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Caption: Large Indian Civet *Viverra zibetha*, Tricoloured Munia *Lonchura malacca* and *Hoya wightii* (Medium—pencil crayon on watercolour paper) © Supriya Samanta.

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COMMUNICATION

Updated distribution of seven *Trichosanthes* L. (Cucurbitales: Cucurbitaceae) taxa in India, along with taxonomic notes

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Abstract: In India, lack of revisionary work in the genus *Trichosanthes* L. (Cucurbitales: Cucurbitaceae) over the past 38 years had resulted in several taxonomic and nomenclatural issues, which had implications in determining actual distribution status of taxa. Based on field observations, collected specimens, data from various specimens in herbaria and critical study of all the resources available, here we confirm the extended distribution of *T. anaimalaiensis* Bedd. in the states of Manipur and Nagaland; *T. cordata* Roxb. in Uttar Pradesh and Bihar; *T. cucumerina* L. subsp. *sublobata* (Kundu) K. Pradheep, D.R. Pani & K.C. Bhatt in Gujarat, Madhya Pradesh and Odisha; *T. dicaelosperma* C.B. Clarke in Nagaland; *T. kerrii* Craib in Arunachal Pradesh and Manipur; *T. majuscula* (C.B. Clarke) Kundu in Arunachal Pradesh, Sikkim and Assam; and *T. truncata* C.B. Clarke in Nagaland. Two taxa, namely, *Trichosanthes dicaelosperma* and *T. majuscula*, earlier subsumed with *T. ovigera* Blume or *T. cucumeroides* (Ser.) Maxim., and *T. dunniana* H. Lév., respectively, have been resurrected at the rank of species. Lectotypes were designated for the names of above two species. For the first time, female plants of *T. majuscula* have been described. This communication provides an updated distribution status of seven taxa of *Trichosanthes* in India along with field and taxonomic notes, and additional taxonomic characters.

Keywords: Lectotypification, new distribution records, northeastern India, range extensions, *Trichosanthes dicaelosperma*, *T. majuscula*.

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INTRODUCTION

Known as the largest genus in the family Cucurbitaceae, *Trichosanthes* L. consists of about 100 species with some having vegetable and medicinal importance, occurring from the Indian subcontinent in the west, to China and Japan in the north and the east, to Australia in the south (de Wilde & Duyfjes 2010, 2012). Chakravarty (1982) and Renner & Pandey (2013) had reported the occurrence of 22 species in India, with more than three-fourths occurring exclusively in the northeastern region of India. Incomplete herbarium collections in species-rich areas, dioecy, nocturnal flowering, heterophylly, and different juvenile morphology, together with the lack of recent revisionary works (since 1982) had resulted to taxonomic misidentifications and nomenclatural instability in the Indian taxa, which in turn led to non-detection of species in a given area, although present. Reporting of extended distribution of wild species related to crop species not only helps updating the floristic databases of the concerned region, but also in augmenting unrepresented germplasm from such regions for conservation and sustainable utilization (Pradheep et al. 2011, 2018).

MATERIALS AND METHODS

This study was based on extensive survey and explorations (23 trips) carried out all over India during 2009–2020 and herbarium studies. Senior author had personally visited various Indian herbaria - ASSAM, BSD, BSHC, BSIS, BSJO, CAL, CUH, DD, KASH, LWG, MH, NEHU, NHCP, PBL, PCM, and RHT [herbaria codes according to Thiers (2020, continuously updated)]. Species geographic occurrence data from the Global Biodiversity Information Facility (GBIF) and various online herbaria – A, B, BM, BR, E, G, HIFB, FRLHT, GH, HBG, IIIM, JCB, K, KFRI, L, LINN, MO, NY, P, PE, and RPRC [herbaria codes according to Thiers (2020, continuously updated)], including type specimens were also consulted. All the specimens cited here were seen either as physical specimens or in the form of online digital images. Detailed observation on qualitative and quantitative characters was made and herbarium specimens were prepared as per standard procedure (Jain & Rao 1977). Thorough verification or cross-checking with floristic as well as other key literature pertaining to the concerned state (Table 1) and other pertinent works (Jeffrey 1980, 1982; Chakravarty 1982; Naithani 1990; Renner & Pandey 2013; Pradheep et al. 2014, 2015; Pandey et al. 2016) was made and the status of species distribution was updated. This resulted in identification of seven *Trichosanthes* species with extended distribution in various Indian states. While herbarium vouchers of these species were deposited in the National Herbarium of Cultivated Plants (NHCP) at ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi, germplasm collections are being conserved in the form of (live) seeds in the National Genebank at ICAR-NBPGR, New Delhi.

Taxonomic Enumeration

1. *Trichosanthes anaimalaiensis*

Bedd., Madras J. Lit. Sci. 3(1): 47. 1864. Chakravarty, Fasc. Fl. Ind. 11: 107. 1982. *T. anamalayanus* Bedd. Trans. Linn. Soc. 25: 217. 1865. *T. palmata* Roxb. var. *tomentosa* B. Heyne ex C. B. Clarke, Fl. Brit. Ind. 2(6): 607. 1879. *T. burmensis* Kundu, J. Bombay Nat. Hist. Soc. 43(2): 381. 1942. *T. burmensis* Kundu var. *alba* Kundu, J. Bombay Nat. Hist. Soc. 43(2): 381. 1942. *T. bracteata* (Lam.) Voigt var. *tomentosa* (B. Heyne ex C.B. Clarke) Chakrav., Rec. Bot. Surv. Ind. 17(1): 47. 1959; Chakravarty, Fasc. Fl. Ind. 11: 110. 1982. *T. tricuspidata* Lour. var. *tomentosa* (B. Heyne ex C.B. Clarke) Kumari, Fl. Tamil Nadu, Ind., Ser I: Analysis 1: 174. 1983.

Type: India, Tamil Nadu, Anaimalai Mts., *Beddome 3234* (holotype BM, available at http://plants.jstor.org/specimen/bm000885793).

Robust dioecious climber, 15–20 m long. Stems: robust, highly striate, grooved, puberulous, pale green; young twigs often reddish. Tendrils: 2–3 fid, one strong. Probracts: elongate, tail-like, 1.5–2.0 × 0.45 cm, distantly irregularly serrate, reflexed. Leaves: petioles stout, 6–8 cm long, striate, puberulous; lamina membranous, ovate-suborbicular in outline, 12–17 × 13–18 cm, shallowly 3–5-lobed, lobes rarely up to middle, upper lobe half-elliptic, base slightly cordate, adaxially bulbous-strigose, very scabrous, pale green, abaxially reticulate, tomentose on nerves, margin irregularly or deeply serrate, 4–5 nerved at base, glands 10–20, medium-sized, at base and along main nerves. Male racemes: 25–30 cm long, 5–8-flowered; peduncles very stout, grooved, puberulous; rachis ± zigzag, withered bracts intact; bracts pale green, puberulous, cucullate, sub-reniform in outline, 3.5–4.2 × 3.8–4.7 cm, apex rotund, prominently corrugated, highly laciniate-lacerate, nerves 12–15, glands 10–15. Male flowers: pedicel 0.6 mm long; flowers highly fragrant, 4–5.5 cm long, 0.35 cm diameter at base or 0.7–0.9 cm at mouth, calyx tube often pinkish-red, glands few. Sepals: gigantic, cucullate, ovate-triangular in outline (of female flower

Figure 1. Occurrence of *Trichosanthes anaimalaiensis, T. cordata, T. dicaelosperma, T. kerrii, T. majuscula* and *T. truncata* in northeastern Indian states (black-filled shapes indicates already-reported, while red-filled ones are new distribution records)

Table 1. Important literature consulted for cross-checking species occurrence in some Indian states.

	State	References
1.	Arunachal Pradesh	Hajra et al. (1996); Dash & Singh (2017)
2.	Assam	Kanjilal et al. (1938)
3.	Bihar	Haines (1921–25)
4.	Manipur	Singh et al. (2000)
5.	Nagaland	Mao et al. (2017)
6.	Odisha	Saxena & Brahmam (1994–1996)
7.	Sikkim	Grierson & Long (1984); Hara (1966)
8.	Uttar Pradesh	Khanna et al. (1999)
9.	West Bengal	Grierson & Long (1984); Paul et al. (2015)

Image 1 . A—Male plant of *Trichosanthes anaimalaiensis* in Nagaland (inset: bract and male flower bud) | B—Female plant of *Trichosanthes anaimalaiensis* in Nagaland | C—Habit of *Trichosanthes kerrii* in Arunachal Pradesh (inset: young twig) | D—Fruiting twig of *Trichosanthes kerrii* (inset: seeds). © K. Pradheep.

– subulate, entire), 2–2.5 × 1 cm, pale pinkish, apex acuminate, margin laciniate or lacerate. Petals: 1.3 × 1.2 cm (excluding frills, frills 0.5–0.7 cm long), adaxially whitish often with pink veins, hirsute. Anthers: stamens 3, conduplicate, arise just above the rim of corolla tube, 11.5–12.5 × 3–3.2 mm; filaments short, 3 mm long, stout. Stigma lobes 3. Fruits: pedicels 2.3–2.7 cm long; fruits solitary, rarely in clusters (see notes), (sub) globose, 5–6 × 5–5.6 cm, umbonate, pulp greenish black. Seeds: oblong, 9–10 × 4–5 × 1.5–2 mm, reddish, margin ± angular (Image 1A & B).

Flowering and fruiting: May–September and August–November, respectively.

Habitat: Evergreen broad-leaved forests up to 1,600 m; found in red lateritic soils.

Distribution: India (Andhra Pradesh, Arunachal Pradesh, Karnataka, Kerala, Maharashtra, Mizoram, Tamil Nadu, and Tripura; new to Manipur and Nagaland (Figure 1)), Sri Lanka (Jeffrey 1982), and Myanmar (now).

Specimens examined: Manipur: 7162 (CAL), 29.ix.2012, Yumnam Khunou, Bishnupur dt., 780 m, Coll. G. Watt; 12-2 (NHCP), 28.ix.2012, Iroisema, Imphal West dt., 750 m, coll. K. Pradheep; 12-3 (NHCP), 30.ix.2012, Kangla, Imphal East dt., 800 m, Coll. K. Pradheep; KP-1263 (living coll. at NBPGR, New Delhi), 01.x.2012, Lilong, Thoubal dt., 780m, Coll. K. Pradheep. Nagaland: 14-1 (NHCP), 11.viii.2014, Chare, Tuensang dt., 1310 m, Coll. K. Pradheep & Soyimchiten; 14-2 (NHCP), 12.viii.2014, Sangsangyu, Hakchang, Tuensang dt., 1350 m, Coll. K. Pradheep & Soyimchiten; KC/S/I-67 (living coll. at NBPGR, New Delhi), 20.x.2011, Mirima, Kohima dt., 870 m, Coll. K.C. Bhatt et al.

Notes: The striking character 'fruits borne in cluster', with which this species traditionally being distinguished from *T. bracteata*, is not a good taxonomic character. It is an unusual tendency of male inflorescence turning

to female, hence retaining bracts; such a kind of sex reversal is of common occurrence in Cucurbitaceae in general, and *Trichosanthes* in particular (Rugayah 1999). In natural conditions as well as in herbaria, authors have come across such tendency in other species too – *T. costata* Blume, *T. cucumerina* subsp. *sublobata*, *T. dicaelosperma*, *T. longispicata* Rugayah, *T. pilosa* Lour., *T. quinquangulata* A.Gray, *T. majuscula* and *T. tricuspidata* Lour. This species is well distinguished from *T. bracteata* (Lam.) Voigt through tomentose nature of leaves (at lower surface), prominent probracts, pinkish-red flowers, highly laciniate bracts and male sepals, and oblong seeds. In herbarium specimens, dried leaves appear dark brownish-red in colour.

Although C.B. Clarke (l.c.) (later Kundu 1943) agreed that *T. palmata* var. *tomentosa* deserves to be a good species with stable diagnostic characters, it appears that Clarke was unaware of *T. anaimalaiensis*, the species which had been published some 15 years back, therefore rule of priority favours latter as the accepted taxon. In agreement with Chakravarty (1959), type specimen (male specimen) study confirms the synonymization of *T. burmensis* and its var. *alba* with var. *tomentosa* (= *T. anaimalaiensis*); however ovoid-oblong fruit shape as mentioned in former's protologue indicates the possibility of erroneous choice of female specimens by Kundu in his herbarium-based study. Renner & Pandey (2013) mentioned its distribution in Andaman & Nicobar Islands, which is clearly outside its distributional range. A live collection (IC587669) at ICAR-NBPGR Base Centre, Cuttack, originally from Mayurbhanj district of Odisha had a close similarity with this species.

2. *Trichosanthes cordata*

Roxb., Fl. Ind. 3: 703. 1832. Clarke in Hook. f., Fl. Brit. Ind. 2: 608. 1879; Prain, Beng. Pl. 1: 363. 1903; Kanjilal et al., Fl. Assam 2: 328. 1938; Chakravarty, Fasc. Fl. Ind. 11: 110. 1982. *T. macrosiphon* Kurz, J. Asiat. Soc. Bengal, Pt. 2, Nat. Hist. 41: 308. 1872. *T. cordata* Roxb. var. *subpedata* C. B. Clarke. Fl. Brit. Ind. 2: 608. 1879.

Type: Icon. Roxb. 1691 (lectotype K, designated by Jeffrey (1980)), available at http://d2seqvvyy3b8p2.cloudfront.net/a9a143009a2e9f6f09529819e3230496.jpg

Dioecious; root tuberous. Stems: robust, angular-sulcate, glabrous or puberulent. Tendrils: usually 3-fid, elongate, sulcate, puberulent. Leaves: petioles 8–15 cm long, striate, puberulent; lamina membranous, broadly cordate, 15–20 × 15–20 cm, papery, unlobed or rarely angular-sublobate, both surfaces shortly hirsute, apex acute or shortly acuminate, margin minutely denticulate. Male racemes: 15–30 cm long, 6–10 flowered; rachis stout, striate, puberulent; bracts ± glabrous, almost entire, oblong-ovate, 4–4.6 cm long as broad. Co-axillary male flower also present. Male flower: pedicels 1–2 mm long; calyx tube 4–5 × 0.5–1 cm, attenuate at apex and base, densely villose; sepals entire, linear-lanceolate, 13-15 × 2-3 mm; petals shortly papillose; Stamens: filaments glabrous; anthers 10–12 × 3–4 mm. Female flower: solitary, pedicel 1 cm long; ovary oblong, puberulent. Fruits: smooth, globose, red, orange-streaked, umbo absent, pulp greenish-black. Seeds: dark brown, oblong, 10–12 × 4–5 × 2–2.5 mm, subquadrangular, belted at middle, slightly angular in margin.

Flowering and fruiting: May–September and August–November, respectively.

Habitat: Occasional in evergreen broad-leaved forest edges/clearings, scrub jungles, Terai areas; 300–1,200 m.

Distribution: India (Arunachal Pradesh, Assam, Manipur, Meghalaya, Mizoram, Nagaland, Sikkim, Uttarakhand, and West Bengal (Figure 1), new to Uttar Pradesh and Bihar), Bangladesh, Bhutan, China, India, Myanmar, and Nepal.

Specimens examined: Bihar: 424 (CAL), 12.ix.1965, Naurangia, (West) Champaran dt., Coll. S.P. Banerjee. Uttar Pradesh: 252617 (LWG), 22.x.2010, Nishangara forest, Katarniyaghat WLS, Bahraich dt., Coll. S.D. Maliya (Image 2); EBH 73 (LWG), 08.viii.1979, Chandar Chowk, Lakhimpur-Kheri dt., Coll. S. Saha et al.; EBH 93 (LWG), 08.viii.1979, Bela Parsua, Kheri dt., Coll. J.K. Maheswari et al.

Notes: Notwithstanding the lectotypification (of Roxburgh's drawing) by Jeffrey (1980) for this species, Chakravarty (1982) and Renner & Pandey (2013) mentioned the herbarium specimen, Wall. Cat. 6686A, housed at K (K001124519) as its 'type'. They further mentioned its distribution in Andhra Pradesh, Chhattisgarh, Jharkhand, Madhya Pradesh, Rajasthan, and Tamil Nadu, which is clearly out of its range, and is based on misidentified specimens quoted in the earlier works, for instance, Kundu (1943) and Chakravarty (1959). As this species is well documented in Dehradun (Uttarakhand) in the west (Babu 1977) and Sikkim/Darjeeling in the eastern side (Chakravarty 1982), it is expected to occur in the in-between areas falling under the states of Uttar Pradesh and Bihar adjoining to Nepal border. Although Chakravarty (1982) and Renner & Pandey (2013) mentioned its distribution in Uttar Pradesh/Bihar, they didn't attribute to any evidence or herbarium details. Studied herbarium specimens from Bihar and Uttar Pradesh (see 'Specimens examined')

Image 2. Herbarium specimen of *Trichosanthes cordata* from Uttar Pradesh at LWG. © Director, CSIR-NBRI, Lucknow.

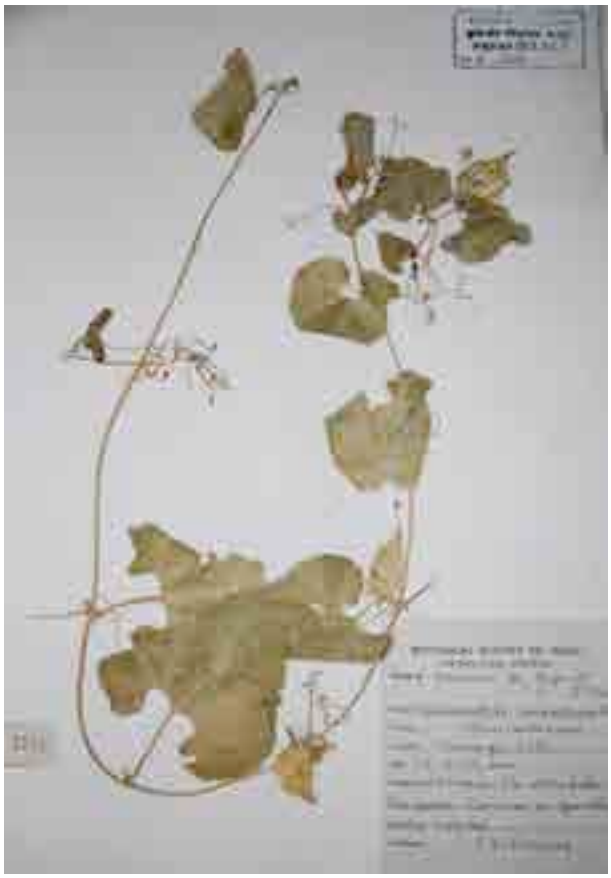

Image 3. Herbarium specimen of *Trichosanthes cucumerina* subsp. *sublobata* from Gujarat at BSJO. © Director, BSI, Kolkata.

were wrongly identified as *T. bracteata* in respective herbaria.

3. ***Trichosanthes cucumerina*** L. subsp. ***sublobata***

(Kundu) K. Pradheep, D.R. Pani & K.C. Bhatt, Novon 24(1): 41. 2015. *T. brevibracteata* Kundu var. *sublobata* Kundu, J. Bot. 77: 11. 1939.

Type: India, Nagpur-Wardha, Central Province, ix.1912, H.H. Haines 3295 (holotype K).

Monoecious, annual climber. Leaves: petioles 4–5 cm long, puberulous; lamina 7–11 × 7–12 cm, shallowly 3-angled or lobed, parrot-green in colour, margins repand, toothed, denticulate, puberulous on both surfaces. Male racemes: puberulous, up to 9 cm long, 6–10 flowered; bracts up to 4 mm long, often 3-lobed. Male flower: pedicels 3–15 mm long, shorter than the associated flower; calyx tube 15–17 mm long, apex stout; sepals 2–4 mm long; petal fringes highly divided. Female flowers: solitary; ovary narrowly elliptic. Fruits: pedicels 2–5 cm long; fruits ovate, 3–4.5 cm long, unripe ones pale green, broadly white-striped, apex strongly beaked, turn orange-red on ripening. Seeds: dark brown, flat, edges toothed-undulate, interspersed in scarlet-red pulp.

Flowering and fruiting: August–September and October–November, respectively.

Habitat: In herbaria, it was mentioned to have a common occurrence in wastelands and gravelly rocky areas, up to 400 m.

Distribution: Endemic to central and western parts of India (Goa, Maharashtra; new to Gujarat, Madhya Pradesh, and Odisha).

Specimens examined: Gujarat: 5796 (BSJO), 27.ix.2003, Taranga Hills, Mehsana dt., Coll. P.J. Parmar (Image 3); 18095 (BSJO), 19.08.2003 Amirgarh Hills, Banaskantha dt., 300 m, Coll. S.L. Meena; 18218 (BSJO), 23.08.2003, Jessore WLS, Coll. S.L. Meena. Odisha: 5852 (MH), 19.viii.1931, Pachidya, Ganjam dt., Coll. V. Narayanaswami. Madhya Pradesh: Ratapani WLS, Raisen dt., https://www.flickr.com/photos/dinesh_valke/9971030404/

Notes: Originally reported from Ratnagiri, Mumbai and Wardha districts of Maharashtra (Pradheep et al. 2015), this taxon was subsequently spotted in adjoining districts of Thane, Raigad (based on Flickr photos) of this

state. Older collections were kept as subsp. *cucumerina*, from which it is easily distinguished by leaves being parrot green in colour, conspicuous bracts in staminate inflorescence and pale-green broadly white-striped unripe fruits and strongly beaked fruit apex.

4. *Trichosanthes dicaelosperma*

C.B. Clarke, Fl. Brit. Ind. 2: 609. 1879. Chakravarty, Fasc. Fl. Ind. 11: 113. 1982. *T. cucumeroides* (Ser.) Maxim. var. *dicaelosperma* (C.B. Clarke) S.K. Chen, Bull. Bot. Res., Harbin 5(2): 118. 1985.

Type (lectotype, designated here): India, Meghalaya, Khasia Hills, 4000 ft, 13.vii.1850, J.D. Hooker & T. Thomson 1495 (K [digital image K000742692]; isolectotype, CAL0000015132)

Dioecious twinning climber. Stems: long, slender, sulcate, puberulent. Tendrils: 2-fid, stout, puberulent. Leaves: petioles 3–5 cm long, striate, shortly villose; lamina membranous, cordate-ovate, 8–15 × 6.5–11 cm, unlobed, lower surface brown-nerved, apex acute-acuminate, nerves tomentose, margin minutely denticulate. Male inflorescences: paired, one early 1-flowered, other racemose, 6–10 cm long, 7–10 flowered, puberulent; bracts minute. Male flowers: pedicels 0.5–2.0 cm long; calyx tube 2.5–3 cm long, narrow, apex dilated, 3–4 mm long, pubescent, lobe spreading, subulate, ±2 mm long. Female flower: pedicel 0.5–1 cm long; ovary oblong, shortly densely villose. Fruits: immature ones pubescent, 10 pale longitudinal banded, orange-red on ripening; ripe ones globose, 4–5 cm diameter, pulp scarlet-red. Seeds: dark-brown, much compressed, 7–9 × 8–9 × 3 mm, subquadrate, equally 3-celled, lateral cells empty, base appendiculate.

Flowering and fruiting: August–September and September–November, respectively.

Habitat: Occasional in subtropical dense broad-leaved forests, from 850–1,500 m.

Distribution: India (Arunachal Pradesh, Sikkim, West Bengal (Darjeeling) and Meghalaya; new to Nagaland (Figure 1)), Bhutan, China, and ?Myanmar.

Specimens examined: Nagaland: 101 (NEHU), Mokokchung, Coll. P.B. Gurung (Image 4).

Notes: While choosing lectotype (J.D. Hooker & T. Thomson 1495, K000742692) according to ICN Article 9.3. and Recommendation 9A.3. (Turland et al. 2018), we have taken into consideration Clarke's annotation on herbarium sheet depicting his justification for new species. Besides, this sheet represents both the male and female plant parts depicting characters of taxonomic value. Renner & Pandey (2013) synonymised this species under an East Asian species *T. cucumeroides* Maxim., whereas Grierson & Long (1991) kept under southeastern Asian *T. ovigera* Blume. In agreement with Chakravarty (1982), here we recognise *T. dicaelosperma* as a distinct species owing to unlobed leaves, globose fruits, scarlet-red pulp and flat subquadrate seeds. Immature fruits emanate odour similar to that of snake gourd. Renner & Pandey (2013), Chakravarty (1982) and Khanna et al. (1999) reported its occurrence in Uttar Pradesh, which is clearly out of its distribution range and no authentic specimens available to substantiate. Though type specimens (CAL0000015132, K000742692) and other specimens (K000742694, L2988267, P03693959) were collected from Khasi Hills of Meghalaya some 150 years back, sincere efforts made to locate this species in original habitats were futile, possibly due to the extensive changes in landscape over the years; also not a single collection available in various herbaria visited. In Arunachal Pradesh, Hajra et al. (1996) reported this species only from Kameng, however we found its common occurrence in eastern parts of the state, i.e., Anjaw, Dibang Valley, and Lohit districts.

5. *Trichosanthes kerrii*

Craib, Bull. Misc. Inform. Kew 1: 7. 1914. Duyfjes & Pruesapan, Thai For. Bull. Bot. 32: 87. 2004; W.J. de Wilde & Duyfjes, Fl. Thailand 9(4): 523. 2008; Huang & Jeffrey in Lu & Jeffrey, Fl. China 19: 39. 2011. *T. tomentosa* Chakrav., J. Bombay Nat. Hist. Soc. 50(4): 894. 1952; Chakravarty, Fasc. Fl. Ind. 11: 121. 1982.

Type: Thailand, Nan, 25.ii.1912, 3,500 ft, A.F.G. Kerr 2454 (holotype K [K000742680, digital image]; isotype BM [BM000944641, digital image]).

