuk Island are densely pubescent (Alharbi and Al-Qthanin, 2020). Leaf shape is varying from cordate to ovate (Figure 4) and the density of the indumentum on leaves also will change from July to February in the same plants (Figure 4). Inflorescence is axillary and sometimes flower solitary to 18 flowers in a raceme (Figure 5). Length of pedicels varies from 0.1 to 1.6 mm and corolla colour ranges from pinkish to brick red to scarlet. Number of pods in a raceme is also varied from 1 to 15 and was also observed on the same plants (Figure 5). All these morphological variations of *I. cordifolia* are meant for ecological adaptation to the climate, edaphic conditions, and growth developments of seedling to mature plant stage. These environmentally induced morphological variations of *I. cordifolia* cannot be considered as diagnostic characters to establish a new taxon.

Above all, these types of morphological or ecological variants can be easily seen in the field and in herbarium collections at different herbaria (BM, BSA, BSI, BSJO, CAL, E, K, L, MH and P).



Figure 1: *Indigofera cordifolia* B.Heyne ex Roth habit variations. A, D & E – Prostate habit; B & C – Erect habit



Figure 2: *Indigofera cordifolia* B.Heyne ex Roth height variations observed in Rajasthan state

We critically examined the protologue, types and other herbarium materials of *I. cordifolia*. We also examined live plants from the type locality of *I. jaisalmerica* Kulloli and *I. jodhpurensis* Bhellum, Dhar, & Magotra, found no differences with *I. cordifolia*. Based on our field observations, study of protologues and type specimens, we found that all the taxonomic characters of *I. jaisalmerica* (Purohit and Kulloli, 2021) and *I. jodhpurensis* (Bhellum et al., 2023) are similar and fall within the circumscription of *I. cordifolia* (Baker, 1876; Cooke, 1902; Haines, 1922; Kort and Thijsse, 1984; Sanjappa, 1995; Alharbi and Al-Qthanin, 2020). Therefore, *I. jaisalmerica* and *I. jodhpurensis* are merged here as a heterotypic synonyms of *I. cordifolia*.

Taxonomic treatment

Indigofera cordifolia B. Heyne ex Roth, Nov. Pl. Sp. 357. 1821. ≡ *Anila cordifolia* (B.Heyne ex Roth) Kuntze, Rev. Gen. Pl. 1: 160. 1891. ≡ *Heylandia cordifolia* (B. Heyne ex Roth) Graham, Numer. List [Wallich] n. 5343. 1831.

Lectotype first-step (inadvertently designated by Kort & Thijsse, 1984): India, *B. Heyne s.n.* (L, 2 sheets); second-step (designated by Turner, 2021): India, *B. Heyne s.n.* (L0052926 [digital image!], Figure 6A); isolectotypes BM012553513 [digital image!, Figure 6B], BM012553516 [digital image!, Figure 6C], K000848576 [digital image!, Figure 6D], K001120616 [digital image!, Figure 7A], L.2050892 [digital image!, Figure 7B].

= *Indigofera jaisalmerica* C.S.Purohit & Kulloli, J. Asia-Pacific Biodivers. 14(4): 628. 2021, ***syn. nov***.

Type: India, Rajasthan, Jaisalmer, Brahamsar Dham, 25˚3' 45.887"N 70˚55' 18.408" E, 157.5 m, 6 October 2017, *C.S. Purohit 33625A* (holotype BSJO000050880!, Figure 7C; isotypes BSJO000050879!, BSJO000050881! Figure 7D).



Figure 3: *Indigofera cordifolia* B.Heyne ex Roth habit variations. A–C – Prostate habit; D – Decumbent habit in the grassland; E – Shorter habit in the gravelly soil and growing along with *I. linifolia* (L.f.) Retz. and *I. tsiangiana* Metcalf; F–G – Decumbent habit; H – Erect habit



Figure 4: *Indigofera cordifolia* B.Heyne ex Roth leaf variations. A & B – Ovate leaves with less dense indumentum; C – Ovate leaves with dense indumentum; D – Ovate leaves with highly dense indumentum; E & F – Cordate leaves with dense indumentum; G & H – Cordate leaves with very dense indumentum



Figure 5: *Indigofera cordifolia* B.Heyne ex Roth flower and pod variations, number of flower and pod at leaf axil. A – single flower to 2 flowers; B – 3 to 4 flowers; C – 3 to 5 flowers; D – 2 to 5 flowers; E – 2 to 10 flowers; F – 2 pods; G – 4 pods; H – 4 to 5 pods; I – 3 to 5 pods; J – 15 pods



Figure 6: A. Lectotype of *Indigofera cordifolia* B.Heyne ex Roth (L0052926, © Naturalis Biodiversity Center, Leiden)**;** B. Isolectotype of *Indigofera cordifolia* B.Heyne ex Roth (BM012553513, © The Natural History Museum, London); C. Isolectotype of *Indigofera cordifolia* B.Heyne ex Roth (BM012553516, © The Natural History Museum, London); D. Isolectotype of *Indigofera cordifolia* B.Heyne ex Roth (K000848576, © The Trustees of the Royal Botanic Gardens, Kew)



Figure 7: A. Isolectotype of *Indigofera cordifolia* B.Heyne ex Roth (K001120616, © The Trustees of the Royal Botanic Gardens, Kew); B. Isolectotype of *Indigofera cordifolia* B.Heyne ex Roth (L.2050892, © Naturalis Biodiversity Center, Leiden); C. Holotype of *Indigofera jaisalmerica* C.S.Purohit & Kulloli (BSJO000050880, © Botanical Survey of India, Jodhpur); D. Isotype of *Indigofera jaisalmerica* C.S.Purohit & Kulloli (BSJO000050881, © Botanical Survey of India, Jodhpur)

= *Indigofera jodhpurensis* Bhellum, Dhar & Magotra, Nordic J. Bot. 2023(12)-e04005: 2. 2023, ***syn. nov*.**

Type: India, Jodhpur district, about 6 km from Bhagat ki Kothi towards Pali, 26˚20˙55.41˝ N 73˚10˙60.40˝ E, 230 m, 16 November 2022, *B.L. Bhellum 16925* (holotype HBJU17621 [digital image!]; isotype RRLH27866).