Dioecious gigantic perennial climber. Stems: robust, elongate; twigs dark brown-yellowish, long hairy. Tendrils: 3–5 fid. Probracts: absent. Leaves: petioles robust, brown-tomentose, 5–12 cm long; lamina membranous, entire (unlobed), cordate-ovate in outline, 12–25 × 10–20 cm, base cordate, apex acuminate with caudate tip, upper surface deep green, short hirsute, occasionally with small white specks, lower surface fine reticulate, densely felty villose, margin entire, glands not obvious. Male inflorescences and female flowers not seen. Fruits: pedicels 3–5 cm long; fruits ellipsoid, 7–10 × 6–7 cm, orange, longitudinally pale-striped, glabrescent, pulp creamy yellow. Seeds dark brown, compressed, broad-elliptic, 11–13 × 9–10 × c. 3 mm, base rounded, apex truncate, edges shallowly undulate or crenate (Image 1C & D).

Flowering and fruiting: February–April and September–December, respectively.

Habitat: Forest edges along streams; 1,100–1,400 m.

Image 4. Herbarium specimen of *Trichosanthes dicaelosperma* from Nagaland at NEHU. © NEHU, Shillong.

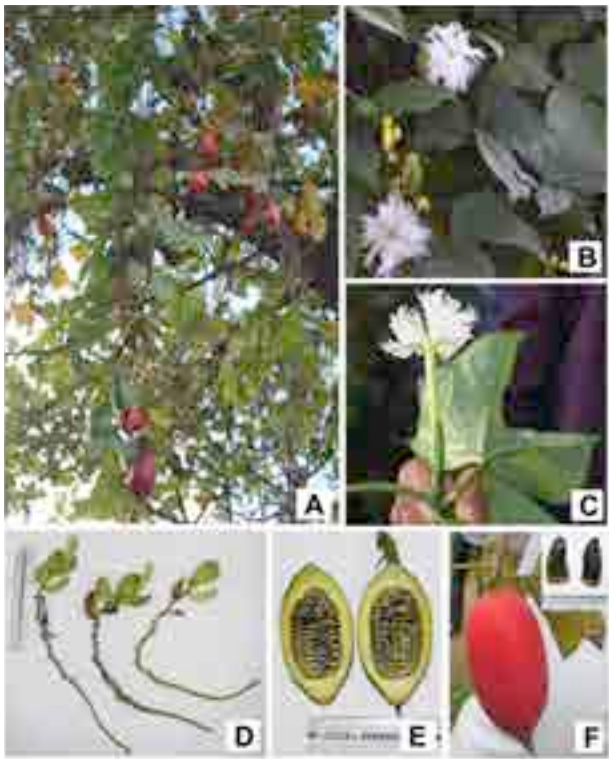

Image 5. *Trichosanthes majuscula*: A—Fruiting plant | B & C—Flowering twigs of male and female plants, respectively | D—Detached male inflorescence | E—Longitudinal section of immature fruit | F—Ripe fruit (inset: seed). © K. Pradheep.

Distribution: India (Nagaland; new to Arunachal Pradesh and Manipur (Figure 1)), Laos, Myanmar, Thailand, and Vietnam.

Specimens examined: Arunachal Pradesh: 7023 (ASSAM), Tirap F.D., Coll. Panigrahi; 16-1 (NHCP), 27.x.2016, Lalpani, Lohit dt., 1,200 m, Coll. K. Pradheep & G.D. Harish. Manipur: 6508 (CAL), xi.1907, Saithu, 3500 ft, Coll. A. Meebold.

Notes: In Nagaland, apart from Mokokchung (originally known from India from this district only), it is commonly found in Mon (vern. 'okhapatchechui') and Longleng districts, and occasional in Wokha and Tuensang districts. Senior and third authors observed this species also from Dibang Valley in Arunachal Pradesh. Long strigose hairs over the stem and petioles, and dense tomentose hairs over leaf surface at once distinguish it from other species. White stripes over fruits are retained even at dead-ripe stage. A fasciation-like disease symptom was observed on the plants in Mon district of Nagaland, similar observation also made in the herbarium collection (L2995297) from northern Thailand.

6. *Trichosanthes majuscula*

(C.B. Clarke) Kundu, J. Bot. 77: 12. 1939. J. Bombay Nat. Hist. Soc. 43(2): 378. 1942; Chakravarty, Fasc. Fl. Ind. 11: 118. 1982. *T. multiloba* Miq. var. *majuscula* C. B. Clarke in Hook.f., Fl. Brit. Ind. 2: 608. 1879. *T. wallichiana* (Ser.) Wight var. *majuscula* (C. B. Clarke) Cogn. in A. & C. DC., Monog. Phan. 3: 369. 1881.

Type (lectotype, designated here): India, Meghalaya, Khasia Hills, 4,000 ft, J. D. Hooker & T. Thomson s.n. (K [digital image K000742692]; isolectotype, K000036897 [digital image])

Perennial woody dioecious climber. Stems: robust, sulcate-striate, glabrous; twigs always green. Tendrils: very robust, woody, 3-fid. Probracts: ovate, 0.6 × 0.4 cm, green, crenulate, punctate. Leaves: petioles sulcate, 6–8 cm long; lamina 15–20(–23) × 15–20 cm, membranous, ± glabrous on both surfaces, abaxially pale green, deeply 3(–5)-lobed with 2 mild side lobes, main lobes elliptic-obovate, cuspidate, narrow towards base, leaf base (sub-)truncate to cordate, margins ± undulate-crenate, glands few, small, scattered over main nerves. Male

Image 6. Herbarium specimen of *Trichosanthes majuscula* from Assam at CAL. © Director, BSI, Kolkata.

inflorescences: thick, accrescent; peduncles striate, 8–10 cm long, rachis 20–26(–30) cm long, (13–)15–20(–24) flowered; bracts oblong, cymbiform, punctuate, margin obscurely and finely serrate at least above middle. Flowers: 8 × 4–5 cm, mildly fragrant; pedicels very short; calyx lobe 1 × 0.5 cm, entire, triangular-lanceolate, calyx tube 5.5–6.3 cm long, widening abruptly from 2/3rd length towards apex, inside white-hairy; anthers 3(2+1), 0.4 cm wide, filaments 0.7 cm long. Female flowers: pedicels 0.8–1.3 cm long; calyx tube 5–6 cm long, tubular, slightly broad at apex; sepals 0.7 cm long, entire; ovary oblong, 1.4–1.6 × 0.8 cm, conspicuously grooved longitudinally; style 3 cm long; stigma lobes 3, greenish, 2.5 mm wide. Fruits: pedicels stout; fruit oblong-ovate, reddish on ripening, mesocarp thick, pulp (endocarp) greenish black. Seeds: 70–100, dark brown, ovate-oblong, 12–13.5 × 7.6–8.2 × 2.5–2.8 mm, flat, often with raised central line, ± angular (Images 5 & 6).

Flowering and fruiting: August–October and September–November, respectively.

Habitat: Common in forest edges in Meghalaya; occasional in Assam and Arunachal Pradesh; rare in Sikkim; (200–)400–1,400 m.

Distribution: India (Meghalaya; new to Assam, Arunachal Pradesh and Sikkim (Figure 1)) and probably also in Bhutan.

Specimens examined: Arunachal Pradesh: 20045 (ASSAM), 12.x.1959, Nampang-Pangsu Pass, Tirap dt., Coll. R.S. Rao; 1107 (NHCP; living coll. at NBPGR, New Delhi), 18.x.2011, Napit, East Siang dt., Coll. K. Pradheep & P.K. Singh; 1114 (living coll. at NBPGR, New Delhi), 19.x.2011, Ranaghat, East Siang dt., 252 m, Coll. K. Pradheep & P.K. Singh; 1156 (NHCP), 18.x.2011, Kabali, Lower Dibang Valley dt., Coll. K. Pradheep & P.K. Singh; 1157 (living coll. at NBPGR, New Delhi), 18.x.2011, Kabali, Lower Dibang Valley dt., 420 m, Coll. K. Pradheep & P.K. Singh; 2677 (NHCP), 27.x.2017, Kornu (Roing), Lower Dibang Valley dt., Coll. K. Pradheep, R.S. Rathi & G.D. Harish; 11-2 (NHCP), 21.x.2011, Chowkham, Lohit dt., Coll. K. Pradheep & P.K. Singh; 1140 (NHCP), 22.x.2011, Tengapani RF, Lohit dt., Coll. K. Pradheep & P.K. Singh; 1146 (NHCP), 24.x.2011, Parasuram Khund, Lohit dt., Coll. K. Pradheep & P.K. Singh. Assam: 32686 (CAL), 25.viii.1909, Sadiya, Lakhimpur dt., Coll. I.H. Burkill; 39364 (ASSAM), viii.1984, Nakhola, Sonaikushi RF, Nowgong dt., Coll. N. P. Balakrishnan; 18-24 (NHCP), 22.ix.2018, Bijoy Nagar, Kamrup dt., Coll. K. Pradheep; 18–23 (NHCP), 19.ix.2018, Rangjuli, Goalpara dt., Coll. K. Pradheep; 1120 (NHCP), 20.x.2011, Simon Chapori, Dhemaji dt., Coll. K. Pradheep & P. K. Singh. Sikkim: 18–15 (NHCP), 13.viii.2018, Kokaley, East Sikkim dt., 813 m, Coll. K. Pradheep; 18-16 (NHCP), Lower Thuminicola, East Sikkim dt., 976 m, Coll. K. Pradheep.

Notes: Out of available syntypes (K000742686, K000036897 and P06393544), former two were selected as lectotype and isolectotype (following Articles 9.3. and 9.12. of ICN; Turland et al. 2018) since Clarke himself annotated on these sheets as "*Trichosanthes multiloba* Miq. var. *majuscula*", in addition, they depict inflorescence characters such as thick and woody rachis, flowers borne from near the base, all of taxonomic value. This distinct species was originally described at reduced rank under a Japanese species *T. multiloba*, thereafter kept under *T. wallichiana* by A. Cogniaux (l.c.), later on synonymised under *T. dunniana* H. Lév. by Jeffrey (1982), which was adopted by Huang & Jeffrey (2011) and Renner & Pandey (2013). Probable reason for this confusion is the lack of details on female flowers, fruits and seeds. It is easily distinguished from *T. wallichiana* by membranous leaves (vs. chartaceous), small ovate probracts (vs. much elongate), shorter peduncle of male inflorescences (vs. very long), serrate male bracts (vs. laciniate), ovate-oblong fruits (vs. globose) and dark

brown seeds (vs. greenish-brown). From *T. dunniana*, it is different in being robust climber (vs. medium climber), large-sized leaves with 3(-5) lobes (vs. small with 5(-7) deep lobes), cymbiform bract (vs. cucullate), oblong ovary (vs. ovate) and big flat seeds with angular ends (vs. small, only slightly compressed with rounded ends).

7. *Trichosanthes truncata*

C.B. Clarke, Fl. Brit. Ind. 2: 608. 1879. Kanjilal et al., Fl. Assam 2: 328. 1938; Chakravarty, Fasc. Fl. Ind. 11: 122. 1982; S.K. Chen, Fl. Yunnan 6: 364. 1995; Duyfjes & Pruesapan, Thai For. Bull. Bot. 32: 99. 2004; W. J. de Wilde & Duyfjes, Fl. Thailand 9(4): 537. 2008; Huang & Jeffrey in Lu & Jeffrey, Fl. China 19: 39. 2011. *T. ovata* Cogn. in A. & C. DC., Monogr. Phan. 3: 365. 1881; Chakravarty, Fasc. Fl. Ind. 11: 120. 1982; S.K. Chen, Fl. Yunnan 6: 364. 1995.

Type: J.D. Hooker & T. Thomson 1188, Khasia Hills, Meghalaya, India, (lectotype K, designated by Duyfjes & Pruesapan (2004)).

Liana-forming dioecious climber. Stems: robust, angular-striate, glabrous; young shoots greenish. Tendrils: robust, simple or 2–3 fid, glabrous. Probracts minute. Leaves: petioles robust, sulcate, glabrous, 4–6 cm long, sometimes irregularly twisted; lamina glabrous, chartaceous, ovate-oblong or cordate in outline, 12–18(–25) × 6–13(–22) cm, entire or occasionally 3-lobed/angled, apex acuminate, base truncate-hastate or obtuse, 3-prominent nerved, margin denticulate or only remotely denticulate, glands few, minute, 10–20 along main nerves. Male inflorescences: glabrescent, 15–20 cm long, 12–20 flowered; rachis stout, striate; bracts glabrous, suborbicular-elliptic, 14–18 × 5–8 mm, slightly dentate, often 3-nerved. Male flowers: pedicels slender, puberulous, 2–4 mm long; calyx tube shortly tomentose, 2–3 cm long, dilated above, calyx lobe 5–7 × 1–2 mm, corolla yellowish-white. Female flowers not seen. Fruits: pedicels 8 mm long; fruits round-oblong, 8–12 × 4–5.5 cm, greenish-yellow at maturity, epicarp tough, pulp whitish. Seeds: dark brown or reddish-brown, oblong-obovate, 2 × 1.2 × 0.3–0.4 cm, base truncate, apex obtuse, compressed and narrowing towards margin.

Flowering and fruiting: May–August and June–October, respectively.

Habitat: Degraded deciduous or evergreen forests, bamboo forests from 400–1,400 m.

Occurrence in India: Arunachal Pradesh, Assam, Meghalaya, Sikkim, West Bengal; new to Nagaland (Figure 1).

Distribution: Bangladesh, Bhutan, China, India, Myanmar, Thailand, and Vietnam.

Specimens examined: Nagaland: 13-1 (NHCP), 25.xi.2013, Longching, Mon dt., 1,350 m, Coll. K. Pradheep & Soyimchiten.

Notes: Chakravarty (1982) and Renner & Pandey (2013) mentioned this species from Andhra Pradesh which is outside its distribution range. Though type specimen was collected from Khasi Hills (almost 150 years ago), no further collections available thereafter and now failed to locate this species due to the extensive topographic change. This species could be a connecting link between *Trichosanthes* and *Hodgsonia* Hook.f. & Thomson owing to the distinct characters – big chartaceous leaves, yellowish-white flowers, big-sized fruits as well as seeds, and whitish mesocarp and pulp. Hajra et al. (1996) mentioned its occurrence from Kameng, Subansiri and Tirap in Arunachal Pradesh; however, we noticed it occasionally in Lohit district as well.

REFERENCES

Babu, C.R. (1977). *Herbaceous Flora of Dehradun*. Council of Scientific and Industrial Research, New Delhi, 721 pp.

Chakravarty, H.L. (1959). Monograph of Indian Cucurbitaceae (taxonomy and distribution). *Records of the Botanical Survey of India* 17: 1–234.

Chakravarty, H.L. (1982). *Fascicles of the Flora of India: Cucurbitaceae, No. 11*. Botanical Survey of India, Calcutta, 135 pp.

Dash, S.S. & P. Singh (2017). *Flora of Kurung Kumey District, Arunachal Pradesh*. Botanical Survey of India, Kolkata, 782 pp.

de Wilde, W.J.J.O. & B.E.E. Duyfjes (2010). *Flora Malesiana, Series I, Seed Plants, Volume 19: Cucurbitaceae*. National Herbarium Nederland, The Netherlands, 342 pp.

de Wilde, W.J.J.O. & B.E.E. Duyfjes (2011). Keys to and checklist of species of the genus *Trichosanthes* L. (Cucurbitaceae) in Indochina. *Adansonia* 34(2): 265–278. http://sciencepress.mnhn.fr/sites/default/files/articles/pdf/a2012n2a6.pdf

Duyfjes, B.E.E. & K. Pruesapan (2004). The genus *Trichosanthes* L. (Cucurbitaceae) in Thailand. *Thai Forest Bulletin (Botany)* 32: 76–109. http://www.frc.forest.ku.ac.th/frcdatabase/bulletin/Document/ThaiForestBulletin32_007.pdf

Grierson, A.J.C. & D.G. Long (1991). *Flora of Bhutan Including a Record of Plants from Sikkim. Vol. 2. Part 1*. Royal Botanic Gardens, Edinburgh, UK, 426 pp.

Haines, H.H. (1921–1925). *The Botany of Bihar and Orissa, 3 Vols*. (reprint 1978). Bishen Singh Mahendra Pal Singh, Dehradun, 958 pp.

Hajra, P.K., D.M. Verma & G.S. Giri (eds.) (1996). *Materials for the Flora of Arunachal Pradesh. Vol. 1. Ranunculaceae-Dipsacaceae*. Botanical Survey of India, Calcutta, 693 pp.

Hara, H. (1966). *Flora of Eastern Himalaya, First Report*. Tokyo University, Japan, 744 pp.

Huang, L.Q. & C. Jeffrey (2011). *Trichosanthes*, pp. 36–45. In: Zhengyi, W., P.H. Raven & H. Deyuan (eds.). *Flora of China 19*. Science Press, Beijing and Missouri Botanical Garden Press, St. Louis. http://www.efloras.org/florataxon.aspx?flora_id=2&taxon_id=200022768

Jeffrey, C. (1980). Further notes on Cucurbitaceae: V. Cucurbitaceae of the Indian Subcontinent. *Kew Bulletin* 34: 789–809.

Jeffrey, C. (1982). Further notes on Cucurbitaceae: VI. Cucurbitaceae of the Indian Subcontinent. *Kew Bulletin* 36: 737–740.

Kanjilal, U.N., P.C. Kanjilal, R.N. De & A. Das (1938). *Flora of Assam (Reprint 1984), Vol. III. Caprifoliaceae-Plantaginaceae*. Govt. of Assam, Shillong, 578 pp.

Khanna, K.K., V. Mudgal, B.P. Uniyal & J.R. Sharma (1999). *Dicotyledonous Plants of Uttar Pradesh: A Checklist*. Bishen Singh Mahenra Pal Singh, Dehra Dun, 455 pp.

Kundu, B.C. (1943). A revision of the Indian species of *Hodgsonia* and *Trichosanthes*. *Journal of the Bombay Natural History Society* 43: 362–388.

Mao, A.A., N. Odyuo, D. Verma & P. Singh (2017). *Checklist of Flora of Nagaland*. Botanical Survey of India, Kolkata, 196 pp.

Naithani, H.B. (1990). *Flowering Plants of India, Nepal and Bhutan: Not Recorded in Sir JD Hooker's Flora of British India*. Surya Publications, Dehradun, 711 pp.

Pandey, S., Rana, T.S. & K.N. Nair (2016). Revision of the *Trichosanthes tricuspidata–bracteata* complex (Cucurbitaceae) in India. *Rheedea* 26(2): 83–93. http://www.iaat.org.in/images/Rheedea_downloads/Rheedea_26_2/Article-01_Trichosanthes.pdf

Paul, T.K., P. Lakshminarasimhan, H.J. Chowdhery, S.S. Dash & P. Singh (eds.) (2015). *Flora of West Bengal, Volume 2: Leguminosae to Aizoaceae*. Botanical Survey of India, Kolkata, 455 pp.

Pradheep, K., A. Pandey & D.C. Bhandari (2011). Notes on naturalized taxa of plant genetic resource value in Himachal Pradesh. *Indian Journal of Plant Genetic Resources* 24(1): 74–80.

Pradheep, K., A. Pandey, E.R. Nayar, Soyimchiten, S.P. Ahlawat & R. Gupta (2018). Extended naturalization records of five non-native plant species to Indian states. *Indian Journal of Plant Genetic Resources* 31(1): 72–77.

Pradheep, K., D.C. Bhandari & K.C. Bansal (2014). *Wild Relatives of Cultivated Plants in India*. Indian Council of Agricultural Research, New Delhi, 728 pp.

Pradheep, K., D.R. Pani & K.C. Bhatt (2015). Taxonomic notes on the *Trichosanthes cucumerina* group (Cucurbitaceae) from India. *Novon* 24(1): 39–45.

Jain, S.K. & R.R. Rao (1977). *A Handbook of Field and Herbarium Methods*. Today and Tomorrow Printers and Publishers, New Delhi, 157 pp.

Renner, S.S. & A.K. Pandey (2013). The Cucurbitaceae of India: Accepted names, synonyms, geographic distribution, and information on images and DNA sequences. *PhytoKeys* 20: 53–118. https://www.ncbi.nlm.nih.gov/pmc/articles/PMC3652411/pdf/PhytoKeys-020-053.pdf

Rugayah (1999). Trichosanthes *(Curcurbitaceae) in Malesia*. Dissertation, Inst. Pertanian Bogor, Indonesia, 239 pp.

Saxena, H.O. & M. Brahmam (1994–1996). *The Flora of Orissa. Vol. I-IV*. Orissa Forest Development Corporation Ltd, Bhubaneswar, India, 2918 pp.

Singh, N.P., A.S. Chauhan & M.S. Mondal (eds.) (2000). *Flora of Manipur, Vol. 1. Ranunculaceae-Asteraceae*. Botanical Survey of India, Kolkata, 600 pp.

Thiers, B. (2020 [continuously updated]) Index Herbariorum: A global directory of public herbaria and associated staff. Available from: http://sweetgum.nybg.org/ih/ (Electronic version accessed 12 June 2020)

Turland, N.J., J.H. Wiersema, F.R. Barrie, W. Greuter, D.L. Hawksworth, P.S. Herendeen, S. Knapp, W.-H. Kusber, D.-Z. Li, K. Marhold, T.W. May, J. McNeill, A.M. Monro, J. Prado, M.J. Price & G.F. Smith (eds.) (2018). *International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code)* adopted by the Nineteenth International Botanical Congress, Shenzhen, China, July 2017. Koeltz Botanical Books, Glashütten. https://doi.org/10.12705/Code.2018

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Dragonflies and Damselflies (Insecta: Odonata) of Aryanad Grama Panchayat, Kerala, India

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Abstract: A year-long study to document the diversity and seasonality of odonates was conducted at Aryanad Grama Panchayat, Thiruvananthapuram district, Kerala, southern India. A total of 93 species (56 dragonflies and 37 damselflies) belonging to 12 families were recorded. Twenty-four species of odonates recorded are endemic to the Western Ghats, three to peninsular India and one to India. Small streams showed the highest species richness, hosting 69 species and ponds the lowest with 59 species. Species richness showed a peak during the southwest monsoon season and a dip in winter. The study highlights the importance of biodiversity documentation at regional level.

Keywords: Endemic, seasonality, southern India, species richness, Western Ghats.

ഇന്ത്യയിലെ തെക്കൻ സംസ്ഥാനമായ കേരളത്തിൽ, തിരുവനന്തപുരം ജില്ലയിലെ ആര്യനാട് പഞ്ചായത്തിൽ തുമ്പികളുടെ വൈവിധ്യവും കാലികമായ മാറ്റങ്ങളും ഒരു വർഷത്തേക്ക് പഠനവിധേയമാക്കി. 12 കുടുംബങ്ങളിലായി 93 ഇനം തുമ്പികളെ (56 ഇനം കല്ലൻതുമ്പികൾ, 37 ഇനം സൂചിത്തുമ്പികൾ) ഈ പഠനത്തിൽ കണ്ടെത്താനായി. ഇതിൽ 24 ഇനം പശ്ചിമഘട്ടത്തിലും, മൂന്നിനം ഇന്ത്യൻ ഉപദ്വീപിലും, ഒരിനം ഇന്ത്യയിലും സ്ഥാനീയമായി കാണപ്പെടുന്നവയാണ്. ചെറിയ അരുവികളിലായിരുന്ന തുമ്പികളുടെ വൈവിധ്യം ഏറ്റവും കൂടുതൽ. ഇവിടങ്ങളിൽ നിന്നും 69 ഇനം തുമ്പികളെ കണ്ടെത്താനായി. വൈവിധ്യം ഏറ്റവും കുറഞ്ഞ ആവാസവ്യവസ്ഥകളായ കുളങ്ങളിൽ 59 ഇനം തുമ്പികളെയാണ് കണ്ടെത്താൻ കഴിഞ്ഞത്. കാലവർഷം തുടങ്ങുന്ന സമയത്ത് തുമ്പികളുടെ വൈവിധ്യം മൂർദ്ധന്യത്തിൽ എത്തുകയും ശൈത്യകാലത്ത് ഏറ്റവും കുറഞ്ഞു കാണപ്പെടുകയും ചെയ്തു. ഇന്ത്യയിൽ പ്രാദേശികതലത്തിൽ കൂടുതൽ ജൈവവൈവിധ്യ പഠനങ്ങൾ നടത്തേണ്ടതുണ്ട് എന്ന് ഈ പഠനം വിളിച്ചോതുന്നു.

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INTRODUCTION

Protected areas are the cornerstones of global biodiversity conservation efforts. India has established a network of protected areas covering approximately 4.8% of its geographical area, but it is impossible to bring the entire range of biodiversity under this network (Mathur & Sinha 2008). It is therefore, imperative that we take measures to document and conserve biodiversity outside protected areas. Under the Biological Diversity Act of 2002, the Grama Panchayats in India are mandated to form Biodiversity Management Committees (BMCs) for the documentation, conservation and sustainable use of bioresources. Kerala is the first state in India to form BMCs in all its local bodies (Kerala State Biodiversity Board 2021). However, the documentation of insect biodiversity is incomplete in most of the People's Biodiversity Registers (PBRs) prepared by the BMCs.

Dragonflies and damselflies, which together form the insect Order Odonata are considered as important components of freshwater ecosystems as well as good indicators of ecosystem health because of their amphibious life history, relatively short generation time, high trophic position and diversity (Corbet 1993; Clark & Samways 1996). Biodiversity of insects is threatened worldwide (Sánchez-Bayo & Wyckhuys 2019) and one in 10 species of dragonflies and damselflies is threatened with extinction (Clausnitzer et al. 2009). This global decline of insect populations is feared to cause a catastrophic collapse of earth's ecosystems (May 2010). The endemic species of odonates have a narrow distribution across the Western Ghats, occurring in only small patches of suitable habitats (Subramanian et al. 2011; Koparde et al. 2014). Aryanad (8.556–8.677 ^{0}N & 77.071–77.224 ^{0}E) is an agricultural village under the foothills of Agasthyamalai of southern Western Ghats in Thiruvananthapuram district, Kerala (Figure 1). The predominant crops grown here are coconut, rubber, banana, and vegetables (Government of Kerala 2021). Aryanad lies adjacent to the Peppara Wildlife Sanctuary and the Karamana River that originates in the Western Ghats flows through the village.

MATERIALS AND METHODS

Four ponds (with area less than 30 m^2), three small streams (with width approximately 0.5 m), five large streams (with width approximately 2 m) and the Karamana River having a width of approximately 6 m were selected in Aryanad Grama Panchayat for sampling odonates (Image 1). Each habitat was visited once every month from 1 December 2019 to 30 November 2020. Visual encounter surveys (VES) were done to

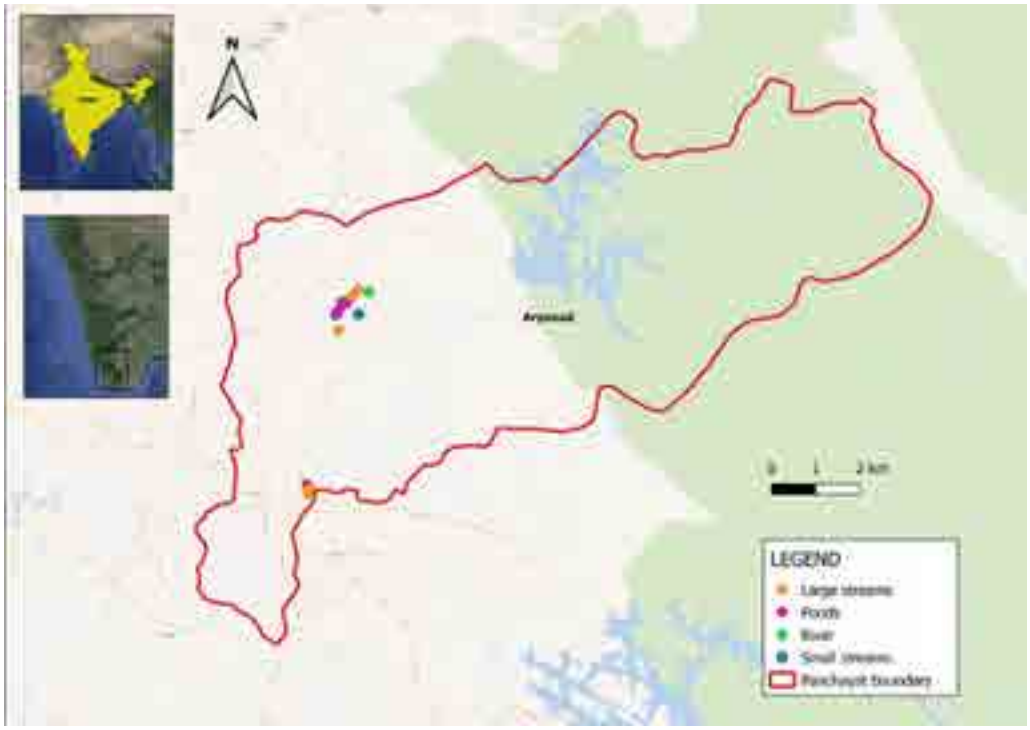

Figure 1. Map of Aryanad showing sampling sites.

document the odonates, where the observer walked along the edge of each waterbody for 20 minutes and recorded all the odonate species encountered. All the field visits were made between 0900 h and 1100 h. The odonates were photographed using a Nikon Z6 mirror-less camera and Nikon 105 mm macro lens. The individual odonates were identified to the species level referring to taxonomic monographs (Fraser 1933, 1934, 1936) and field guides (Subramanian 2005, 2009; Kiran & Raju 2013). A checklist was prepared using systematic arrangement and taxonomy according to Kalkman et al. 2020. The study period was divided into four seasons for data analysis—winter (December–February), summer (March–May), south-west monsoon (June–August), and north-east monsoon (September–November).

RESULTS AND DISCUSSION

A total of 93 species of odonates (56 dragonflies and 37 damselflies) from 12 families were recorded from Aryanad Grama Panchayat (Table 1, Images 2–6). This accounts for more than half (53%) of the odonate species recorded from the state of Kerala till date (Society for Odonate Studies 2021). In comparable studies, only 82 species of odonates were recorded from Thattekkad Bird Sanctuary (Varghese et al. 2014) and 48 from Chinnar Wildlife Sanctuary (Adarsh et al. 2015). The high odonate diversity documented from Aryanad Grama Panchayat is probably due to the diverse habitats it sustains and its proximity to forests including those of Peppara Wildlife Sanctuary. Out of the 93 species recorded from Aryanad, 24 are endemic to the Western Ghats, three to Peninsular India and one to India. Small streams had the highest species count and ponds the least (Figure 2). The species richness showed a peak during the south-west monsoon when 90 species were recorded and a dip in winter, when only 30 species could be seen (Figure 3).

The records of the following species are significant considering their endemicity, rarity and threat status (Subramanian et al. 2018; IUCN 2021):

***Protosticta sanguinostigma* Fraser, 1922**

This species, easily identified by the reddish brown equatorial band in its eyes and the peculiar shape of anal appendages is categorized as 'Vulnerable' by the International Union for Conservation of Nature and Natural Resources (IUCN) in its Red List of Threatened Species. It was recorded only from the lotic habitats of Aryanad and was unrecorded during winter.

***Calocypha laidlawi* (Fraser, 1924)**

This small damselfly brightly coloured with sky blue, black and vermilion is the only extant species of the genus. It is endemic to the southern Western Ghats and has so far been recorded only from a few locations in Kerala and Karnataka. It was recorded from all three lotic habitat types of Aryanad Grama Panchayat and was sighted in all the seasons. An extensive search of literature and websites failed to produce even a single photograph of the female of this species. Hence, this is most probably the first photographic record of the female from the wild (Image 7). It remains a 'Data Deficient' species in the IUCN Red List.

***Elattoneura souteri* (Fraser, 1924)**

This damselfly coloured brightly with red and black is a 'Data Deficient' species in the IUCN Red List and has so far been recorded only from a few locations in Kerala and Karnataka. It was recorded from all three lotic habitat types of Aryanad and could not be seen in winter.

***Esme longistyla* Fraser, 1931**

This species was identified referring to characters like complete anal bridge vein, blue annules on abdomen, blue stripes on legs and structure of anal appendages. Even though it is classified as a 'Least Concern' species in the IUCN Red List, only very scarce reports of this species exist from Kerala and Karnataka. In Aryanad, it was recorded from both small and large streams. It could not be seen in winter.

***Melanoneura bilineata* Fraser, 1922**

This rare and relatively large damselfly species is the sole representative of the genus and has so far been recorded only from a few locations in Kerala and Karnataka. It is coloured blue and black and can be distinguished by the absence of the anal bridge vein in its wings. This species, classified as 'Near Threatened' in the IUCN Red List was recorded from Aryanad in all four seasons. It could be seen only in the small streams and hence appears to show high habitat specificity.

***Burmagomphus laidlawi* Fraser, 1924**

This medium-sized clubtail dragonfly has till now been recorded only from montane forest streams of Kerala, Karnataka and Tamil Nadu. It can be easily separated from other clubtail species by the structure of its anal appendages. It was recorded only during the southwest monsoon season and could be seen only in large streams. Hence, this species is highly seasonal and has specific habitat requirements. It remains a 'Data

Table 1. Checklist of Odonata recorded from Aryanad Grama Panchayat, Kerala, southern India.
Endemicity: EN WG—Endemic to the Western Ghats | EN P—Endemic to peninsular India | EN I—Endemic to India.
IUCN Red list status: NE—Not Evaluated | DD—Data Deficient | LC—Least Concern | NT—Near Threatened | VU—Vulnerable.
Habitats: P—Ponds | SS—Small streams | LS—Large streams | R—River.
Seasons: M1—Southwest Monsoon | M2—Northeast Monsoon | W—Winter | S—Summer.

	Species	Endemicity	IUCN Red List status	Habitats recorded from	Seasons recorded in
	Zygoptera (Damselflies)				
	Family: Lestidae				
1	*Lestes elatus* Hagen in Selys, 1862		LC	P, SS	M1
2	*Lestes praemorsus* Hagen in Selys, 1862		LC	P	M1, M2
	Family: Platystictidae				
3	*Protosticta gravelyi* Laidlaw, 1915	EN WG	LC	P, SS, LS, R	M1, M2, W, S
4	*Protosticta sanguinostigma* Fraser, 1922	EN WG	VU	SS, LS, R	M1, M2, S
	Family: Calopterygidae				
5	*Neurobasis chinensis* (Linnaeus, 1758)		LC	SS, LS, R	M1, M2, W, S
6	*Vestalis apicalis* Selys, 1873		LC	P, SS, LS, R	M1, M2, W, S
7	*Vestalis gracilis* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, S
8	*Vestalis submontana* Fraser, 1934	EN WG	NE	P, SS, LS, R	M1, M2, S
	Family: Chlorocyphidae				
9	*Calocypha laidlawi* (Fraser, 1924)	EN WG	DD	SS, LS, R	M1, M2, W, S
10	*Heliocypha bisignata* (Hagen in Selys, 1853)	EN P	LC	SS, LS, R	M1, M2, W, S
11	*Libellago indica* (Fraser, 1928)	EN P	NE	SS, LS, R	M1, M2, W, S
	Family: Euphaeidae				
12	*Dysphaea ethela* Fraser, 1924	EN P	LC	SS, LS, R	M1, M2, S
13	*Euphaea fraseri* (Laidlaw, 1920)	EN WG	LC	SS, LS	M1, M2, S
	Family: Platycnemididae				
14	*Caconeura risi*(Fraser, 1931)	EN WG	DD	P, SS, LS	M1, M2, W, S
15	*Copera marginipes* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, W, S
16	*Copera vittata* (Selys, 1863)		LC	P, SS, LS, R	M1, M2, W, S
17	*Elattoneura souteri* (Fraser, 1924)	EN WG	DD	SS, LS, R	M1, M2, S
18	*Elattoneura tetrica* (Laidlaw, 1917)	EN WG	LC	SS, LS, R	M1, M2, S
19	*Esme longistyla* Fraser, 1931	EN WG	LC	SS, LS	M1, M2, S
20	*Melanoneura bilineata* Fraser, 1922	EN WG	NT	SS	M1, M2, W, S
21	*Onychargia atrocyana* Selys, 1865		LC	P, SS	M1, M2, S
22	*Prodasineura verticalis* (Selys, 1860)		LC	P, SS, LS, R	M1, M2, W, S
	Family: Coenagrionidae				
23	*Aciagrion occidentale* Laidlaw, 1919		LC	LS, R	M1, M2, S
24	*Agriocnemis pieris* Laidlaw, 1919		LC	P, SS, LS, R	M1, M2, W, S
25	*Agriocnemis pygmaea* (Rambur, 1842)		LC	P	M1, M2
26	*Agriocnemis splendidissima* Laidlaw, 1919		LC	P, R	M1, M2
27	*Archibasis oscillans* (Selys, 1877)		LC	SS, LS, R	M1, M2, S
28	*Ceriagrion cerinorubellum* (Brauer, 1865)		LC	P	M1, M2, W, S
29	*Ceriagrion coromandelianum* (Fabricius, 1798)		LC	P	M1, M2
30	*Ceriagrion rubiae* Laidlaw, 1916		LC	LS, R	M1, S
31	*Ischnura rubilio* Selys, 1876		NE	P, R	M1, M2
32	*Ischnura senegalensis* (Rambur, 1842)		LC	P	M2, S
33	*Pseudagrion decorum* (Rambur, 1842)		LC	P, LS, R	M1, S

	Species	Endemicity	IUCN Red List status	Habitats recorded from	Seasons recorded in
34	*Pseudagrion indicum* Fraser, 1924	EN WG	LC	P, LS, R	M1, M2, S
35	*Pseudagrion malabaricum* Fraser, 1924		LC	LS, R	M1, S
36	*Pseudagrion microcephalum* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, S
37	*Pseudagrion rubriceps* Selys, 1876		LC	P, SS, LS, R	M1, M2, W, S
	Anisoptera (Dragonflies)				
	Family: Aeshnidae				
38	*Anax immaculifrons* Rambur, 1842		LC	LS, R	M1, M2, S
39	*Gynacantha dravida* Lieftinck, 1960		DD	P, LS, SS, R	M1, M2
	Family: Gomphidae				
40	*Burmagomphus laidlawi* Fraser, 1924	EN WG	DD	LS	M1
41	*Gomphidia kodaguensis* Fraser, 1923	EN WG	DD	P, SS, LS, R	M1, M2, W, S
42	*Heliogomphus promelas* (Selys, 1873)	EN WG	NT	P, SS	M1, M2
43	*Ictinogomphus rapax* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, W, S
44	*Macrogomphus wynaadicus* Fraser, 1924	EN WG	DD	P, SS, LS, R	M1, M2
45	*Melligomphus acinaces* (Laidlaw, 1922)	EN WG	DD	LS	M1, M2
46	*Merogomphus tamaracherriensis* Fraser, 1931	EN WG	NE	P, SS, LS, R	M1, M2, S
47	*Microgomphus souteri* Fraser, 1924	EN WG	LC	SS, LS, R	M1, M2, S
48	*Nychogomphus striatus* (Fraser, 1924)		DD	P, SS, LS, R	M1, M2
49	*Paragomphus lineatus* (Selys, 1850)		LC	P, SS, LS	M1, M2, W, S
	Family: Macromiidae				
50	*Epophthalmia frontalis* Selys, 1871		LC	LS, R	M1, M2, S
51	*Epophthalmia vittata* Burmeister, 1839		LC	LS, R	M1, M2
52	*Macromia bellicosa* Fraser, 1924	EN WG	LC	SS, LS, R	M1
53	*Macromia cingulata* Rambur, 1842	EN WG	LC	SS, LS	M1, S
54	*Macromia flavocolorata* Fraser, 1922		LC	SS, LS, R	M1, M2, S
55	*Macromia ida* Fraser, 1924	EN WG	LC	R	M1
56	*Macromia irata* Fraser, 1924	EN WG	LC	SS, LS	S
	Family: Libellulidae				
57	*Acisoma panorpoides* Rambur, 1842		LC	P, SS	M1, M2
58	*Aethriamanta brevipennis* (Rambur, 1842)		LC	P, SS	M1, M2
59	*Brachydiplax chalybea* Brauer, 1868		LC	P, SS, LS, R	M1, M2, W, S
60	*Brachydiplax sobrina* (Rambur, 1842)		LC	P, SS	M1, M2
61	*Brachythemis contaminata* (Fabricius, 1793)		LC	P, SS, LS, R	M1, M2, W, S
62	*Bradinopyga geminata* (Rambur, 1842)		LC	SS	M1, M2
63	*Cratilla lineata* (Brauer, 1878)		LC	SS, LS, R	M1, M2, S
64	*Crocothemis servilia* (Drury, 1773)		LC	P, SS, LS, R	M1, M2, S
65	*Diplacodes trivialis* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, W, S
66	*Hydrobasileus croceus* (Brauer, 1867)		LC	P, SS, LS, R	M1, M2, S
67	*Hylaeothemis apicalis* Fraser, 1924	EN I	DD	P, SS	M1, M2, S
68	*Lathrecista asiatica* (Fabricius, 1798)		LC	P, SS, LS, R	M1, M2, S
69	*Neurothemis fulvia* (Drury, 1773)		LC	P, SS	M1, M2, S
70	*Neurothemis tullia* (Drury, 1773)		LC	P, SS, LS, R	M1, M2, W, S
71	*Onychothemis testacea* Laidlaw, 1902		LC	LS, R	M1, M2
72	*Orthetrum chrysis* (Selys, 1891)		LC	P, SS, LS, R	M1, M2, W, S
73	*Orthetrum glaucum* (Brauer, 1865)		LC	P, SS, LS, R	M1, M2, W, S

	Species	Endemicity	IUCN Red List status	Habitats recorded from	Seasons recorded in
74	*Orthetrum luzonicum* (Brauer, 1868)		LC	P, SS, LS, R	M1, M2, W, S
75	*Orthetrum pruinosum* (Burmeister, 1839)		LC	P, SS, LS, R	M1, M2, W, S
76	*Orthetrum sabina* (Drury, 1770)		LC	P, SS, LS, R	M1, M2, W, S
77	*Palpopleura sexmaculata* (Fabricius, 1787)		LC	SS	M2
78	*Pantala flavescens* (Fabricius, 1798)		LC	P, SS, LS, R	M1, M2, W, S
79	*Potamarcha congener* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2
80	*Rhodothemis rufa* (Rambur, 1842)		LC	P, LS, R	M1, M2, W, S
81	*Rhyothemis triangularis* Kirby, 1889		LC	P	M1, M2, W, S
82	*Rhyothemis variegata* (Linnaeus, 1763)		LC	P, LS, R	M1, M2
83	*Tetrathemis platyptera* Selys, 1878		LC	P, SS	M1, M2, S
84	*Tholymis tillarga* (Fabricius, 1798)		LC	P, LS, R	M1, M2
85	*Tramea limbata* (Desjardins, 1832)		LC	P, LS, R	M1, M2
86	*Trithemis aurora* (Burmeister, 1839)		LC	P, SS, LS, R	M1, M2, W, S
87	*Trithemis festiva* (Rambur, 1842)		LC	P, SS, LS, R	M1, M2, S
88	*Urothemis signata* (Rambur, 1842)		LC	P, SS	M1, M2, S
89	*Zygonyx iris* Selys, 1869		LC	SS, LS, R	M1, M2
90	*Zyxomma petiolatum* Rambur, 1842		LC	P, SS	M1, M2, S
	Genera incertae sedis				
91	*Idionyx gomantakensis* Subramanian, Rangnekar & Naik, 2013	EN WG	NE	SS	M1, S
92	*Idionyx saffronata* Fraser, 1924	EN WG	DD	SS	M1, S
93	*Macromidia donaldi* (Fraser, 1924)		LC	SS, LS, R	M1, M2, S

Deficient' species in the IUCN Red List.

***Nychogomphus striatus* (Fraser, 1924)**

This medium-sized clubtail dragonfly has very few previous records from Kerala and Tamil Nadu. The record from Nepal requires validation. It has peculiar claw-shaped anal appendages that help to distinguish it easily from other clubtail species. It is a 'Data Deficient' species in the IUCN Red List and was recorded from all four habitat types sampled in Aryanad. It could be seen in both southwest monsoon and northeast monsoon seasons.

***Epophthalmia frontalis* Selys, 1871**

Fraser (1924) described *Macromia binocellata* based on a single male specimen collected by C.M. Inglis from Palni hills, Western Ghats. Subsequently, more specimens were obtained from Tamaracherry, Calicut and Walayar in the Western Ghats after which he treated it as *Epophthalmia frontalis malabarensis* (Fraser 1935) and later, as *Epophthalmia frontalis binocellata* (Fraser 1936). According to the last source, within Indian limits, *E. frontalis frontalis* occurs in Assam and *E. frontalis binocellata* is confined to the Western Ghats. The taxon in the Western Ghats is described as a much darker insect compared to its congenerics. Its abdominal segments 4 to 6 have paired isolated sub-basal spots instead of rings. Also, its inferior anal appendage is distinctly longer and curves up between the apices of superiors. According to Lieftinck (1931) and Fraser (1936) *E. frontalis* and *E. vittata* can be separated from each other based on their facial markings, but Asahina (1987) disagrees and states that these markings vary depending on maturity and individuals. A large Macromiid was seen in the large streams and Karamana River in Aryanad, but its markings seem to match more with *E. frontalis frontalis* as described by Fraser (1936) and Asahina (1987). Its terminal abdominal segments, including the anal appendages were predominantly yellow. The inferior anal appendage was longer than the superiors whose apices it covered by curving in. A comparative analysis using the available resources and photographs lets us place the taxon encountered as *Epophthalmia frontalis* (Image 8), but taxonomic resolution beyond this level was impossible without examining specimens. Tiple & Payra (2020) while reporting *E. frontalis* from Central India encountered a similar problem and suggested a taxonomic revision of South and Southeast Asian

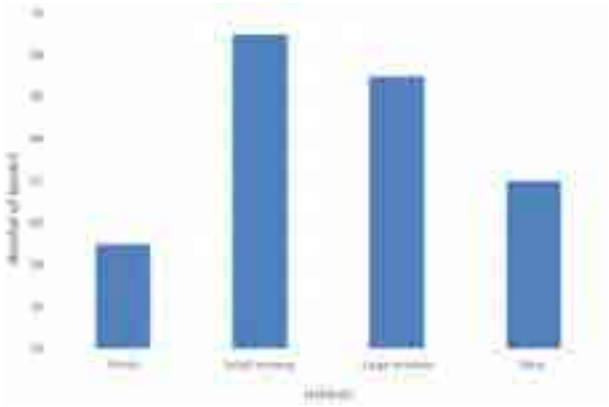

Figure 2. Odonate species richness in each habitat type of Aryanad Grama Panchayat.

Figure 3. Odonate species richness in different seasons at Aryanad Grama Panchayat.

Image 1. The different habitat types sampled for odonates in Aryanad Grama Panchayat: A—Pond | B—Small stream | C—Large stream | D—Karamana River. © Reji Chandran.

Epophthalmia species, particularly *E. frontalis* and *E. vittata*.

Another large Macromiid with its superior and inferior anal appendages of almost the same length was identified as *E. vittata*. Its last segments including the anal appendages were reddish brown with restricted yellow markings (Image 9).

Image 2. 1—*Lestes praemorsus* | 2—*Protosticta gravelyi* | 3—*Protosticta sanguinostigma* | 4—*Vestalis submontana* | 5—*Calocypha laidlawi* | 6—*Dysphaea ethela*. © Reji Chandran.

***Macromia ida* Fraser, 1924**

It is a rare species recorded only from a few locations in Kerala, Karnataka and Tamil Nadu. A single female of this species was sighted near the Karamana River in the southwest monsoon season. It was identified referring to its facial markings and paired dorsal spots on its second abdominal segment.

***Idionyx gomantakensis* Subramanian, Rangnekar & Naik, 2013**

This species was described based on specimens collected from Goa and it remains 'Not Evaluated' in the IUCN Red List. Only very few records of this species are available, all of them from Goa and Kerala. It was

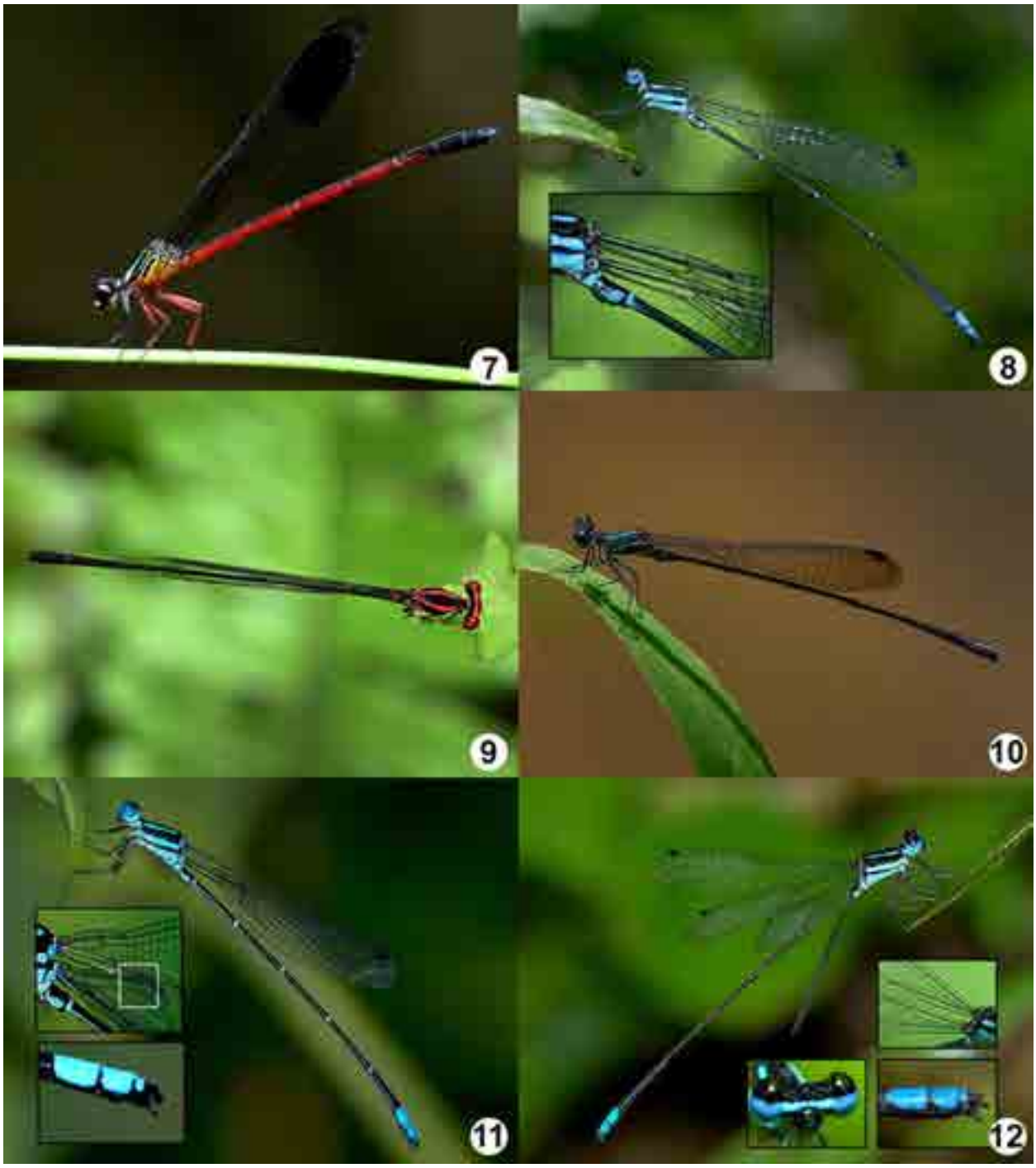

Image 3. 7—*Euphaea fraseri* | 8—*Caconeura risi* | 9—*Elattoneura souteri* | 10—*Elattoneura tetrica* | 11—*Esme longistyla* | 12—*Melanoneura bilineata*. © Reji Chandran.

recorded only from the small streams of Aryanad in summer and southwest monsoon seasons.