Typification notes

Indigofera cordifolia was described by Roth (1821) based on the specimens collected by Benjamin Heyne (1770–1819) from India. No original material is extant for the name *I. cordifolia* B.Heyne ex Roth at B. We traced six original herbarium specimens of *I. cordifolia* collected by Benjamin Heyne from India, two at BM (BM012553513 and BM012553516), two at K (K000848576 and K001120616) and two at L (L0052926 and L.2050892). The specimens of B. Heyne at BM and K with barcodes BM012553516, K000848576 and K001120616 were incorporated by J.P. Rottler in his herbarium. Of these BM012553516 and K001120616 are become a part of N. Wallich's herbarium (catalogue no. 5343A). The two specimens of B. Heyne at L with barcodes L0052926 and L.2050892 belongs to A.W. Roth's herbarium. The collection date 20 November 1798 was mentioned by B. Heyne on herbarium sheet with barcode nos. BM012553516, K000848576 and K001120616. Kort & Thijsse (1984) cited the type of *I. cordifolia* B. Heyne ex Roth as "Type: *Heyne s.n.* (L), Ind. Or." this constitutes an inadvertent lectotypification according to Art. 7.11 of the ICN (Turland et al., 2018). This has the first-step of lectotypification of *I. cordifolia*. Recently, Turner (2021) overlooked this lectotypification and designated the specimen with barcode L0052926 as lectotype which is considered as an effective lectotypification according to the Article 9.17 of ICN (Turland et al., 2018).

Specimens examined: Andhra Pradesh, Guntur, Kondaveedu Sacred Groove, 12 October 2015, *J. Swamy & S. Nagaraju 7195* (BSID); Chittoor, Thamballapalli, 14 November 2000, *G.V.S. Murthy 111963* (BSID); Seshachalam Biosphere Reserve, 19 November 2013, *M.S. Rao 3809* (BSID); Daman, 24 September 1964, *M.Y. Ansari 93538* (BSI); Karimnagar, Kodimial, 400 m, 28 September 1965, *G.V. Subbarao 25669* (MH). Tamil Nadu, Salem, Hogainakkal, 300 m, 26 November 1964, *E. Vajravelu 21952* (MH); North Arcot, Synagunta reserve forest, 27 October 1986, *M.B. Viswanathan 1235* (MH); Coimbatore, Edyarhalli reserve forest, 2000 ft., 28 November 1837, *K.C. Jacob 488* (MH); Coimbatore, 1869, *R.H. Beddome s.n.* (MH). Karnataka, Tumkur, Manchaldore, 29 October 1975, *N.P. Singh 141132* (BSI); Chikmagalur, 15 October 1974, *R.S. Raghavan 132304* (BSI); Kupgal, 30 September 1958, *B.M. Wadhwa 44930* (BSI). Lakshadweep, 3 m, 8 October 1986, *P. Bhargavan 108337* (MH). Maharashtra, Sholapur district, Naldurg along river bed, 12 September 1964, *K.P. Janardhanam 100687* (BSI); West Khandesh, Dhulia, Mukli Lake, 23 August 1956, *R.D. Pataskar 118221* (BSI); Khambatki Ghat, 2 November 1964, *R.S. Raghvan 104082* (BSI). Rajasthan, Gajner Lake, 13 July 1958, *G.S. Puri 39789* (BSI); Jodhpur - Bijolai, 31 July 1958, *S.K. Jain 40191* (BSI); Barmer, back of Mataji Temple, 7 October 1960, *R.S. Rao 66979* (BSI); Jaisalmer, near Dark Banglow, 11 October 1960, *R.S. Rao 67055* (BSI); Jodhpur, Kayalana Hills, 20 August 1957, *G.H. Khisti 23026* (BSI); Sambhar Lake Ramsar site, Naliyasar mode, 26°51.834' N 75°11.327'E, 379 m, 11 August 2023, *R.K.*

Arigela et al. 37431 (BSJO); Bundi, Ramgarh Visdhari Tiger Reserve, Dalelpura Beet, 25°28.596' N 75°39.758' E, 316 m, 6 August 2024, *R.K. Singh et al. 40012* (BSJO); Jaisalmer, near Shri Brahmsar Tirth, 24 November 2022, *R.K. Arigela s.n.* (BSJO); Jodhpur, Pali road, 23 September 2023, *R.K. Arigela & R.K. Singh s.n.* (BSJO); Jodhpur, Mehrangarh fort road, Ghodaghati, 23 July 2023, *R.K. Arigela & R.K. Singh s.n.* (BSJO). Telangana, Warangal, 20 September 1995, *R.K. Premanath 105362* (BSID); Khammam, Bandi Reserve Forest, 21 September 1994, *R. Chandrasekaran 99097* (BSID); Khammam, Rollapadu, 28 December 1996, *R. Rajan 108040* (BSID).

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