Our study has unveiled crucial information regarding the distribution, habitat preference and seasonality of a large number of odonate species in the Western Ghats landscape. While the five *Orthetrum* species were recorded from all the sampled habitats and in all four seasons, many of the endemic species showed high habitat specificity and definite seasonality. The former can be called eurytopic or generalist species and the latter are stenotopic or specialist species. The peak in

Image 4. 13—*Pseudagrion indicum* | 14—*Gomphidia kodaguensis* | 15—*Burmagomphus laidlawi* | 16—*Heliogomphus promelas* | 17—*Macrogomphus wynaadicus* | 18—*Melligomphus acinaces*. © Reji Chandran.

species richness during the southwest monsoon season was expected because most odonate species in India are known to emerge and breed during the monsoon (Subramanian 2005). Odonate diversity dips in winter coinciding with a fall in water level in their habitats and picks up in summer with the pre-monsoon showers. The small streams support the highest number of species probably because they have different microhabitats in the form of pools, marshes and slow flowing stretches. Aryanad village, with its plantations, home gardens and forests at the fringes probably functions as an ecotone, hosting rich biodiversity. Ecotones are ecological

Image 5. 19—*Merogomphus tamaracherriensis* | 20—*Microgomphus souteri* | 21—*Nychogomphus striatus* | 22—*Epophthalmia frontalis* | 23—*Macromia bellicosa* | 24—*Macromia cingulata*. © Reji Chandran.

transition zones characterised by high species turnover rates and local biodiversity peaks (Risser 1995; Odum & Barrett 2005). This calls for effective conservation measures to protect the microhabitats of odonates by the local administration of Aryanad.

REFERENCES

Adarsh, C.K., R. Arunraj & P.O. Nameer (2015). Odonata (Insecta) diversity of Chinnar Wildlife Sanctuary, the Southern Western Ghats, India. *Journal of Threatened Taxa*: 7(2): 6910–6919. https://doi.org/10.11609/JoTT.o3771.6910-9

Asahina, S. (1987). A list of the Odonata recorded from Thailand. Part XVIII. Corduliidae 2 *Kontyu* 55(4): 699–720

Image 6. 25—*Macromia flavocolorata* | 26—*Macromia ida* (female) | 27—*Macromia irata* | 28—*Idionyx gomantakensis* | 29—*Idionyx saffronata* | 30—*Macromidia donaldi*. © Reji Chandran.

Clark, T.E. & M.J. Samways (1996). Dragonflies (Odonata) as indicators of biotope quality in the Kruger National Park, South Africa. *Journal of Applied Ecology* 33(5): 1001–1012.

Clausnitzer V., V.J. Kalkman, M. Ram, B. Collen, J.E.M. Baillie, M. Bedjanič, W.R.T. Darwall, K.B. Dijkstra, R. Dow, J. Hawking, H. Karube, E. Malikova, D. Paulson, K. Schütte, F. Suhling, R.J. Villanueva, N. Ellenrieder & K. Wislon (2009). Odonata enter the biodiversity crisis debate: The first global assessment of an insect group. *Biological Conservation* 142: 1864–1869.

Corbet, P.S. (1993). Are Odonata useful as bioindicators? *Libellula* 12(3–4): 91–102.

Fraser, F.C. (1924). A Survey of the Odonata Fauna of Western India with special remarks on the genera Macromia and Idionyx and descriptions of thirty new species. *Records of the Indian Museum* 26(5): 423–522.

Fraser, F.C. (1933). *The Fauna of British-India including Ceylon and*

Image 7. *Calocypha laidlawi* female (left) and mating pair (right). © Reji Chandran.

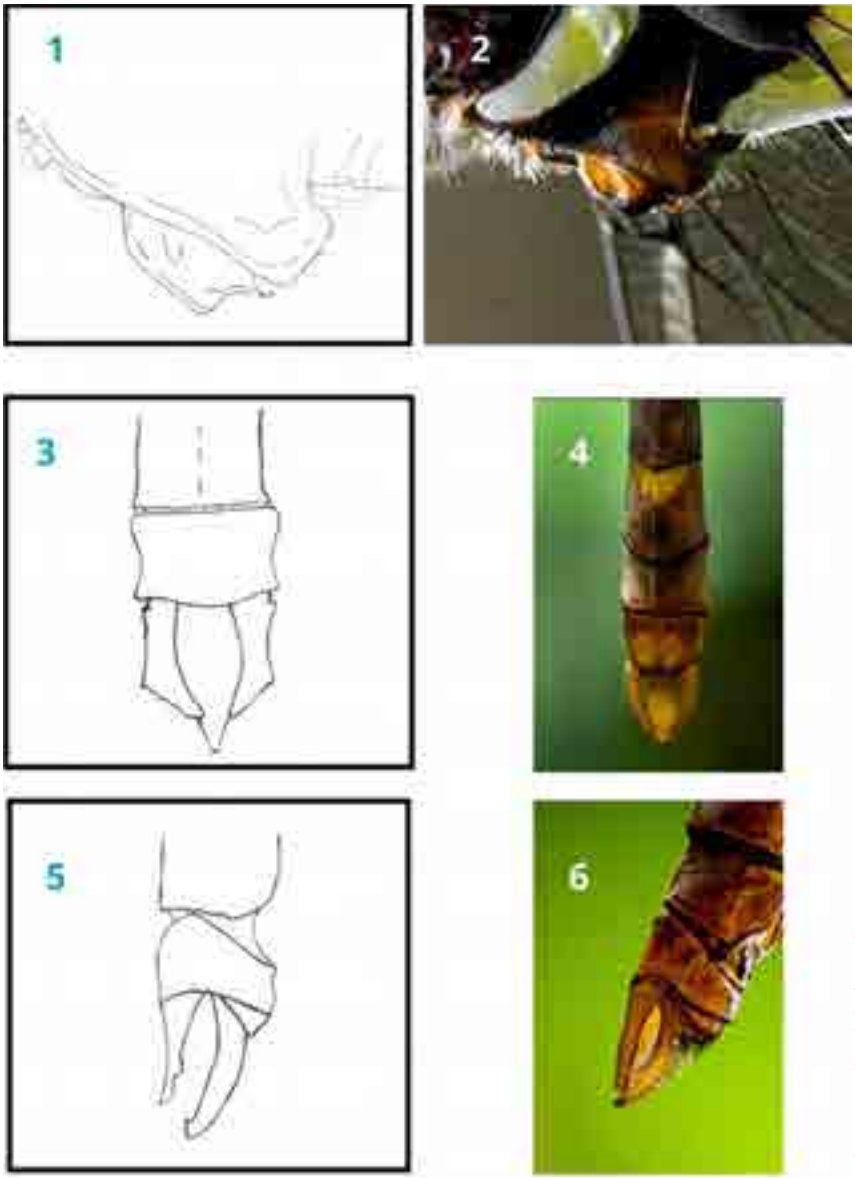

Image 8. *Epophthalmia frontalis*: 1—Accessory genitalia of *E. frontalis frontalis* redrawn from Asahina (1987) | 2—Accessory genitalia of *E.frontalis* photographed from Aryanad | 3 & 5—dorsal & right lateral views of anal appendages of *E. frontalis binocellata* redrawn from Fraser (1936) | 4 & 6—dorsal & right lateral views of *E. frontalis* photographed from Aryanad.
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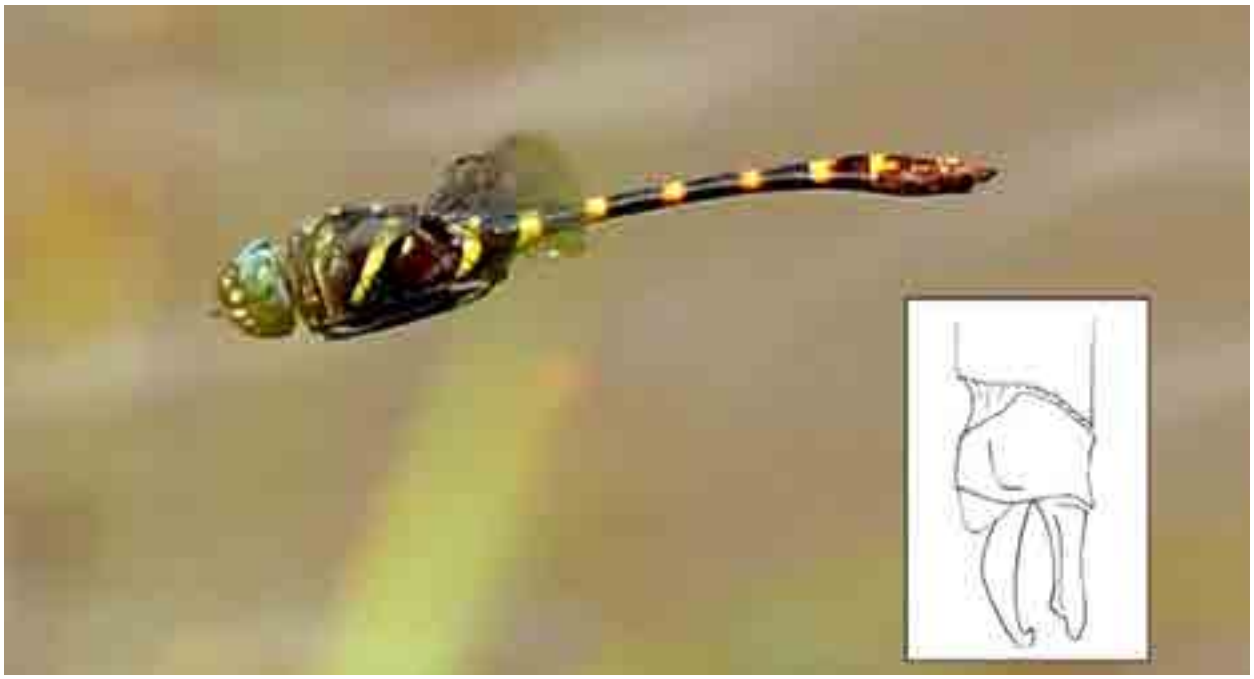

Image 9. *Epophthalmia vittata* in flight; inset—right lateral view of anal appendages of *Epophthalmia vittata vittata* redrawn from Fraser (1936). © Image—Reji Chandran; Drawing—A. Vivek Chandran.

Burma, Odonata. Vol. I. Taylor and Francis Ltd., London, 436 pp.

Fraser, F.C. (1934). *The Fauna of British-India including Ceylon and Burma, Odonata. Vol. II.* Taylor and Francis Ltd., London, 442 pp.

Fraser, F.C. (1935). New Oriental Dragonflies (Order Odonata). *Records of the Indian Museum* 37(3): 321–333.

Fraser, F.C. (1936). *The Fauna of British-India including Ceylon and Burma, Odonata. Vol. III.* Taylor and Francis Ltd., London, 461 pp.

Government of Kerala (2021). https://lsgkerala.gov.in/en/lbelection/electdmemberdet/2010/255 Accessed on 16 April 2021.

IUCN (2021). Red List of Threatened Species. International Union for Conservation of Nature https://www.iucnredlist.org/ Accessed on 16 April 2021.

Kalkman, V.J., R. Babu, M. Bedjanič, K. Conniff, T. Gyeltshen, M.K. Khan, K.A. Subramanian, A. Zia & A.G. Orr (2020). Checklist of the dragonflies and damselflies (Insecta: Odonata) of Bangladesh, Bhutan, India, Nepal, Pakistan and Sri Lanka. *Zootaxa* 4849(1): 001–084. https://doi.org/10.11646/zootaxa.4849.1.1

Kerala State Biodiversity Board (2021). https://www.keralabiodiversity.org/ Accessed on 16 April 2021.

Kiran, C.G. & D.V. Raju (2013). *Dragonflies and damselflies of Kerala* (*Keralathile Thumbikal*). Tropical Institute of Ecological Sciences, 156pp.

Koparde P., P. Mhaske & A. Patwardhan (2014). New records of dragonflies and damselflies (Insecta: Odonata) from the Western Ghats of Maharashtra, India. *Journal of Threatened Taxa* 6(5): 5744–5754. https://doi.org/10.11609/JoTT.o3402.5744-54

Lieftinck, M.A. (1931). A revision of genus *Epophthalmia* Burmeister (Odonata: Corduliinae) with notes on habits and larvae. *Treubia* 13: 21–80.

Mathur, P.K. & P.R. Sinha (2008). Looking Beyond Protected Area Networks: A Paradigm Shift in Approach for Biodiversity Conservation. *International Forestry Review* 10(2): 305–314.

May, R.M. (2010). Ecological science and tomorrow's world. *Philosophical Transactions of the Royal Society: Biological Sciences.* 365: 41–47.

Odum, E.P. & G.W. Barrett (2005). *Fundamentals of Ecology*, 5th edition, Thomson Brooks/Cole, Belmont, California, 598pp.

Risser, P.G. (1995). The Status of the Science Examining Ecotones: A dynamic aspect of landscape is the area of steep gradients between more homogeneous vegetation associations. *BioScience* 45(5): 318–325. https://doi.org/10.2307/1312492

Sánchez-Bayo, F. & K.A.G. Wyckhuys (2019). Worldwide decline of the entomofauna: A review of its drivers. *Biological Conservation* 232: 8–27.

Society for Odonate Studies (2021). List of odonates of Kerala. https://odonatesociety.org/list-of-odonates-of-kerala/ Electronic version accessed on 15 April 2021.

Subramanian, K.A. (2005). *India-A Lifescape, Dragonflies of India – A Field Guide.* Vigyan Prasar, India Offset Press, New Delhi, 118pp.

Subramanian, K.A. (2009). *Dragonflies and Damselflies of Peninsular India - A Field Guide*. Vigyan Prasar, Noida, India, 168pp.

Subramanian, K.A., F. Kakkassery & M.V. Nair (2011). The status and distribution of dragonflies and damselflies (Odonata) of the Western Ghats, pp. 63–72. In: Molur, S., K.G. Smith, B.A. Daniel & W.R.T. Darwall (comp.). The Status and Distribution of Freshwater Biodversity in the Western Ghats, India. IUCN, Cambridge, UK and Glad, Switzerland and Zoo Outreach Organization, Coimbatore, India, 116 pp.

Subramanian, K.A., K.G. Emiliyamma, R. Babu, C. Radhakrishnan & S.S. Talmale (2018). *Atlas of Odonata (Insecta) of the Western Ghats, India.* Zoological Survey of India, Kolkata, 417 pp.

Tiple, A.D & A. Payra (2020). First Record of *Epophthalmia frontalis* from Central India (Insecta: Odonata: Macromiidae). *Travaux du Muséum National d'Histoire Naturelle "Grigore Antipa"* 63(2): 127–130. https://doi.org/10.3897/travaux.63.e52897

Varghese, A.P., P.R. Nikesh & J. Mathew (2014). Odonata (Insecta) diversity of Salim Ali Bird Sanctuary and its adjacent areas in Thattekkad, Kerala, India. *Journal of Threatened Taxa* 6(6): 5887–5893. https://doi.org/10.11609/JoTT.o3395.5887-93

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Checklist of Odonata (Insecta) of Doon Valley, Uttarakhand, India

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Abstract: In this communication, we have collated a checklist of 97 species of odonates from Doon valley, Uttarakhand by reviewing the literature. These species are distributed across 13 families, 58 genera, and eight superfamilies. Of these species, 60 were Anisoptera (dragonflies) and 37 were Zygoptera (damselflies). Three species of dragonflies and two damselflies are endemic to India. This checklist updates existing knowledge on insect diversity in the Doon valley and will aid conservation management of wetlands in the region.

Keywords: Anisoptera, conservation, damselfly, diversity, dragonfly, endemic species, Zygoptera.

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Author contributions: KD—conceptualization, formal analysis, writing original draft; SB—writing original draft; APS–writing original draft, MU—writing original draft, VPU—supervision, review, and editing the draft.

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INTRODUCTION

Odonates are relatively well known because the adults are colourful, relatively large, and easily visible as they pursue insect prey in freshwater habitats ranging from permanent water bodies to pools and puddles (Thorp & Rogers 2011). They are excellent indicators for monitoring the health of freshwater ecosystems. The order Odonata is divided into three suborders, with 6,337 recorded species (Paulson et al. 2021), of which 493 (plus 27 subspecies) in 154 genera and 18 families are reported from India (Subramanian & Babu 2019). Of these, the Himalaya account for 257 species under 112 genera and 18 families (Subramanian & Babu 2018), and Indian endemics include 186 species (including subspecies) belonging to 69 genera, with 34 species being endemic to the Himalaya (Subramanian & Babu 2018).

The earliest accounts of odonates in the Doon valley were by Singh & Prasad (1976) and Prasad & Singh (1976), which documented the Anisoptera and Zygoptera, respectively. Subsequently, Kumar & Prasad (1981) published a list of western Himalayan odonates, which included odonates of Doon valley, and Hamalainen (1989) studied the odonate diversity of Dehradun valley. The diversity of odonates in Rajaji National Park was documented by Prasad & Singh (1995) and Kumar & Sharma (2003) documented the odonate fauna of Doon Valley's Asan Wetland. The diversity of odonates in Sahastradhara and other parts of Dehradun was documented by Husain (2018).

The Doon valley in the Indian state of Uttarakhand is a mountain valley bounded in the south-west by the Siwalik Range, in the north-east by the Mussoorie Range of the Lesser Himalaya, in the north-west by the Yamuna River, and in the south-east by the Ganga River. Habitats include hardwood deciduous forest, blossoming and fruiting trees, wetlands, Terai, and Bhabar ecosystems. There are several rivers: Song, Tons, Suswa, Jakhan, Rispana, and Asan, plus many lesser streams moving through Doon Valley, providing ideal wildlife habitats. Because there is no recent updated information on odonates of the Doon valley, the creation of a checklist with updates was deemed necessary for conservation management of the dragonflies and damselflies the valley.

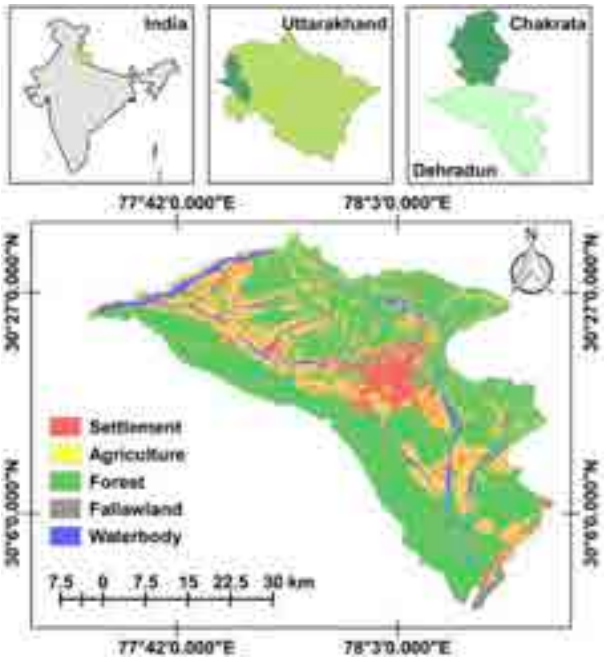

Figure 1. Location and major land-use types of Doon valley.

MATERIALS AND METHODS

The checklist provided in this communication is based on a review of existing literature (Sangal & Kumar 1970a,b; Singh & Prasad 1976; Prasad & Singh 1976, 1995; Kumar & Prasad 1978, 1981; Sangal & Tyagi 1985; Hamalainen 1989; Mitra, 1999, 2000a,b; Kumar & Sharma 2003; Husain 2018) on the odonate fauna of Doon valley (Figure 1). For the systematic position of the odonates, we followed Dijkstra et al. (2013). The nomenclature and endemic status of the species follow Kalkman et al. (2020).

RESULTS AND DISCUSSION

Currently, 97 species of odonates were reported from the Doon valley, Uttarakhand. This include 60 species, 37 genera, five families and four superfamilies of dragonflies (Anisoptera) (Table 1) and 37 species, 21 genera, eight families, and four superfamilies of damselflies (Zygoptera) (Table 2) (Figure 2).

Among the dragonflies, maximum number of species and genus were reported from Libellulidae (38 species, 22 genera), followed by Gomphidae (14 species, 10 genera), Aeshnidae (six species, three genera), Cordulegastridae (one genus, one species), and Macromiidae (one genus, one species) (Figure 3A).

Among the damselflies, maximum number of species

and genus were reported from the Coenagrionidae (16 species, six genera), followed by the Platycnemididae (six species, four genera), Chlorocyphidae (five species, four genera), Lestidae (four species, two genera), Euphaeidae (three species, two genera); Calopterygidae, Platystictidae, and Synlestidae were represented with one genus and one species, each (Figure 3B). Percentage of genera and species of five families of Anisoptera and eight families of Zygoptera are given in Figure 4.

Among the odonates reported from the Doon valley, three dragonflies namely *Anormogomphus heteropterus* Selys, 1854, *Burmagomphus sivalikensis* Laidlaw, 1922, and *Hylaeothemis gardeneri* Fraser, 1927 and two damselflies *Agriocnemis corbeti* Kumar & Prasad, 1978 and *Calicnemia doonensis doonensi* Sangal & Tyagi, 1984 are endemic to India.

Insect populations are supposedly encountering broad decays; however, we, for the most part, have inadequate information on their abundance (Bried et al. 2020). There is a scarcity of knowledge on environmental variables and Odonata diversity in the Doon valley. Aquatic ecosystems are typically spatially and temporally constrained, and are often found in largely rural landscapes, making them vulnerable to farmland water management activities, which can put additional

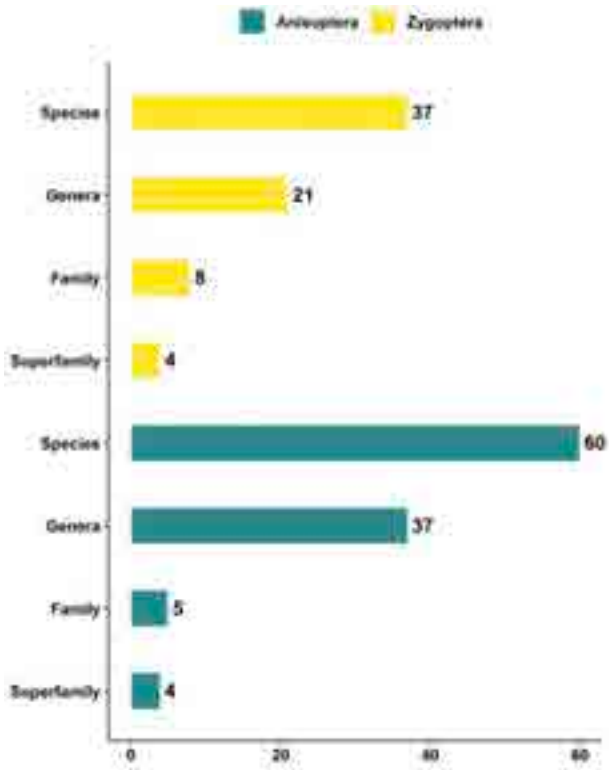

Figure 2. Taxa of Anisoptera and Zygoptera reported from Doon valley.

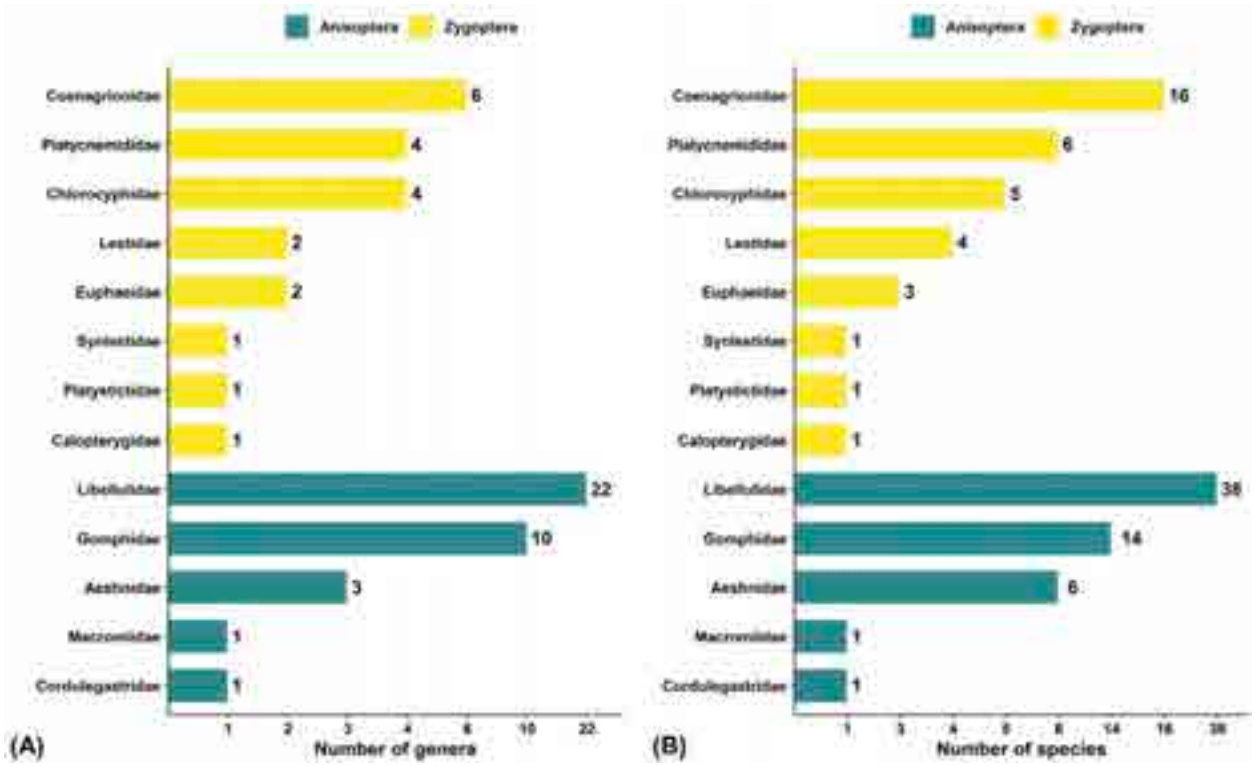

Figure 3. A—numbers of genera | B—species under different families of Anisoptera and Zygoptera.

Table 1. List of dragonflies reported from the Doon valley.

Suborder: Anisoptera Selys, 1854		
Superfamily: Aeshnoidea Leach, 1815		
Family: Aeshnidae Leach, 1815		
Genus: *Anax* Leach in Brewster, 1815		
	Anax guttatus (Burmeister, 1839)	
	Anax immaculifrons Rambur, 1842	
	Anax nigrofasciatus nigrolineatus Fraser, 1935	
	Anax parthenope (Selys, 1839)	
Genus: *Gynacantha* Rambur, 1842		
	Gynacantha bayadera Selys, 1891	
Genus: *Gynacanthaeschna* Fraser, 1921		
	Gynacanthaeschna sikkima (Karsch, 1891)	
Superfamily: Gomphoidea Rambur, 1842		
Family: Gomphidae Rambur, 1842		
Genus: *Anisogomphus* Selys, 1858		
	Anisogomphus occipitalis (Selys, 1854)	
Genus: *Anormogomphus* Selys, 1854		
	Anormogomphus heteropterus Selys, 1854	Endemic to India
	Anormogomphus kiritschenkoi Bartenef, 1913	
Genus: *Burmagomphus* Williamson, 1907		
	Burmagomphus hasimaricus Fraser, 1926	
	Burmagomphus sivalikensis Laidlaw, 1922	Endemic to India
Genus: *Ictinogomphus* Cowley, 1934		
	Ictinogomphus rapax (Rambur, 1842)	
Genus: *Lamelligomphus* Fraser, 1922		
	Lamelligomphus biforceps (Selys, 1878)	
	Lamelligomphus risi (Fraser, 1922)	
Genus: *Nepogomphus* Fraser, 1934		
	Nepogomphus modestus (Selys, 1878)	
Genus: *Nychogomphus* Carle, 1986		
	Nychogomphus duaricus (Fraser, 1924)	
Genus: *Onychogomphus* Selys, 1854		
	Onychogomphus cerastis (Selys, 1854)	
Genus: *Paragomphus* Cowley, 1934		
	Paragomphus lineatus (Selys, 1850)	
Genus: *Scalmogomphus* Chao, 1990		
	Scalmogomphus bistrigatus (Hagen in Selys, 1854)	
	Scalmogomphus schmidti Fraser, 1937	
Superfamily: Libelluloidea Leach, 1815		
Family: Libellulidae Leach, 1815		
Genus: *Acisoma* Rambur, 1842		
	Acisoma panorpoides Rambur, 1842	
Genus: *Brachydiplax* Brauer, 1868		
	Brachydiplax sobrina (Rambur, 1842)	
Genus: *Brachythemis* Brauer, 1868		
	Brachythemis contaminata (Fabricius, 1793)	
Genus: *Bradinopyga* Kirby, 1893		
	Bradinopyga geminata (Rambur, 1842)	
Genus: *Cratilla* Kirby, 1900		
	Cratilla lineata calverti Förster, 1903	
Genus: *Crocothemis* Brauer, 1868		
	Crocothemis erythraea (Brullé, 1832)	
	Crocothemis servilia (Drury, 1773)	
Genus: *Diplacodes* Kirby, 1889		
	Diplacodes lefebvrii (Rambur, 1842)	
	Diplacodes nebulosa (Fabricius, 1793)	
	Diplacodes trivialis Rambur, 1842	
Genus: *Hylaeothemis* Ris, 1909		
	Hylaeothemis gardeneri Fraser, 1927	Endemic to India
Genus: *Neurothemis* Brauer, 1867		
	Neurothemis fulvia (Drury, 1773)	
	Neurothemis intermedia intermedia (Rambur, 1842)	
	Neurothemis tullia (Drury, 1773)	
Genus: *Orthetrum* Newman, 1833		
	Orthetrum brunneum (Fonscolombe, 1837)	
	Orthetrum glaucum Brauer, 1865	
	Orthetrum internum McLachlan, 1894	
	Orthetrum luzonicum (Brauer, 1868)	
	Orthetrum pruinosum neglectum (Burmeister, 1839)	
	Orthetrum sabina sabina (Drury, 1770)	
	Orthetrum taeniolatum (Schneider, 1845)	
	Orthetrum triangulare triangulare (Selys, 1878)	
Genus: *Palpopleura* Rambur, 1842		
	Palpopleura sexmaculata (Fabricius, 1787)	
Genus: *Pantala* Hagen, 1861		
	Pantala flavescens (Fabricius, 1798)	
Genus: *Potamarcha* Karsch, 1890		
	Potamarcha congener (Rambur, 1842)	
Genus: *Rhyothemis* Hagen, 1867		
	Rhyothemis variegate variegata (Linnaeus, 1763)	
Genus: *Sympetrum* Newman, 1833		
	Sympetrum striolatum commixtum (Selys, 1884)	
Genus: *Tetrathemis* Brauer, 1868		
	Tetrathemis platyptera Selys, 1878	
Genus: *Tholymis* Hagen, 1867		
	Tholymis tillarga (Fabricius, 1798)	
Genus: *Tramea* Hagen, 1861		
	Tramea basilaris (Palisot de Beauvois, 1817)	
	Tramea virginia (Rambur, 1842)	
Genus: *Trithemis* Brauer, 1868		
	Trithemis aurora (Burmeister, 1839)	

	Trithemis festiva (Rambur, 1842)	
	Trithemis kirbyi Selys, 1891	
	Trithemis pallidinervis (Kirby, 1889)	
Genus: *Urothemis* Brauer, 1868		
	Urothemis signata (Rambur, 1842)	
Genus: *Zygonyx* Selys in Hagen, 1867		
	Zygonyx torridus isis Fraser, 1924	
Genus: *Zyxomma* Rambur, 1842		
	Zyxomma petiolatum Rambur, 1842	
Family: Macromiidae Needham, 1903		
Genus: *Macromia* Rambur, 1842		
	Macromia moorei Selys, 1874	
Superfamily: Cordulegastroidea Hagen, 1875		
Family: Cordulegastridae Hagen, 1875		
Genus: *Cordulegaster* Leach in Brewster, 1815		
	Cordulegaster brevistigma (Selys, 1854)	

Table 2. List of damselflies reported from the Doon valley.

Suborder: Zygoptera Selys, 1854		
Superfamily: Calopterygoidea Selys, 1850		
Family: Calopterygidae Selys, 1850		
Genus: *Neurobasis* Selys, 1853		
	Neurobasis chinensis (Linnaeus, 1758)	
	Family: Chlorocyphidae Cowley, 1937	
Genus: *Aristocypha* Laidlaw, 1950		
	Aristocypha quadrimaculata (Selys, 1853)	
	Aristocypha trifasciata (Selys, 1853)	
Genus: *Libellago* Selys, 1840		
	Libellago lineata (Burmeister, 1839)	
Genus: *Heliocypha* Fraser, 1949		
	Heliocypha biforata (Selys, 1859)	
Genus: *Paracypha* Fraser, 1949		
	Paracypha unimaculata Selys, 1853	
Family: Euphaeidae Yakobson & Bianchi, 1905		
Genus: *Anisopleura* Selys, 1853		
	Anisopleura comes Hagen, 1880	
	Anisopleura lestoides Selys, 1853	
Genus: *Bayadera* Selys, 1853		
	Bayadera indica (Selys, 1853)	
Superfamily: Coenagrionoidea Kirby, 1890		
Family: Coenagrionidae Kirby, 1890		
Genus: *Agriocnemis* Selys, 1877		
	Agriocnemis clauseni Fraser, 1922	
	Agriocnemis corbeti Kumar & Prasad, 1978	Endemic to India
	Agriocnemis pygmaea (Rambur, 1842)	
Genus: *Amphiallagma* Kennedy, 1920		
	Amphiallagma parvum (Selys, 1876)	
Genus: *Ceriagrion* Selys, 1876		
	Ceriagrion cerinorubellum (Brauer, 1865)	
	Ceriagrion coromandelianum (Fabricius, 1798)	
	Ceriagrion fallax Ris, 1914	
Genus: *Ischnura* Charpentier, 1840		
	Ischnura rubilio Selys, 1876	
	Ischnura forcipata Morton, 1908	
	Ischnura nursei Morton, 1907	
	Ischnura senegalensis Rambur, 1842	
Genus: *Paracercion* Weekers & Dumont, 2004		
	Paracercion calamorum (Ris, 1916)	
Genus: *Pseudagrion* Selys, 1876		
	Pseudagrion rubriceps rubriceps Selys, 1876	
	Pseudagrion decorum (Rambur, 1842)	
	Pseudagrion laidlawi Fraser, 1922	
	Pseudagrion spencei Fraser, 1922	
Family: Platycnemididae Yakobson & Bianchi, 1905		
Genus: *Calicnemia* Strand, 1928		
	Calicnemia doonensis doonensi Sangal & Tyagi, 1984	Endemic to India
	Calicnemia eximia Selys, 1863	
	Calicnemia miles (Laidlaw, 1917)	
Genus: *Copera* Kirby, 1890		
	Copera marginipes (Rambur, 1842)	
Genus: *Elattoneura* Cowley, 1935		
	Elattoneura campioni campioni (Fraser, 1922)	
Genus: *Prodasineura* Cowley, 1934		
	Prodasineura autumnalis (Fraser, 1922)	
Superfamily: Lestoidea Calvert, 1901		
Family: Lestidae Calvert, 1901		
Genus: *Indolestes* Fraser, 1922		
	Indolestes cyaneus (Selys, 1862)	
Genus: *Lestes* Leach in Brewster, 1815		
	Lestes concinnus Hagen in Selys, 1862	
	Lestes praemorsus decipiens Kirby, 1893	
	Lestes viridulus Rambur, 1842	
Family: Synlestidae Tillyard, 1917		
Genus: *Megalestes* Selys, 1862		
	Megalestes major Selys, 1862	
Superfamily: Platystictoidea Kennedy, 1920		
Family: Platystictidae Kennedy, 1920		
Genus: *Drepanosticta* Laidlaw, 1917		
	Drepanosticta carmichaeli (Laidlaw, 1915)	

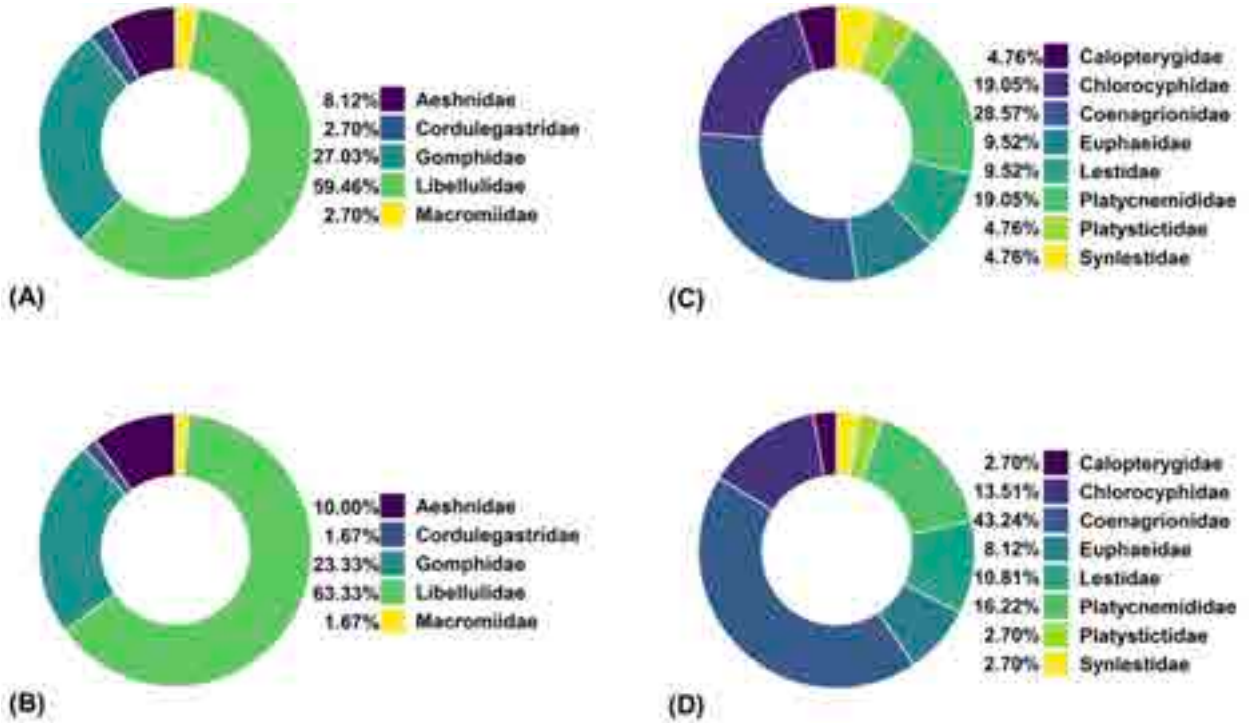

Figure 4. A—Percentage of genera | B—Percentage of species of five families of Anisoptera | C—Percentage of genera | D—Percentage of species of eight families of Zygoptera.

strain on water supplies (Balzan 2012). Since water and habitat management projects are the two most significant trend drivers, conservation research should pay more attention to understanding their function and mechanisms in driving Odonata trend changes (Tang & Visconti 2020). For appropriate biodiversity conservation and management practises, future research should focus on how odonate assemblage structure and diversity are correlated with different habitat variables in Doon valley.

REFERENCES

Balzan, M.V. (2012). Associations of Dragonflies (Odonata) to Habitat Variables within the Maltese Islands: A Spatio-Temporal Approach. *Journal of Insect Science* 12(87): 1–18. https://doi.org/10.1673/031.012.8701

Bried, J., L. Ries, B. Smith, M. Patten, J. Abbott, J. Ball-Damerow, R. Cannings, A. Cordero-Rivera, A. Córdoba-Aguilar, P. De Marco Jr, K-D Dijkstra, A. Dolný, R. van Grunsven, D. Halstead, F. Harabiš, C. Hassall, M. Jeanmougin, C. Jones, L. Juen, V. Kalkman, G. Kietzka, C.S. Mazzacano, A. Orr, M.A. Perron, M. Rocha-Ortega, G. Sahlén, M. Samways, A. Siepielski, J. Simaika, F. Suhling, L. Underhill & E. White (2020). Towards Global Volunteer Monitoring of Odonate Abundance. *BioScience* 70(10): 914–923. https://doi.org/10.1093/biosci/biaa092

Dijkstra, K.D.B., G. Bechly, S.M. Bybee, R.A. Dow, H.J. Dumont, G. Fleck, R.W. Garrison, M. Hämäläinen, V.J. Kalkman, H. Karube & M.L. May (2013). The classification and diversity of dragonflies and damselflies (Odonata). *Zootaxa* 3703(1): 36–45. https://doi.org/10.11646/zootaxa.3703.1.9

Hamalainen, M. (1989). Odonata from Dehradun Valley (Uttar Pradesh, India) with notes on synonymy of some west Himalayan species. *Odontologica* 18(1): 13–20.

Husain, A. (2018). Review on Odonate Diversity of Sahastradhara and Distribution Elsewhere in Dehra Dun and Uttarakhand. *BioBulletin* 4(1): 01–34.

Kalkman, V.J., R. Babu, M. Bedjanič, K. Conniff, T. Gyeltshen, M.K. Khan, K.A. Subramanian, A. Zia & A.G. Orr (2020). Checklist of the dragonflies and damselflies (Insecta: Odonata) of Bangladesh,Bhutan, India, Nepal, Pakistan and Sri Lanka. *Zootaxa* 4849 (1): 001–084. https://doi.org/10.11646/zootaxa.4849.1.1

Kumar, A & G. Sharma (2003). Insecta: Odonata, pp. 11–13. In: Anon. (ed.). Wetland Ecosystem Series 5: Fauna of Asan Wetland (Dehra Dun Valley: Uttaranchal). Zoological Survey of India, Kolkata, 56pp.

Kumar, A & M. Prasad (1981). Field ecology, zoogeography and taxonomy of Odonata of Western Himalaya, India. *Records of the Zoological Survey of India, Occasional Paper* 20: 1–118.

Kumar, A. & M. Prasad (1978). On a new species of Agriocnemis Selys, 1869 with description of its larva from Dehradun Valley, India. *Journal of the Bombay Natural History Society* 75: 174–179.

Mitra, A. (1999). Two new odonate records for the Western Himalaya, India (Anisoptera: Macrodiplactidae, Libellulidae). *Notulae Odonatologicae* 5(3): 39.

Mitra, A. (2000a). Annotated Odonata inventory of the Asan Reservoir, Dehra Dun, India. *Notulae Odonatologicae* 5(5): 37–68.

Mitra, A. (2000b). New record of Gynacantha bayadera Selys (Odonata: Anisoptera: Aeshnidae) from Dehra Dun valley, India. *Sherub Doenme* 5: 44–46.

Prasad, M. & A. Singh (1976). Odonata of Doon Valley 2. Zygoptera. *Records of the Zoological Survey of India* 70: 121–131

Prasad, M. & A. Singh (1995). Odonata, pp. 195–215. In: Anon. (ed.). Fauna of Conservation Areas 5: Fauna of Rajaji National Park. Zoological Survey of India, Kolkata, 323pp.

Sangal, S.K. & A. Kumar (1970a). Studies on the taxonomy of larvae of Doon Valley Odonata. *Journal of Natural History* 4(1): 33–38.

https://doi.org/10.1080/00222937000770041

Sangal, S.K. & A. Kumar (1970b). Studies on the taxonomy of larvae of Doon Valley Odonata II. *Journal of Natural History* 4(3): 305–313. https://doi.org/10.1080/00222937000770291

Sangal, S.K. & B.K. Tyagi (1985). *Calcnemia miniata doonensis*, a new subspecies from the Dehra Dun valley (Dehra Dun, India) (Zygoptera: Platycnemididae), pp. 193–197. Proceedings of the First Indian Symposium of Odontology, Madurai.

Singh, A. & M. Prasad (1976). Odonata of Doon Valley 1. Zygoptera. *Records of the Zoological Survey of India* 70: 21–38

Subramanian, K.A. & R. Babu (2018). Insecta: Odonata, pp. 227–240. In: Chandra, K., D. Gupta, K.C. Gopi, B. Tripathy & V. Kumar (eds.). *Faunal Diversity of Indian Himalaya*. Zoological Survey of India, Kolkata, 872pp.

Subramanian, K.A. & R. Babu (2019). Dragonflies and damselflies (Insecta: Odonata of India), pp. 29–45. In: Ramani, S., P. Mohanraj & H.M. Yeshwanth (eds.). *Indian Insects: Diversity and Science*. CRC Press, London, 472pp.

Tang, D.H.Y. & P. Visconti (2020). Biases of Odonata in Habitats Directive: Trends, trend drivers, and conservation status of European threatened Odonata. *Insect Conservation and Diversity* 14(1): 1–14. https://doi.org/10.1111/icad.12450

Thorp, J.H. & D.C. Rogers (2011). Dragonflies and Damselflies, pp. 191–197. In: Thorp, J.H. & D.C. Rogers (eds.). *Field Guide to Freshwater Invertebrates of North America*. Academic Press, Cambridge, Massachusetts, 274 pp. https://doi.org/10.1016/b978-0-12-381426-5.00021-1

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COMMUNICATION

Diversity of moths from the urban set-up of Valmiki Nagar, Chennai, India

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Abstract: A study was conducted at Valmiki Nagar, Chennai, Tamil Nadu, India to explore its moth diversity from December 2018 to May 2021. This manuscript presents a partial checklist of moths from Valmiki Nagar. Four locations around the colony were studied to record the moth fauna. The study sites were surveyed twice a month using a mercury vapour lamp along with a white sheet, along with over 100 visits at night. Diurnal surveys were conducted bimonthly to observe larval host plants and day flying moths. A total of 135 species were recorded from the study area, belonging to nine superfamilies. The most diverse family of moths recorded was family Erebidae, with 39% of moths recorded in the study belonging to this family, followed by Crambidae (30%), Geometridae (8%), and other families constituting the rest. The moth diversity in the month of July was seen to be the highest. Along with this study, future studies on similar lines will help in documenting the moth diversity of Chennai.

Keywords: Ecology, Endemic, Lepidoptera, nocturnal, pollinators, seasonality, species richness.

Editor: Anonymity requested.

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Author contributions: VMN—conceived and designed the study, conducted a survey, prepared the checklists and photographed the moths. RS—helped in literature and comparison of specimens, results and discussion of the paper, helped compile the picture collage and map. MN—contributed to results and discussion and literature review also helped preparing charts. All three authors approve the final version.

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INTRODUCTION

Moths are predominantly nocturnal and complement butterflies, their daytime counterparts, as important pollinators of flowers especially the night blooming ones (Anil & Parthasarathy 2017).

Moths play an important role in the food chain as prey for diverse organisms such as bats, birds, insects, and reptiles (Raju & Ramana 2020). Several species of moths are important ecological indicators of the ecosystem's health (Warren & Bourn 2011) due to their sensitivity to the changes in the environment and are model organisms for habitat quality and climate change. Moths are often considered as pests in agroecosystems due to the large-scale crop damage caused predominantly in their larval stages (Sinu et al. 2013) and by some species in their adult stages, like the fruit piercing moths (*Eudocima* spp.).

India has recorded over 12,000 species of moths across 40 families (Chandra & Nema 2007). Several studies have been conducted across various locations in southern India. A large section of the studies that were conducted in Tamil Nadu are from the ghat regions with none from urban residential set-ups. Several studies from Tamil Nadu recorded varying moth diversity, including 188 species of Noctuoidea from four families (Sivasankaran et al. 2017), five species of fruit piercing moths of the genus *Eudocima* (Ramkumar et al. 2010a) and 27 species of moths belonging to the family Sphingidae from Kanyakumari (Iyer & Kitching 2019). The most recently published moth diversity study at Chennai is from the Adyar Eco-Park, where 90 species of moths (Nagarajan et al. 2021) were recorded. Another study dealt with the coast of Chennai recorded 42 species (Nagarajan et al. 2022).

The current study aims at documenting the species diversity of Valmiki Nagar (Chennai), thereby giving an insight into the urban moth diversity of Chennai.

Study area

Chennai is the capital city of the state of Tamil Nadu, situated along the Coromandel coast. The mean temperature of Chennai is around 28.6 °C and it receives an annual mean rainfall of 140 cm. However, most of the rain Chennai receives is in bulk during the north-east monsoon. It also houses tropical dry evergreen forest, scrub forests, grasslands, mangroves, and sand dune habitats. This wide range of habitats is favourable for Chennai to host a variety of fauna. A total of 1,039 species of plants have been recorded in Chennai, 322 species of birds (eBird India 2020), and 18 species of mammals have also been reported from Chennai. So far, no study on the moths recorded in the whole of Chennai has been published, though several works are being pursued by the authors to shed light on the same.

Valmiki Nagar is a residential colony located in Thiruvanmiyur, Chennai, Tamil Nadu, India. Several private gardens and avenue trees growing in the neighbourhood encompass the natural vegetation of the study area. The most predominant trees (mostly non-native) in the locality are Copperpod Tree *Peltophorum pterocarpum*, Rain Tree *Albizia saman*, Neem Tree *Azadirachta indica*, Indian Ash Tree *Lannea coromandelica*, Portia Tree *Thespesia populnea*, Gulmohar *Delonix regia*, Pongame Tree *Millettia pinnata*, and Peepal Tree *Ficus religiosa*. It is a coastal colony, located along the Bay of Bengal. Thickets growing in the fringes of the beach account for species normally found in grasslands and open country. This vegetation consists of Calotropis, Devil's Grass *Cynodon dactylon*, and *Acalypha indica*. To the north lies Kalakshetra, a thickly vegetated campus that is known to house several forest fauna, including the Slender Loris (Kumara et al. 2017). Thiruvanmiyur is known to house 72 species of butterflies, with a majority of species recorded from Valmiki Nagar. Valmiki Nagar alone has 98 species of birds recorded (eBird India 2021). With such data publicly availed, the authors aim to shed light on the moth diversity of the locality.

METHODS

A preliminary survey was conducted to find suitable light trapping sites. Four sites where substantial moth diversity was observed were selected as survey sites. The locations have been marked in Figure 1. From December 2018, regular and periodic moth observations were made by setting up a moth sheet and surveying the walls of apartments in the locality.

The moth sheet has been described in the sentences that follow. A single white cloth (134 x 130 cm) was spread out between two vertical poles. Above this cloth, a 150 W power mercury vapour lamp was placed and connected to the nearest power supply. This screen was set up from 1930 h till 0030 h once every 15 days. This was done to record changes in diversity due to changes in the lunar phase, if any. Apart from the moth sheet, species visiting tube lights in common areas of the community that were easily accessible moths were also recorded. These were recorded in various staircases of apartment complexes in the community. These surveys were conducted at least twice a week to generate significant data to assess the

Figure 1. Map depicting the study area, with sampling sites marked in red.

seasonality of species and moth abundance throughout the year. To maintain uniformity in data collection, the survey was conducted individually along a transect and observations were made around the same time (2030–2200 h). There are a few studies in India on the moth diversity in urban spaces. Thus, this was conducted to show the cohabitation of moths in urban landscapes. Opportunistic nocturnal walks and day walks were also carried out. Day walks were conducted to record species that were active pollinators and to find moths that might have been otherwise missed.

No live moths were collected during the study attributing to the ethical beliefs of the authors. Moths were recorded using visual observation and photographs. A Canon 5D Mark IV camera along with a 100 mm macro lens was used to photograph the moths. No external flash was used. However, in some cases, a flashlight was used to provide illumination. Identification of the various species of moths was done by comparing the external morphology of the observed moths to the descriptions provided by Hampson (1892). Consultation with experts wherever possible, references from citizen science initiatives like www.mothsofindia.org and www.inaturalist.org, and the field guide by Shubhalaxmi (2018) were made uses for identifying moths. Difficult to confirm species were left at genus level.

RESULTS AND DISCUSSION

During the defined period of observation, a total of 135 species of moths were recorded from the locality. These include 11 species belonging to the superfamily Bombycoidea, one species of Gelechioidea, 11 species of Geometroidea, one species of Hyblaeoidea, 66 species of Noctuoidea, 42 species of Pyraloidea, one species of Thyridoidea, one species of Yponomeutoidea, and one species of Tortricidae. A complete annotated checklist of moths recorded in the study can be found in Table 1. Out of these listed species, 97 of them were photographed and have been represented in Image 1–98.

Out of the 135 species of moths, 100 species were seen in Site 1, 84 species were seen in Site 2, and 36 species were seen in Site 3. Twenty-three species of moths were seen opportunistically and not during the moth screen sessions.

Moth studies on the moth diversity from Tamil Nadu are family- or subfamily-specific. The current study attempts to understand the moth diversity from various families found in the study area.

A study on Sphingid moths from Kanyakumari (Iyer & Kitching 2019), the first of its kind from the state, records 27 species of moths, of which six were recorded in the current study. *Cephonodes picus* was not recorded in the study at Kanyakumari, while being observed regularly at Valmiki Nagar. Both *Cephonodes* spp. were observed in the day. During this time, they were observed on flowers such as Alexandrian Laurel (*Calophyllum inophyllum*). *Neolamarckia kadamba* was the observed host plant for *Cephonodes* sp. They were seen visiting walls in hot afternoons. They were only seen in June and July in the study. In the current study, an interesting striped *Hippotion* moth was observed. Iyer & Kitching (2019) described *Hippotion boerhavia* as a difficult species to confirm based on morphology and is said to only be confirmable with genitalia examination of a male specimen; but they do mention that *H. boerhavia* has a more striped appearance and elongated forewing, as seen in the specimen that was recorded in our current study, eliminating it from *H. rosetta*, which

was also seen during the study. Another similar species, *H. rafflesii* is known to occur in southern India, but this species is known to have a rich brown ground colour and poses a pink shaded hind wing upper side tornus (pale in the specimen dealt with in our study). This leaves us with the only other option, *H. echeclus*, a species known to occur in drier parts of southern India. However, this was also eliminated due to the absence of a black upper margined under wing in the specimen seen in our study. However, without a proper examination of the genitilia, it was decided to leave the specimen encountered as a *Hippotion* sp. *Hippotion* were seen nectaring and resting in the mornings on *Sensieveria zylanica*. Caterpillars of *Hippotion* sp. were seen feeding on the Pongame Tree, which also served as the host plant for *Psilogramma vates*. They were best seen from June till October, most commonly in the months of July and August. Caterpillars of *Daphnis nerii* were observed feeding on *Nerium oleander*.

Superfamily Noctuoidea was the most diverse superfamily in the study area, with moths belonging to the family Erebidae being the most common and diverse in the study area. Subfamily Erebinae was the most diverse in this family. The most common species from the subfamily include *Parallelia stuposa, Gramodes geometrica, Achaea janata*, *Pandesma* sp., *Trigonodes hyppasia, Mocis undata, Pericyma glaucinans*, and *Lacera noctilo*. Subfamily Artcinae were infrequently observed in the study area, except *Amata passalis,* which was seen commonly throughout the year, especially after heavy rains. *Amata passalis* caterpillars were observed eating dead wood on several occasions, as well as on *Millettia pinnata*. *Amyna axis*, *Helicoverpa armigera, Spodoptera litura, Pseudozarba opella*, and *Chrysodeixis* sp. were the most commonly seen members of the family Noctuidae. *Spodoptera litura* catterpillars were seen on a wide variety of garden plants and weeds. The moth is known to have a wide variety of host plants according to (Jian-Xiang et al. 2011).

A detailed diversity and seasonality study on fruit piercing moths (genus *Eudocima*) from the state describes the presence of five species, which are usually seen from September to January (Ramkumar et al. 2010b). The current study was able to find three out of these five, with the seasonality of the species matching the trends observed by Ramkumar. In our study, *E. materna* had a longer on wing period among the fruit piercing moths, for almost eight months of the year, followed by *E. phalonia*, as was the case in Ramkumar's study. It is also noteworthy that the present study and Ramkumar's record the same relative abundance

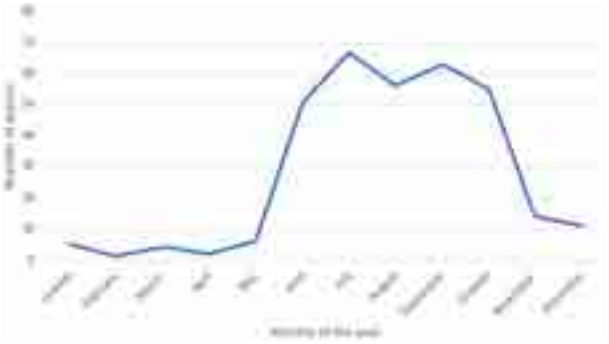

Figure 2. Seasonality of moths observed during the study.

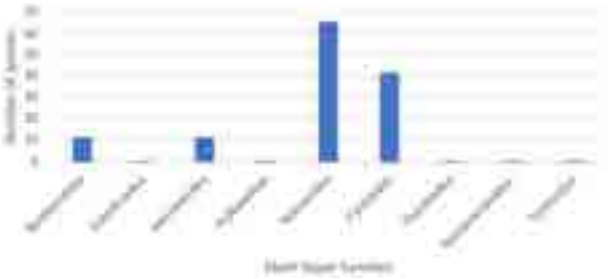

Figure 3. Moth family diversity from Valmiki Nagar.

between the species, *E. materna* > *E. phalonia* > *E. homaena.* These moths were found mainly in the second and third floors of apartments, at a height of 20 and 30 feet from the ground, respectively. *E. phalonia* was often seen hovering near pomegranate plants, while *E. materna* was seen laying its eggs on a *Citrus* sp., both known host plants for the respective species (Shubhalaxmi 2018).

A study by Rathikannu in 2018 recorded 188 species of moths from this family from various locations in Tamil Nadu (Rathikannu et al. 2018), which lists most of the species seen in the current study. The most diverse subfamily recorded in the study was subfamily Spilomelinae. The most common species observed were *Euclasta* sp., *Paliga* sp., *Antigastra catalaunalis*, *Cnaphalocrocis medinalis*, *Sameodes cancellalis*, *Spoladea recurvalis*, and *Pygospila tyres.* During the observations made in this study, crambid moths were most common in the second floor of apartments, at an height of 6.1m (20 ft) from the ground. The most preferred season for moths from this family was from June till October. *Cnaphalocrocis medinalis* in particular was seen in swarms of up to 200 individuals during the month of October. *Cydalima laticostalis* was the only observed exception, only seen in the study area from November to March. Among the rare species,

Table 1. Checklist of moths observed at Valmiki Nagar during the study.

	Super-Family	Family	Sub-Family	Species
1.	Bombycoidea	Eupterotidae	Eupterotinae	*Eupterote* sp. Hübner, 1820
2.	Bombycoidea	Saturniidae	Saturniinae	*Actias selene* (Hübner, [1807])
3.	Bombycoidea	Sphingidae	Sphinginae	*Cephonodes hylas* (Linnaeus, 1771)
4.	Bombycoidea	Sphingidae	Sphinginae	*Cephonodes picus* (Cramer, [1777])
5.	Bombycoidea	Sphingidae	Sphinginae	*Daphnis nerii* (Linnaeus, 1758)
6.	Bombycoidea	Sphingidae	Sphinginae	*Hippotion* sp. Hübner, 1819
7.	Bombycoidea	Sphingidae	Sphinginae	*Hippotion celerio* (Linnaeus, 1758)
8.	Bombycoidea	Sphingidae	Sphinginae	*Hippotion rosetta* (Swinhoe, 1892)
9.	Bombycoidea	Sphingidae	Sphinginae	*Macroglossum gyrans* Walker, 1856
10.	Bombycoidea	Sphingidae	Sphinginae	*Psilogramma vates* (Butler, 1875)
11.	Bombycoidea	Sphingidae	Sphinginae	*Theretra nessus* (Drury, 1773)
12.	Gelechioidea	Gelechiidae	Dichomeridinae	*Dichomeris* sp. Hübner, 1818
13.	Geometroidea	Geometridae	Ennominae	*Achrosis* sp. *Guenée, 1857*
14.	Geometroidea	Geometridae	Ennominae	*Chiasmia eleonora* (Cramer, [1780])
15.	Geometroidea	Geometridae	Ennominae	*Chiasmia emersariaa* (Walker, 1861)
16.	Geometroidea	Geometridae	Ennominae	*Chiasmia* sp. Hübner, 1823
17.	Geometroidea	Geometridae	Ennominae	*Cleora sp.* Curtis, 1825
18.	Geometroidea	Geometridae	Ennominae	*Hyperythra lutea* (Stoll, [1781])
19.	Geometroidea	Geometridae	Sterrhinae	*Chrysocraspeda faganaria* Guenée, [1858]
20.	Geometroidea	Geometridae	Sterrhinae	*Idaea* sp. Treitschke, 1825
21.	Geometroidea	Geometridae	Sterrhinae	*Scopula caesaria* (Walker, 1861)
22.	Geometroidea	Geometridae	Sterrhinae	*Scopula* sp. Schrank, 1802
23.	Geometroidea	Geometridae	Sterrhinae	*Traminda mundissima* (Walker, 1861)
24.	Hyblaeoidea	Hyblaeidae		*Hyblaea puera* (Cramer, 1777)
25.	Noctuoidea	Erebidae	Aganainae	*Asota caricae* (Fabricius, 1775)
26.	Noctuoidea	Erebidae	Aganainae	*Asota producta* (Butler, 1875)
27.	Noctuoidea	Erebidae	Aganainae	*Diagama hearseyana* Moore, 1859
28.	Noctuoidea	Erebidae	Anobinae	*Plecoptera sp* Gueén, 1852
29.	Noctuoidea	Erebidae	Anobinae	*Tephriopis* sp. Walker, 1865
30.	Noctuoidea	Erebidae	Arctinae	*Amata passalis* (Fabricius, 1781)
31.	Noctuoidea	Erebidae	Arctinae	*Ceryx sp* Wallengren, 1863
32.	Noctuoidea	Erebidae	Arctinae	*Cyana bhatejai* Singh & Kirti 2015
33.	Noctuoidea	Erebidae	Arctinae	*Creatonotos gangis (complex)*
34.	Noctuoidea	Erebidae	Arctinae	*Mangina syringa* (Cramer, [1775])
35.	Noctuoidea	Erebidae	Boletobiinae	*Ataboruza divisa* (Walker, 1862)
36.	Noctuoidea	Erebidae	Calpinae	*Eudocima homaena* (Hübner, [1823])
37.	Noctuoidea	Erebidae	Calpinae	*Eudocima materna* (Linnaeus, 1767)
38.	Noctuoidea	Erebidae	Calpinae	*Eudocima phalonia* (Linnaeus, 1763)
39.	Noctuoidea	Erebidae	Eulepidotinae	*Anticarsia irrorata* (Fabricius, 1781)
40.	Noctuoidea	Erebidae	Erebinae	*Acantholipes* sp. (Lederer, 1857)
41.	Noctuoidea	Erebidae	Erebinae	*Achaea janata* (Linnaeus, 1758)
42.	Noctuoidea	Erebidae	Erebinae	*Achaea serva* (Fabricius, 1775)
43.	Noctuoidea	Erebidae	Erebinae	*Artena dotata* (Fabricius, 1794)
44.	Noctuoidea	Erebidae	Erebinae	*Bastilla crameri* (Moore, [1885])
45.	Noctuoidea	Erebidae	Erebinae	*Bastilla simillima* (Guenée, 1852)

	Super-Family	Family	Sub-Family	Species
46.	Noctuoidea	Erebidae	Erebinae	*Chalciope mygdon* (Cramer, [1777])
47.	Noctuoidea	Erebidae	Erebinae	*Parallelia stuposa* (Fabricius, 1794)
48.	Noctuoidea	Erebidae	Erebinae	*Dysgonia cf torrida* (Guenee, 1852)
49.	Noctuoidea	Erebidae	Erebinae	*Ericeia pertendens* (Walker, 1858)
50.	Noctuoidea	Erebidae	Erebinae	*Ericeia inangulata* (Guenée, 1852)
51.	Noctuoidea	Erebidae	Erebinae	*Erebus hieroglyphica* (Drury, 1773)
52.	Noctuoidea	Erebidae	Erebinae	*Erebus macrops* (Linnaeus, 1768)
53.	Noctuoidea	Erebidae	Erebinae	*Fodina cuneigera* (Butler, 1889)
54.	Noctuoidea	Erebidae	Erebinae	*Grammodes geometrica* (Fabricius, 1775)
55.	Noctuoidea	Erebidae	Erebinae	*Grammodes stolida* (Fabricius, 1775)
56.	Noctuoidea	Erebidae	Erebinae	Hypocala subsatura Guenée, 1852
57.	Noctuoidea	Erebidae	Erebinae	*Hypocala cf deflorta* (Fabricius, 1794)
58.	Noctuoidea	Erebidae	Erebinae	*Ischyja* sp. Hübner, [1823]
59.	Noctuoidea	Erebidae	Erebinae	*Lacera noctilio* (Fabricius, 1794)
60.	Noctuoidea	Erebidae	Erebinae	*Macaldenia palumba* (Guenée,1852)
61.	Noctuoidea	Erebidae	Erebinae	*Mocis frugalis* (Fabricius, 1775)
62.	Noctuoidea	Erebidae	Erebinae	*Mocis undata* (Fabricius, 1775)
63.	Noctuoidea	Erebidae	Erebinae	*Ophiusa cf triphaenoides* (Walker, 1858)
64.	Noctuoidea	Erebidae	Erebinae	*Pandesma sp* Guenée, 1852
65.	Noctuoidea	Erebidae	Erebinae	*Pericyma glaucinans* (Guenée, 1852)
66.	Noctuoidea	Erebidae	Erebinae	*Polydesma boarmoide* Guenée, 1852
67.	Noctuoidea	Erebidae	Erebinae	*Rhesala sp.* Walker, 1858
68.	Noctuoidea	Erebidae	Erebinae	*Serrodes campana* (Guenée, 1852)
69.	Noctuoidea	Erebidae	Erebinae	*Serrodes partita* (Fabricius, 1775)
70.	Noctuoidea	Erebidae	Erebinae	*Sphingomorpha chlorea* (Cramer, 1777)
71.	Noctuoidea	Erebidae	Erebinae	*Spirama* sp. Guenée, 1852
72.	Noctuoidea	Erebidae	Erebinae	*Trigonodes hyppasia* Cramer, [1779]
73.	Noctuoidea	Erebidae	Herminiinae	*Hydrillodes* sp. Guenée, 1854
74.	Noctuoidea	Erebidae	Herminiinae	Herminiinae sp. Leach, 1815
75.	Noctuoidea	Erebidae	Hypeninae	*Dichromia sagitta* (Fabricius, 1775)
76.	Noctuoidea	Erebidae	Hypeninae	*Hypena laceratalis* Walker, [1859]
77.	Noctuoidea	Erebidae	Hypeninae	*Hypena cf obacerralis* Walker, 1859
78.	Noctuoidea	Erebidae	Lymantriinae	*Olene mendosa* Hübner, 182
79.	Noctuoidea	Erebidae	Lymantriinae	*Somena scintillans* Walker, 1856
80.	Noctuoidea	Erebidae	Scoliopteryginae	*Anomis flava* (Fabricius, 1775)
81.	Noctuoidea	Noctuidae	Acontiinae	*Acontia* sp. Ochsenheimer, 1816
82.	Noctuoidea	Noctuidae	Eustrotiinae	*Amyna axis* Guenée, 1852
83.	Noctuoidea	Noctuidae	Eustrotiinae	*Maliattha signifera* (Walker, [1858])
84.	Noctuoidea	Noctuidae	Eustrotiinae	Pseudozarba opella (Swinehoe, 1855)
85.	Noctuoidea	Noctuidae	Heliothinae	*Helicoverpa armigera* Hübner, [1809]
86.	Noctuoidea	Noctuidae	Noctuinae	*Spodoptera exigua* (Hübner, 1808)
87.	Noctuoidea	Noctuidae	Noctuinae	*Spodoptera litura* (Fabricius, 1775)
88.	Noctuoidea	Noctuidae	Noctuinae	*Leucania* sp. Ochsenheimer, 1816
89.	Noctuoidea	Noctuidae	Plusiinae	*Chrysodeixis spp* Hübner, 1821
90.	Noctuoidea	Nolidae	Risobinae	*Risoba obstructa* Moore, 1881
91.	Pyraloidea	Crambidae	Acentropinae	*Parapoynx affinialis* Guenée, 1854

	Super-Family	Family	Sub-Family	Species
92.	Pyraloidea	Crambidae	Acentropinae	*Parapoynx diminutalis* Snellen, 1880
93.	Pyraloidea	Crambidae	Acentropinae	*Parapoynx stagnalis* (Zeller, 1852)
94.	Pyraloidea	Crambidae	Acentropinae	*Nymphicula blandialis* (Walker, 1859)
95.	Pyraloidea	Crambidae	Glaphyriinae	*Crocidolomia sp* Zeller, 1852
96.	Pyraloidea	Crambidae	Glaphyriinae	*Hellula undalis* (Fabricius, 1781)
97.	Pyraloidea	Crambidae	Glaphyriinae	*Noorda blitealis* Walker, 1859
98.	Pyraloidea	Crambidae	Pyraustinae	*Euclasta* sp. Lederer, 1855
99.	Pyraloidea	Crambidae	Pyraustinae	*Paliga* sp. Moore, 1886
100.	Pyraloidea	Crambidae	Pyraustinae	*Pyrausta phoenicealis* (Hübner, 1818)
101.	Pyraloidea	Crambidae	Pyraustinae	*Isocentris filalis* (Guenée, 1854)
102.	Pyraloidea	Crambidae	Schoenobiinae	*Scirpophaga* sp. Treitschke, 1832
103.	Pyraloidea	Crambidae	Schoenobiinae	*Scirpophaga incertulas* (Walker, 1863)
104.	Pyraloidea	Crambidae	Spilomelinae	*Agrotera basinotata* Hampson, 1891
105.	Pyraloidea	Crambidae	Spilomelinae	*Antigastra catalaunalis* (Duponchel, 1833)
106.	Pyraloidea	Crambidae	Spilomelinae	*Chabula acamasalis* (Walker, 1859)
107.	Pyraloidea	Crambidae	Spilomelinae	*Cnaphalocrocis medinalis* (Guenée, 1854)
108.	Pyraloidea	Crambidae	Spilomelinae	*Cnaphalocrocis patnalis* (Bradley, 1981)
109.	Pyraloidea	Crambidae	Spilomelinae	*Cnaphalocrocis rutilalis* (Walker, [1859])
110.	Pyraloidea	Crambidae	Spilomelinae	*Cydalima laticostalis* (Guenée, 1854)
111.	Pyraloidea	Crambidae	Spilomelinae	*Diaphania indica* (Saunders, 1851)
112.	Pyraloidea	Crambidae	Spilomelinae	*Herpetogramma licarsisalis* (Walker, 1859)
113.	Pyraloidea	Crambidae	Spilomelinae	*Haritalodes derogate* (Fabricius, 1775)
114.	Pyraloidea	Crambidae	Spilomelinae	*Hodebertia testalis* (Fabricius, 1794)
115.	Pyraloidea	Crambidae	Spilomelinae	*Hydriris ornatalis* (Duponchel, 1832)
116.	Pyraloidea	Crambidae	Spilomelinae	*Maruca vitrata* Fabricius, 1787
117.	Pyraloidea	Crambidae	Spilomelinae	*Nausinoe geometralis* (Guenée, 1854)
118.	Pyraloidea	Crambidae	Spilomelinae	*Nausinoe pueritia* (Cramer, [1780])
119.	Pyraloidea	Crambidae	Spilomelinae	*Notarcha aurolinealis* (Walker, 1859)
120.	Pyraloidea	Crambidae	Spilomelinae	*Omiodes* sp. Guenée, 1854
121.	Pyraloidea	Crambidae	Spilomelinae	*Pagyda salvalis* Walker, 1859
122.	Pyraloidea	Crambidae	Spilomelinae	*Palpita annulifer (complex)* Inoue, 1996
123.	Pyraloidea	Crambidae	Spilomelinae	*Parotis* sp. Hübner, 1831
124.	Pyraloidea	Crambidae	Spilomelinae	*Poliobotys ablactalis* (Walker, 1859)
125.	Pyraloidea	Crambidae	Spilomelinae	*Pycnarmon cribata* (Fabricius, 1794)
126.	Pyraloidea	Crambidae	Spilomelinae	*Pygospila costiflexalis* Guenée, 1854
127.	Pyraloidea	Crambidae	Spilomelinae	*Pygospila tyres* (Cramer, [1780])
128.	Pyraloidea	Crambidae	Spilomelinae	*Sameodes cancellalis* (Zeller, 1852)
129.	Pyraloidea	Crambidae	Spilomelinae	*Spoladea recurvalis* (Fabricius, 1775)
130.	Pyraloidea	Crambidae	Spilomelinae	*Syngamia latimarginalis* (Walker, 1859)
131.	Pyraloidea	Pyralidae	Galleriinae	*Lamoria* sp. Walker, 1863
132.	Pyraloidea	Pyralidae	Pyralinae	*Endotricha cf repandalis* Fabricius, 1794
133.	Thyridoidea	Thyrididae	Strigliniinae	*Banisia* sp. Walker, 1863
134.	Yponomeutoidea	Plutellidae	Pyralinae	*Plutella xylostella* (Linnaeus, [1758])
135.	Tortricoidea	Tortricidae	Olethreutinae	*Loboschiza koenigiana* (Fabricius, 1775)

Agrotera basinotata, *Cnaphalocrocis patnalis*, and *Pygospila costiflexalis* were only seen once during the study. *Ipomea pes-caprae* and *Canavalia rosea* grow in abundance along the beaches of Valmiki Nagar, which attracted moths like *Maruca vitrata, Hellula undalis, Spoladea recurvalis*, and *Cnaphalocrocis medinalis*. The plants also served as diurnal roosting spots for these moths, along with *Plutella xylostella, Scopula* sp., *Spodoptera* spp., and *Achyra* sp. *Spoladea recurvalis* was also observed nectaring on *Ixora* sp., *Wedelia tribobata* and Madagascar Periwinkle *Catharanthus roseus* in apartment complexes during the day. From Chennai, it would be important to survey moths from forested set-ups such as the Indian Institute of Technology, Guindy National Park, Madras Christian College, and Theosophical Society to ascertain the diversity of crambid moths in the area. Crambid moths have been used in the field of environmental monitoring of genetically modified crops (Lang et al. 2011).

Two species of micromoths were commonly recorded in the study, namely, *Plutella xylostella* and *Loboschiza koenigiana*. Both species were seen throughout the year, though more often in June and July. The known host plant for *Loboschiza koenigiana*, *Hibiscus rosa sinensis* (Shubhalaxmi 2018), is abundant in the study area, accounting for its common presence.

Moth diversity was not constant through the various months of the year. The data collected by the authors suggests that moth diversity peaked from June till October, with the month of July recording the greatest number of species of moths. The rise and fall in the diversity of months were very drastic as seen in Figure 2. The sudden peak in May to June may be due to occasional showers and possible local movement of moths due to the south-west monsoon. The second peak was seen during the month of October that dropped post November. A similar trend was observed during the survey carried out at Adyar Eco-Park, Chennai in 2019 (Nagarajan et al. 2021). A conjecture that may be derived based on the observations from the current study, is that the north-east monsoon, which is known to arrive in Tamil Nadu during that time, may facilitate moth emergence in that period. These are conjectures that need a continuous study to confirm. However, moth diversity was seen to drop post November at the study site. Further study on the effect of temperature on moth diversity must be conducted.

The most diverse family of moths recorded was the family Erebidae, with 39% of moths recorded in the study belonging to this family, followed by Crambidae (30%), Geometridae (8%) and other families. This order in species diversity among the various moth families was similar to the diversity of moths from a study recently conducted from Banaras Hindu University, Varanasi, India (Nayak & Ghosh 2020). The study highlights that the polyphagous nature of moths belonging to the superfamily Noctuoidea might account for their higher species richness in the urban localities like Banaras. The results of the current study were compared to the findings of other moth diversity studies (Singh et al. 2021) recorded 19 species of moths from the urban landscape of Jodhpur. However, this lower species diversity can be attributed to the difference the in the natural vegetation between Jodhpur and Chennai. Since there is a deficit in published urban moth studies from India, the authors of the current study have chosen to highlight our results with any published report from an urban environment. Figure 3 shows the species distribution among the various families of moths recorded.

CONCLUSION

Moths are as abundant as butterflies in urban spaces. A total of 135 species of moths were recorded from Valmiki Nagar over a span of two years. Of these, 97 species were photographed and have been presented in the current work. The most diverse family in the study area was the family Erebidae. Nectaring plants that were often used by moths in the study area were observed and reported in the current work. The current work would hopefully serve to bring more urbanites to watch moths, thereby contributing to a greater understanding of the role of moths in urban ecosystems.

REFERENCES

Anil, K. & N. Parthasarathy (2017). Flower traits of plant species and floral resource users in tropical dry evergreen forest on Coromandel Coast of India. *Tropical Ecology* 58(3): 539–545.

Chandra, K. & D. Nema (2007). *Fauna of Madhya Pradesh (including Chhattisgarh) part-I, State Fauna Series-15.* Zoological Survey of India, Kolkata, 1–347.

eBird India (2020). Chennai | eBirdhttps://ebird.org/india/subnational2/IN-TN-CH?yr=all&m=&rank=lrec accessed June 1, 2020.

eBird India (2021). Valmiki Nagar Beach & Thickets, Kancheepuram County, TN, IN - eBird Hotspothttps://ebird.org/india/hotspot/L4890545 accessed April 9, 2021.

Iyer, G. & I.J. Kitching (2019). A preliminary study of the hawkmoth diversity (Lepidoptera: Sphingidae) of Kanyakumari District, Tamil Nadu, India. *Journal of Threatened Taxa* 11(5): 13592–13604.; https://doi.org/10.11609/jott.4694.11.5.13592-13604

Jian-Xiang, X., H. Shahout, J. Xu, X. Yao & Q. Jia (2011). Influence and Mechanism of Different Host Plants on the Growth, Development and, Fecundity of Reproductive System of Common Cutworm

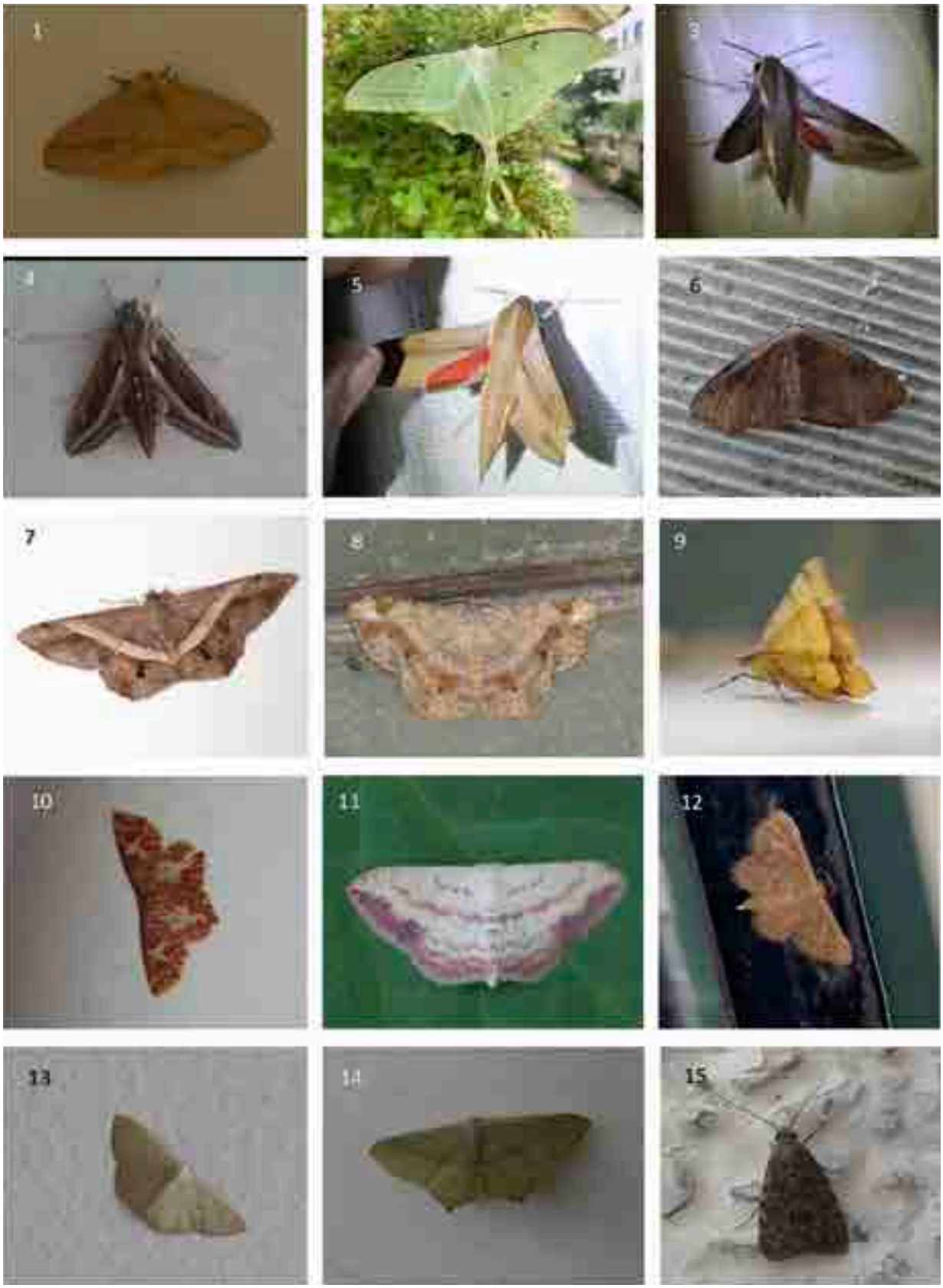

Image 1–15. 1—*Eupterote* sp. | 2—*Actias selene* | 3—*Hippotion* sp. | 4—*Hippotion celerio* | 5—*Hippotion rosetta* | 6—*Achrosis* sp. | 7—*Chiasmia eleonora* | 8—*Chiasmia* sp. | 9—*Hyperythra lutea* | 10—*Chrysocraspeda faganaria* | 11—*Scopula caesaria* | 12—*Idaea* sp. | 13—*Scopula* sp. | 14—*Traminda mundissima* | 15—*Diagama hearseyana*.

Image 16–30. 16—*Plecoptera* sp. | 17—*Ceryx* sp. | 18—*Cyana bhatejai* | 19—*Creatonotos gangis* (complex) | 20—*Mangina syringa* | 21—*Eudocima homaena* | 22—*Eudocima materna* | 23—*Eudocima phalonia* | 24—*Anticarsia irrorata* | 25—*Acantholipes* sp. | 26—*Achaea janata* | 27—*Achaea serva* | 28—*Artena dotata* | 29—*Bastilla crameri* | 30—*Bastilla simillima*.

Image 31–45. 31—*Chalciope mygdon* | 32—*Parallelia cf stuposa* | 33—*Dysgonia cf torrida* | 34—*Ericeia pertendens* | 35—*Erebus hieroglyphica* | 36—*Erebus macrops* | 37—*Grammodes geometrica* | 38—*Grammodes stolida* | 39—*Hypocala subsatura* | 40—*Hypocala* cf. *deflorta* | 41—*Ischyja* sp. | 42—*Lacera noctilio* | 43—*Macaldenia palumba* | 44—*Mocis undata* | 45—*Mocis frugalis.*

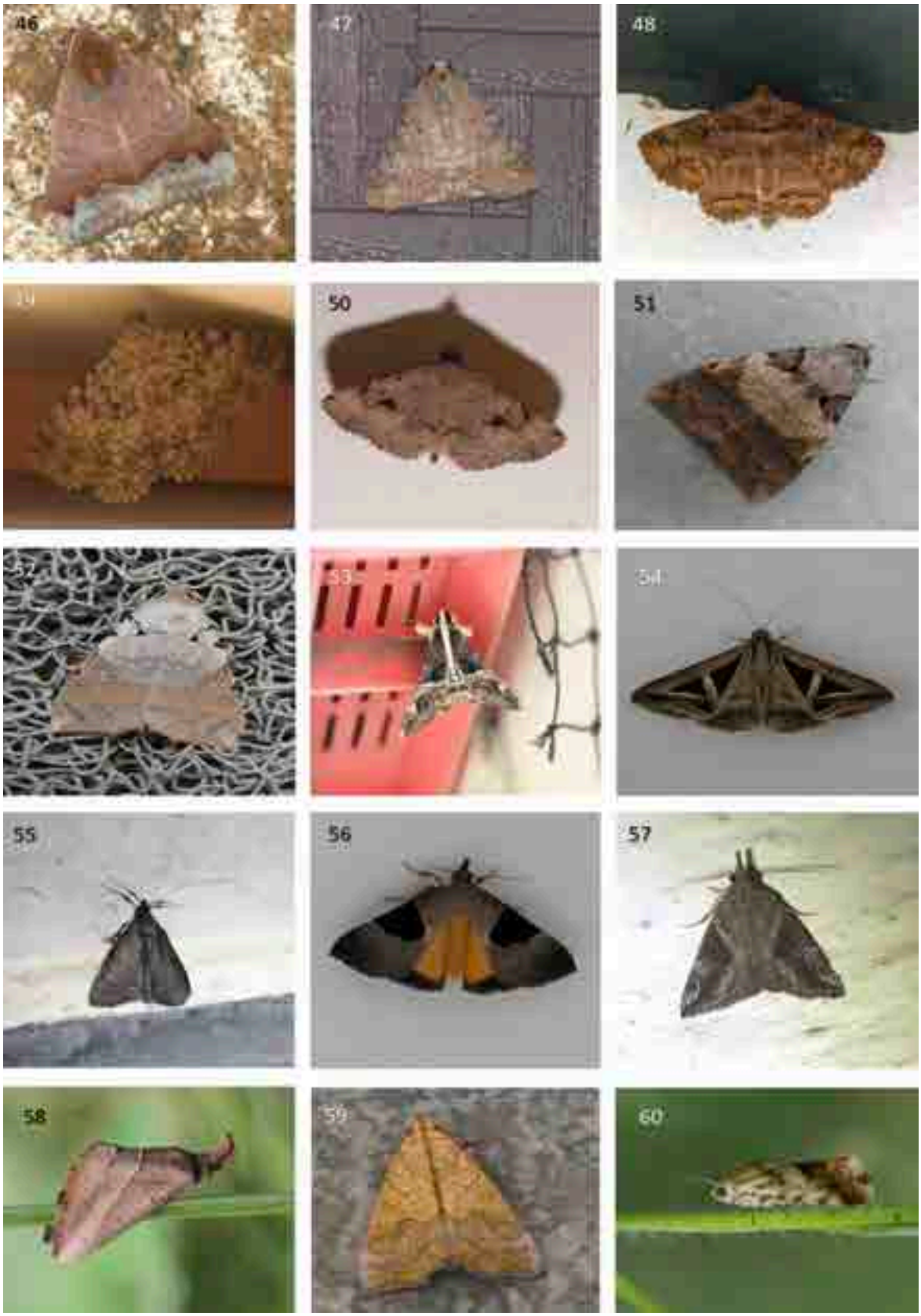

Image 46–60. 46—*Ophiusa cf triphaenoides* (Female) | 47—*Pandesma* sp. | 48—*Pericyma glaucinans* | 49—*Polydesma boarmoide* | 50—*Rhesala* sp. | 51—*Serrodes campana* | 52—*Serrodes partita* | 53—*Sphingomorpha chlorea* | 54—*Trigonodes hyppasia* | 55—Herminiinae sp. | 56—*Dichromia sagitta* | 57—*Hypena laceratalis* | 58—*Hypena* cf. *obacerralis* | 59—*Anomis flava* | 60—*Acontia* sp.

Image 61–75. 61—*Amyna axis* | 62—*Pseudozarba opella* | 63—*Leucania* sp. | 64—*Chrysodeixis* sp. | 65—*Risoba obstructa* | 66—*Crocidolomia* sp. | 67—*Hellula undalis* | 68—*Noorda blitealis* | 69—*Euclasta* sp. | 70—*Paliga* sp. | 71—*Isocentris filalis* | 72—*Agrotera basinotata* | 73—*Chabula acamasalis* | 74—*Cnaphalocrocis medinalis* | 75—*Antigastra catalaunalis.*

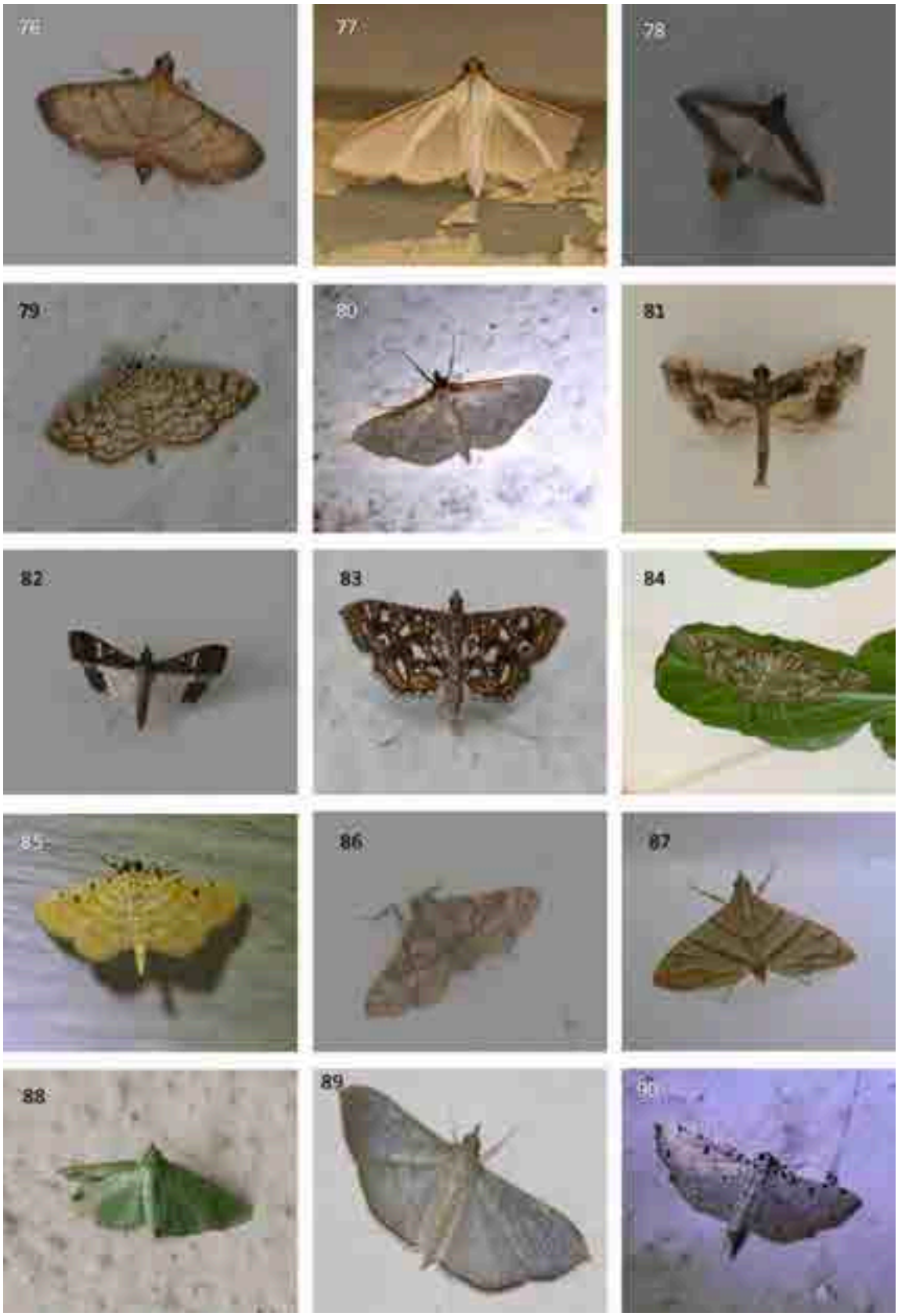

Image 76–90. 76—*Cnaphalocrocis patnalis* | 77—*Cydalima laticostalis* | 78—*Diaphania indica* | 79—*Haritalodes derogata* | 80—*Hodebertia testalis* | 81—*Hydriris ornatalis* | 82—*Maruca vitralis* | 83—*Nausinoe geometralis* | 84—*Nausinoe pueritia* | 85—*Notarcha aurolinealis* | 86—*Omphisa* sp. | 87—*Pagyda salvalis* | 88—*Parotis* sp. | 89—*Poliobotys ablactalis* | 90—*Pycnarmon cribata.*

Image 91–98. 91—*Pygospila costiflexalis* | 92—*Pygospila tyres* | 93—*Samoedes cansalis* | 94—*Spoladea recurvalis* | 95—*Syngamia latimarginalis* | 96—*Lamoria* sp. | 97—*Endotricha cf repandalis* | 98—*Banisia* sp.

Spodoptera litura (Fabricius) (Lepidoptera: Noctuidae). *Asian Journal of Agricultural Science* 3(4): 291–300.

Kumara, H.N., R. Sasi, S. Chandran & S. Radhakrishna (2017). Distribution of the Grey Slender Loris (*Loris lyddekerianus* Cabrera, 1908) in Tamil Nadu, Southern India. *Folia Primatologica* 87(5): 291–302. https://doi.org/10.1159/000452405

Lang, A., M. Dolek, B. Theißen & A. Zapp (2011). Are Adult Crambid Snout Moths (Crambinae) and Larval Stages of Lepidoptera Suitable Tools for an Environmental Monitoring of Transgenic Crops? — Implications of a Field Test. *Insects* 2: 400–411. https://doi.org/10.3390/insects2030400

Muthiah, S. & Association of British Scholars (India). Chennai Chapter (2008). *Madras, Chennai: A 400-year Record of the First City of Modern India*. Palaniappa Brothers, 74–75 pp.

Nagarajan, V.M., M. Yuvan & R. Srinivasan (2021). A partial checklist of moths from Adyar Eco-Park , Chennai , India : a baseline study. *Zoo's Print Journal* 36(23): 1–16.

Nagarajan, V.M., M. Yuvan, R. Srinivasan, N.R. Satagopan, A. Asokan & A. Anooja (2022). Status of important coastal habitats of North Tamil Nadu: Diversity, current threats and approaches for conservation. *Regional Studies in Marine Science* 49: 102106. https://doi.org/10.1016/j.rsma.2021.102106

Nayak, A. & S. Ghosh (2020). Moth diversity (Lepidoptera: Heterocera) of Banaras Hindu University, Varanasi, India: a preliminary checklist. *Notulae Scientia Biologicae* 12(3): 592–607. https://doi.org/10.15835/nsb12310749

Raju, A.J.S. & K.V. Ramana (2020). Contribution to the Lepidopterans of Visakhapatnam Region Contribution to the Lepidopterans of Visakhapatnam Region, Andhra Pradesh, India. *Species* 21(68): 275–280.

Ramkumar, J., M. Swamiappan, S. Raguraman & A. Sadasakthi (2010a). Species diversity and seasonal abundance of fruit piercing moth complex in Tamil Nadu. *Journal of Biopesticides* 3(1 SPEC. ISSUE): 11–15.

Ramkumar, J., M. Swamiappan, S. Raguraman & A. Sadasakthi (2010b). Species diversity and seasonal abundance of fruit piercing moth complex in Tamil Nadu. *Journal of Biopesticides* 3(1 SPEC. ISSUE): 11–15.

Rathikannu, S., M. Ganeshkumar & N. Chitra (2018). Checklist of crambidae (Lepidoptera) from Tamil Nadu. *Indian Journal of Entomology* 80(3): 885–896. https://doi.org/10.5958/0974-8172.2018.00117.7

Robinson, G.S. (n.d.). Hostplants of the Moth and Butterfly Caterpillars of the Oriental Region

Shubhalaxmi, V. (2018). *Birdwing field guide to Indian Moths*. Birdwing Publishers (enterprise of Ladybird Environmental Consulting LLP); First edition (1 January 2018), 474pp.

Singh, M., B. Tanwar, M. Soni & S. Bhadala (2021). *Sighting and Documentation of Butterflies and Moths (Lepidoptera: Insecta) from Urban Region of Jodhpur, Rajasthan, India. Biological Forum* 13(1): 33–38.

Sinu, P.A., P. Mandal, D. Banerjee, S. Mallick, T. Talukdar & S.K. Pathak (2013). Moth pests collected in light traps of tea plantations in North East India: species composition, seasonality and effect of habitat type. *Current Science* 104(5): 646–651.

Sivasankaran, K., S. Anand, P. Mathew & S. Ignacimuthu (2017). Checklist of the superfamily Noctuoidea (Insecta, Lepidoptera) from Tamil Nadu, Western Ghats, India. *Check List* 13(6): 1101–1120. https://doi.org/10.15560/13.6.1101

Warren, M.S. & N.A.D. Bourn (2011). Ten challenges for 2010 and beyond to conserve Lepidoptera in Europe. *Journal of Insect Conservation* 15(1): 321–326. https://doi.org/10.1007/s10841-010-9356-5

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COMMUNICATION

Ichthyofaunal diversity with relation to environmental variables in the snow-fed Tamor River of eastern Nepal

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Abstract: Tamor River in eastern Nepal supports diverse hill stream fishes. From winter, spring, summer, and autumn of 2020, we investigated the ichthyofaunal diversity with environmental variables in the snow-fed Tamor River covering four seasons (winter, spring, summer, and autumn) and field surveys were carried out in January, April, July, and October 2020. We used two cast nets of different sizes, one with a mesh size of 2 cm, 6 m diameter and 6 kg weight and another having 0.5 cm, 3 m diameter and 2 kg weight. In addition, monofilament gill nets with mesh sizes of 6, 8, and 10 were used for fish sampling. A total of 6,373 fish individuals representing 28 species belonging to three orders, seven families, and 16 genera were recorded. One-way permutational multivariate analysis of variance (perMANOVA) on the Non-metric Multidimensional Scaling (NMDS) showed no significant (P >0.05) difference between winter, spring, and autumn season but summer season showed significant (P <0.05) difference from winter, spring, and autumn seasons. Furthermore, one-way analysis of variance on redundancy analysis (RDA) vindicated that among the selected parameters, pH, air temperature and total hardness were the influencing factors (P <0.05) to determine the fish community structure in Tamor River.

Keywords: Field survey, fish diversity, hill-stream, multivariate, spatio-temporal.

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Author contributions: JT, JHL and DKL performed field surveys, collected data and prepared the manuscript. AP and BRS supervised the research and provided inputs on manuscript preparation. JHL analyzed the data.

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INTRODUCTION

Fish community structure, which is regionally diverse and seasonally varied, is often influenced by many environmental variables, as well as biotic interactions like competition and predation (Gorman 1988; Harvey & Stewart 1991; Grossmann et al. 1998; Frelat et al. 2018; He et al. 2020). Habitat variables such as water temperature, depth (Kadye et al. 2008; Hossain et al. 2012; Li et al. 2012), water velocity (Yu & Lee 2002; Arvendo & Ramirez 2017; Limbu et al. 2019), stream width (Gerhard et al. 2004), substrate, altitude, conductivity (Yu & Lee 2002; Kadye et al. 2008; Yan et al. 2010), dissolved oxygen, pH, free-carbon dioxide (Limbu et al. 2019; Prasad et al. 2020) and climate (Magalhaes et al. 2002) have all been shown to affect fish assemblages. However, changing environmental parameters can affect biotic communities in multiple ways and influence the function of ecosystems (McGill et al. 2006; Conversi et al. 2015). Environmental variables are reported to shape the spatial distribution of species (Perry et al. 2005; Vieira & Garro 2020) and influence the temporal variation of communities (Rouyer et al. 2008; Vieira & Garro 2020).

The spatial and temporal variations of the fish community structure in rivers and streams of eastern Nepal are poorly understood (Limbu et al. 2019; Adhikari et al. 2021). However, some of the important studies done in eastern Nepal's rivers and streams include (Shrestha 2009; Shrestha 2016; Shah 2016; Subba et al. 2017; Limbu & Prasad 2017, 2020; Limbu et al. 2018, 2019, 2020). Some outlook of the fisheries and fish ecological studies such as their diversity, spatial & seasonal distribution, and plenty in rivers of Nepal are needed (Mishra & Baniya 2017). To better understand, manage, and conserve (Ngor et al. 2018), and also to know the status (Limbu et al. 2019) of the fisheries, there is an urgent need to update the information on the spatial and temporal fish diversity, community structure and distribution patterns (Ngor et al. 2018).

Thus, the present study aimed to understand relationships among spatio-temporal variation in fish and environmental variables of Tamor River, to reduce the gap in the information and hence dilate the fish diversity profile of Nepal. The present study hypothesized that fish numbers in the Tamor River would be greater during the annual dry season when water current and volume are reduced. We also hypothesized that fish assemblage structure would vary between seasonal variation defined by environmental variables.

MATERIALS AND METHODS

Study area

Tamor River lies in eastern Nepal, which begins around Kanchenjunga. The Tamor and the Arun join the Sunkoshi at Tribeni Ghat to form the giant SaptaKoshi which flows through Mahabharat range (Shrestha 2009). It lies in the latitude and longitude co-ordinates of 26.913° N and 87.157° E respectively. The total length of this river is about 190 km with 5,817 km catchment area (Shrestha et al. 2009). The study area has connections with four districts, i.e., Taplejung, Panchthar, Terathum, and Dhankuta. Boulders, pebbles, sand, and gravels were the major characteristic features of this river.

Data collection, Identification and Preservation

Fish sampling was done in winter, spring, summer, and autumn (January, April, July, and October) of 2020. It started on the 15th and continued to the 30th of the selected months. We made 28 samples at seven stations, namely, (SA) Kabeli Dovan, (SB) Hewa Dovan, (SC) Nawa Khola Dovan, (SD) Chharuwa Dovan, (SE) Yakchana Ghat, (SF) Mulghat, and (SG) Triveni with fish sampling carried out between 0700 and 1100 h. We used two cast nets of different sizes, one with mesh size of 2 cm, 6 m diameter, and 6 kg weight and another with 0.5 cm mesh size, 3 m diameter, and 2 kg weight. Cast netting was carried out covering 150–200 m (Limbu et al. 2021) across each station and all possible habitats were covered. In addition, monofilament gill nets with mesh sizes of 6, 8, and 10 were used to capture the fish. In each station, nine gill nets were left late in the evening (1700–1800 h) and taken out early in the morning (0600–0700 h) in a sampling distance of 150–200 m.

The collected fish were photographed in a fresh condition and identified in the field and if not, then the voucher specimens were preserved in 10% formalin. After the photography, the remaining samples were returned to their own natural habitat from where they were captured. Fishes were identified with the help of standard literature (Talwar & Jhingran 1991; Jayaram 2010; Shrestha 2019) and other available standard literature. The environmental variables were examined during field visit following the standard methods of American Public Health Association (APHA 2012). Water temperature, dissolved Oxygen (DO), pH, total hardness, water velocity, conductivity, alkalinity, and free carbon-dioxide (CO). Water temperature (°C) was measured with a digital thermometer by placing it in the water at a depth of 0.3 m. DO (mg/l) was measured by the Winkler titrimetric method. pH was measured using a pH meter

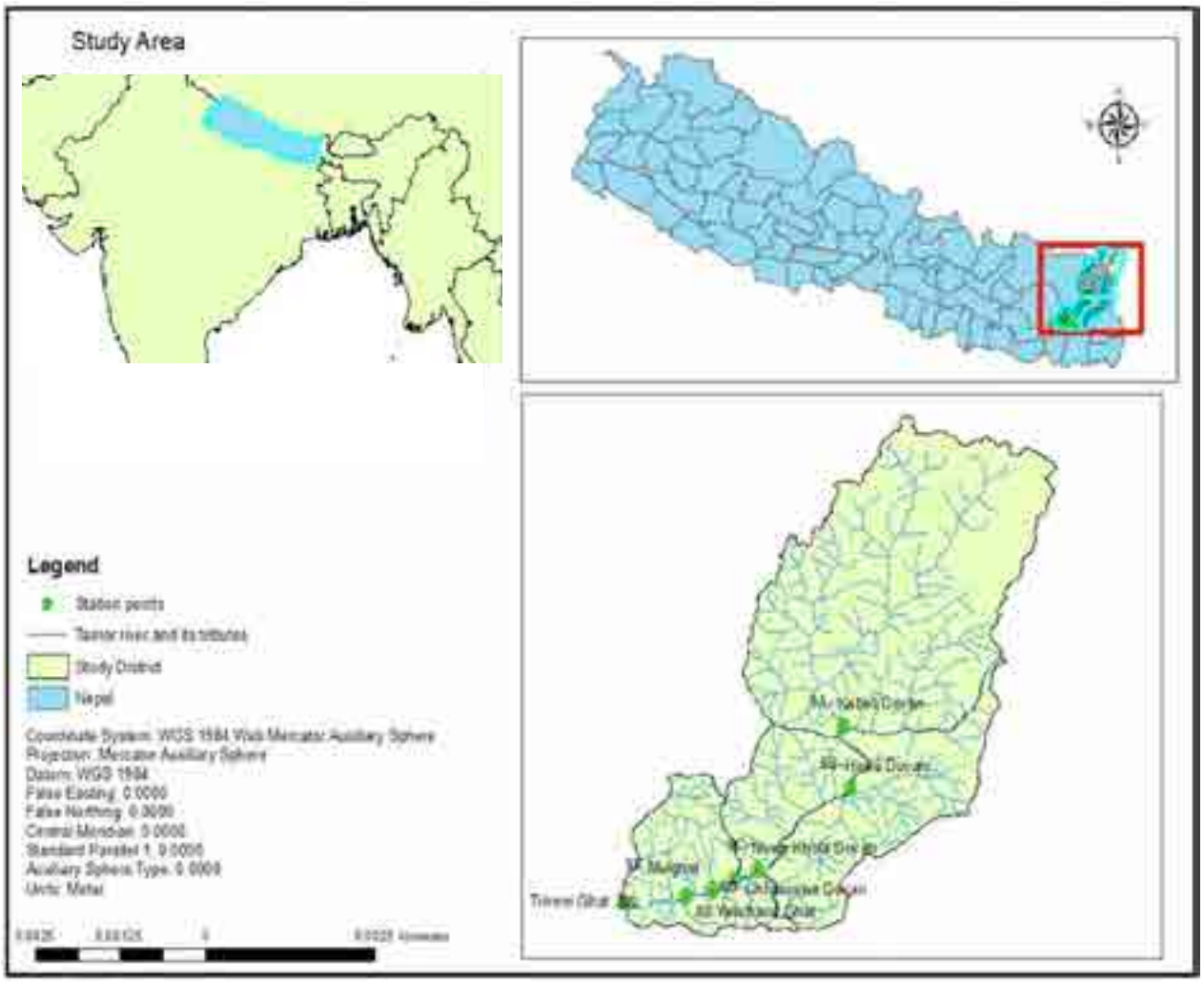

Figure 1. Location of map of study sites in Tamor River, eastern Nepal [SA–Kabeli Dovan; SB – Hewa Dovan; SC – Nuwa Khola Dovan; SD – Chhaurawa Dovan: SE – Yakchana Ghat; SF – Mulghat; SG – Triveni Ghat]

(HI 98107, HANNA Instrument). Total hardness (mg/l) was determined using EDTA titrimetric method. Water velocity (m/s) was measured by the float method with the help of a stop watch, small ball and measuring tape. Titration method was used to measure the alkalinity (mg/l). Free carbon dioxide (mg/l) was measured by the titrimetric method using phenolphthalein as an indicator.

Data analysis

One-way analysis of variance (ANOVA) was used for temperature, pH, dissolved oxygen, hardness and water velocity to calculate the existence of any differences between space and time spectrum. A post-hoc Tukey HSD test was used to test which means were significantly different at a 0.05 level of probability (Spjøtvoll & Stoline 1973). The diversity of the fish assemblage was quantified in the first step of data processing, and then statistical comparison was performed (Appendix I). Fish abundance data were subjected to various diversity indices (Shannon, Simpson, an evenness). All three diversity indices were generated using data from the four seasons (in each season seven samples were made, SA–SG) and seven stations (in each station four samples were made, winter, spring, summer, and autumn), and were used directly in the analysis (Yan et al. 2010) for each fish community sample according to Magurran (1988). Shannon diversity index (Shannon & Weaver 1963) considers both the number of species and the distribution of individuals among species. The Shannon diversity was calculated by following formula:

$$H = \sum_{i=1}^{s} Pi * logPi$$

where S is the total number of species and *Pi* is the relative cover of i_{th} of species.

The dominance index (Harper 1999) was calculated by using following formula:

$D = \sum_i (\frac{ni}{n}) 2$

where n_i is number of individuals of species *i*.

Evenness index (Pieleu 1966) was determined by the following equation:

E= H'/ log S

where, H'= Shannon-Weiner diversity index

S= Total number of species in the sample.

All of the sample (28) was used in the multivariate analysis, and no species or environmental variables were excluded (Appendix I & II). Collected fish abundance and determined environmental variables were used directly in the multivariate analysis (Yan et al. 2010; Hossain et al. 2012; Vieira et al. 2020)

One-way permutational multivariate analysis of variance (perMANOVA) (Clarke 1993) was used to test the significant difference among the spatial and temporal scales of the collected fish data. To visualize the major contributing species both to space and time, similarity percentage (SIMPER) (Clarke 1993) analysis was performed.

Detrended correspondence analysis (DCA) (Hill & Gouch 1983) was used to investigate the relationship between fish community structure and environmental variables. The eigen value (0.13) and axis length (1.17) obtained from DCA suggested that the linear model associated with RDA was more applicable. Therefore, a direct multivariate ordination method (Legendre & Legendrem 1998) based on a linear response of species to environmental gradients was applied. In addition, using non-metric multi-dimensional scaling analysis (NMDS), the relationships between assemblages from each station and seasons are graphically depicted (Clarke & Warwick 2001).

Table 1. List of fish collected from Tamor River.

Order	Family	Code	Species
Cypriniformes	Danionidae	C3	*Barilius barila* Hamilton, 1822
		C4	*Opsarius bendelisis* Hamilton, 1822
		C5	*Opsarius shacra* Hamilton, 1822
	Cyprinidae	C8	*Tarquilabeo latius* Hamilton, 1822
		C9	*Culpisoma garua* Hamilton, 1822
		C10	*Gara annandeli* Hora, 1921
		C11	*Garra gotyla* Gray, 1830
		C15	*Labeo angra* Hamilton, 1822
		C16	*Bangano dero* Hamilton-Buchanan, 1822
		C17	*Labeo gonius* Hamilton-Buchanan, 1822
		C18	*Neolissochilus hexagonolepis* McClelland, 1839
		C24	*Schizothorax labitus* McClelland, 1839
		C25	*Schizothorax progastus* McClelland, 1839
		C26	*Schizothorax richardsonii* Gray, 1832
		C27	*Tor putitora* Hamilton, 1822
		C28	*Tor tor* Hamilton, 1839
	Psilorhynchidae	C20	*Psilorhynchus pseudecheneis* Menon & Datta, 1964
	Botiidae	C6	*Botia almorhae* Gray, 1831
		C7	*Botia lohachata* Chaudhauri, 1912
	Cobitidae	C21	*Schistura beavani* Gunther, 1868
		C22	*Schistura horai* Menon, 1952
		C23	*Schistura savona* Hamilton-Buchanan, 1822
Siluriformes	Sisoridae	C2	*Bagarius bagarius* Hamilton-Buchanan, 1822
		C12	*Glyptothorax cavia* Hamilton-Buchanan, 1822
		C13	*Glyptothorax telchitta* Hamilton-Buchanan, 1822
		C14	*Glyptothorax pectinopterus* McClelland, 1842
		C14	*Pseudecheneis sulcatus* McClelland, 1842
Anguilliformes	Anguillidae	C1	*Anguilla bengalensis* Gray, 1832

RESULTS AND DISCUSSION

Fish Community structure

A total of 6,373 fish individuals representing 28 species belonged to three orders, seven families, and 16 genera were recorded during the investigation period (Table 1). Among these, Cypriniformes comprise most of the species with 78.57%, followed by Siluriformes 17.86%, and Anguilliformes with 3.57%. Cyprnidae was the most abundant family which contributed 46.14%, followed by Sisoridae 18%, Cobitidae 10.7%, Danionidae 10.7%, Botiidae 7.14%, Anguillidae 3.5%, and *Psilorhynchidae* 3.5% (Figure 2). The Cyprinidae was the most species rich family (13 species), followed by Sisoridae (5 species), Danionidae (3 species), Cobitidae (3 species), Botiidae (2 species), Psilorhynchidae and Anguillidae with single species. An environmental impact assessment (EIA) study for the Tamor Hydropower Project has reported the presence of 19 fish species in Tamor River (Swar & Shrestha 1998) while EIA study of Kabeli Hydropower Project has reported the presence of 21 fish species (Swar & Upadhaya 1998) and fish

diversity study reported 30 species in Tamor River (Shrestha 2009). The diversity in terms of number (28 species) observed in the present study was nine species greater than Swar & Shrestha (1998), seven species greater than Swar & Upadhaya (1998). It's possible that this is due to the preceding report's limited scope of research. Furthermore, the species diversity may be influenced by fishing gear selectivity and survey efforts. As a result, the current investigation identified a greater number of fish species. But the present study reported two species lower than Shrestha et al. (2009). It might be due to riparian loss, deforestation, river corridor engineering, dams and water diversion, aquatic habitat loss and fragmentation (Dudgeon et al. 2006; Limbu et al. 2021). Ongoing road development, micro-hydropower generation, poisonous herbicide use, illegal electro-fishing, deforestation, and water diversion are all found to be major threats to the current fish species of Nepal's hillside rivers and streams, according to Limbu et al. (2021) and Adhikari et al. (2021).

Garra nasuta, Botia Dario, Schistura rupecula, Schistura multifaciata, and *Pseudecheneis crossicauda,* according to local fishermen, have suffered a serious drop in population and are not detected in our collection. The most abundant and species-rich order and family, respectively, were Cypriniformes and Cyprinidae. This is in line with the results of previous studies conducted in Nepal's various rivers and streams. For instance, Subba et al. (2017), Limbu et al. (2018, 2019, 2020), GC & Limbu (2020), Limbu & Prasad (2020), Prasad et al. (2020, 2021a,b), Chaudhary et al. (2020) from Tamor, Triyuga, Dewmai, Melamchi, Morang district, Damak, Ratuwa, eastern Nepal, Nuwa Babai River, River Andhi Khola, Seti Gandaki, West Rapti and Betani River. Nelson (2007) also stated that the majority of the fish in the river belong to the Cypriniformes order, which includes 2,422 species of freshwater fish.

Results from the similarity percentage analysis (SIMPER), 64.53% similarity were found among the seasons and major contributing species were *Labeo gonius* (9.72%), *Labeo angra* (8.46%), *Schizothorax richardsonii* (5.92%), *Opsarius shacra* (5.87%), *Garra gotyla* (5.55%), *Pseudecheneis sulcata* (5.48%), *Labeo dero* (5.36%), and *Botia lohachata* (5.30%). On the contrary, 50.33% similarity were found among the sites and major contributing species were *Labeo gonius* (7.54%), *Labeo angra* (6.69%), *Schizothorax richardsonii* (5.35%), *Psilorhynchus pseudecheneis* (5.30%), and *Pseudecheneis sulcata* (5.09%) (Table 2).

The present study reported two mahseer fishes (*Tor* spp.) representing an iconic genus of large-bodied species of the Cyprinidae family. Throughout southern and southeastern Asia, these species are revered for their religious and cultural significance (Pinder et al. 2019). Despite their economic and cultural importance, *Tor* fishes have seen their riverine habitats damaged

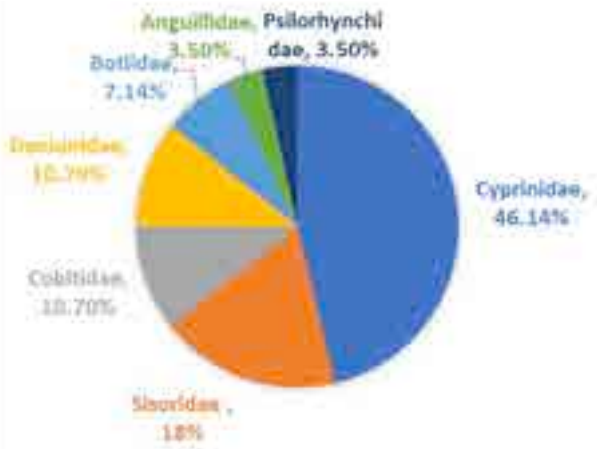

Figure 2. Family wise percentage composition.

Image 1. ***Tor putitora***

Image 2. ***Tot tor***

Table 2. Average similarity and discriminating fish in each season and station using SIMPER analysis.

Season (64.53%)	Contribution	Stations (50.33%)	Contribution
Contributory species	%	Contributory species	%
Labeo gonius	9.72	*Labeo gonius*	7.54
Labeo angra	8.46	*Labeo angra*	6.69
Schizothorax richardsonii	5.92	*Schizothorax richardsonii*	5.35
Opsarius shacra	5.87	*Psilirhynchus pseudecheneis*	5.30
Gara gotyla	5.55	*Pseudecheneis sulcata*	5.09
Pseudecheneis sulcate	5.48	*Neolissochilus hexagonolepis*	4.98
Bangano dero	5.36	*Opsarius shacra*	4.98
Botia lohachatta	5.30	*Gara gotyla*	4.95
Glyptothorax pectinopterus	4.70	*Glyptothorax telchitta*	4.78
Glyptothorax telchitta	4.51	*Labeo dero*	4.48
Barilius barila	4.13	*Botia lohachata*	4.47
Tarquilabeo latius	4.01	*Schizothorax progastus*	4.26
Psilorhynchus pseudecheneis	3.64	*Gara annandalei*	4.24
Schistura savana	3.51	*Glyptothorax pectinopterus*	4.00
Tor tor	3.18	*Schistura savana*	3.57
Schizothorax progastus	3.05	*Barilius barila*	3.55
Neolissochilus hexagonolepis	3.00	*Opsarius bendelisis*	3.5
Gara annandalei	3.00	*Botia almorhae*	3.49
Opsarius bendelisis	2.88	*Tarquilabeo latius*	3.33
Botia almorhae	2.53	*Glyptothorax cavia*	3.3
Schistura horai	2.12	*Tor tor*	2.5
Glyptothorax cavia	1.97	*Schistura horai*	2.01

by anthropogenic activities such as hydroelectric dam construction and exploitation, putting their survival in jeopardy. Furthermore, conservation attempts have been hampered by the fact that the genus' expertise is primarily bent toward aquaculture with significant knowledge gaps on their taphonomy (Bhatt & Pandit 2016; Pinder et al. 2019). The IUCN Red List has classified *Tor putitora* as an 'Endangered' species, whereas *Tor tor* has been classified as 'Data Deficient' (Image 1, 2). Urbanization, poaching, overfishing, and ecological changes in the natural environment's physical, chemical, and biological qualities, according to local fishermen and consent authority, have severely reduced the population of these species in their native habitat. As a result, the conservation of these species is critical.

Diversity status

The Shannon diversity index considers the richness and proportion of each species, while the Evenness and Dominance indices represent the sample's relative number of individuals and the proportion of common species, respectively (Hossain et al. 2012). Highest Shannon diversity index (2.88) was found at station SB and in summer (3.01) whereas lowest (2.63) was found at SE and in winter (2.56). In contrast, highest Simpson dominance index value was observed at station SA, SB, and SC (0.932, 0.93, 0.93) and in summer (0.94) whereas lowest value was observed at, SG (0.908) and in winter (0.90). Similarly, highest value of evenness index was observed at SB (0.69) and in summer (0.65) whereas lowest value of evenness index was observed at SG and in winter (0.62) (Table 4 & 5). According to Hossain et al. (2012), a high Shannon diversity index is associated with a small number of individuals, whereas a low Shannon diversity index is associated with a large number of individuals. A biodiversity index attempts to classify the diversity of a sample (Magurran 1988) and is easily affected by the number of specimens, sampling size, and ecological factors (Leonard et al. 2006).

Fish community structure vs. environmental variables

The result obtained after the redundancy analysis

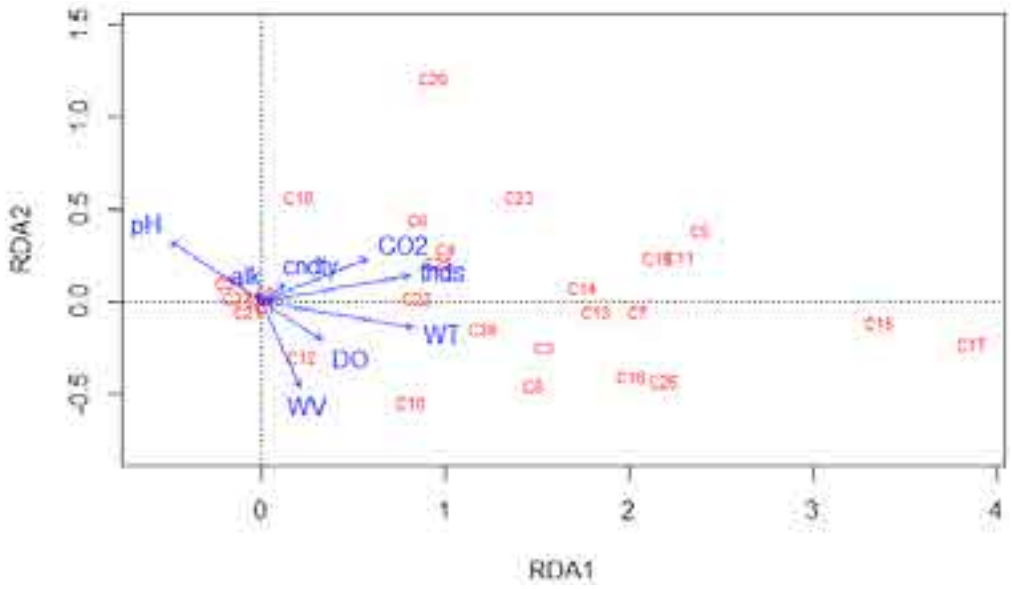

Figure 3. Redundancy analysis (RDA) ordination between fish community structure and environmental variables (for species code refer table 1). thds—total hardness, do dissolved oxygen | WT—water temperature | WV—water velocity | cndty—conductivity | alk—alkalinity | DO—dissolved oxygen | CO_2—free carbon-dioxide.

Table 4. Station-wise fish faunal diversity indices in the snow-fed Tamor River, Nepal.

Station	Shannon Weiner index (H)	Simpson index (D)	Evenness index (E)
SA- Kabeli Dovan	2.82±0.15	0.932±0.012	0.64±0.008
SB Hewa Dovan	2.88±0.13	0.93±0.012	0.646±0.008
SC– Nuwa Khola Dovan	2.87±0.126	0.93±0.01	0.64±0.0075
SD– Chhaurawa Dovan	2.66±0.25	0.91±0.026	0.63±0.018
SE– Yakchana Ghat	2.63±0.307	0.91±0.031	0.63±0.022
SF– Mulghat	2.74±0.209	0.924±0.018	0.63±0.012
SG– Triveni Ghat	2.66±0.29	0.908±0.038	0.62±0.026

(RDA) was plotted in Figure 3. The first and second axis of the RDA accounted for 76% and 5.6%, respectively. The fish species of *Glyptothorax cavia* (C12), *Garra annandalei* (C10), *Tor tor* (C28), *Tarquilabeo latius* (C8), *Barilius barila* (C3), *Glyptothorax pectinopterus* (C13), *Botia lohachata* (C7), *Bangana dero* (C16), *Schizothorax richardsonii* (C26), *Labeo angra* (C15), and *Labeo gonius* (C17) are positively related to water velocity, dissolved oxygen and water temperature but negatively related to pH and alkalinity. Fish species of *Bagarius bagarius* (C2) and *Schizothorax labiatus* (C24) are positively related to pH and alkalinity but negatively related to water velocity, DO, and water temperature. In contrast, species of *Anguilla bengalensis* (C1), *Neolissochilus hexagonolepis* (C18), *Botia almorhae* (C6), *Barilius bendelisis* (C4), *Schizothorax progastus* (C25), *Schistura horai* (C22), *Glyptothorax telchitta* (C14), *Schistura savana* (C23), *Psilorhynchus pseudecheneis* (C20), *Pseudecheneis sulcata* (C19), *Garra gotyla* (C11), and *Opsarius shacra* (C5) are positively related to conductivity, free carbon-dioxide and total hardness. One way analysis of variance on redundancy analysis (RDA) vindicated that among the selected parameters, pH, air temperature and total hardness were the influencing factors (P <0.05) to shape the fish community structure.

One-way permutational multivariate analysis of variance (perMANOVA) on the Non-metric Multidimensional Scaling (NMDS) showed no significant (P >0.05) difference between winter, spring, and autumn season but summer season showed significant (P <0.05) differences with winter, spring and autumn seasons. Furthermore, there was no substantial (P >0.05) difference in fish population structure of spatial variation between the various sampling stations.

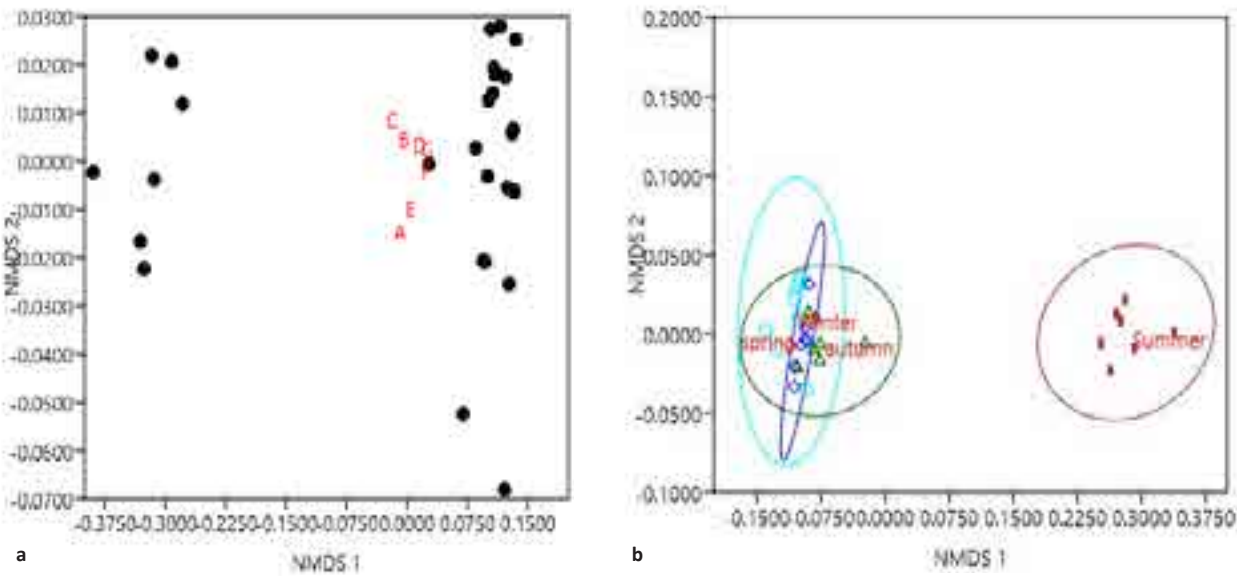

Figure 4. a—NMDS ordination of spatial variation of fish assemblage in the snow-fed Tamor River | b—NMDS ordination of temporal variation of fish assemblage in the snow-fed Tamor River.

Table 5. Season-wise fish faunal diversity indices in the snow-fed Tamor River, Nepal.

Season	Shannon Weiner index (H)	Simpson index (D)	Evenness index (E)
winter	2.56±0.21	0.90±0.02	0.62±0.01
spring	2.703±0.12	0.92±0.01	0.63±0.01
summer	3.01±0.02	0.94±0.003	0.65±0.002
autumn	2.74±0.16	0.92±0.01	0.63±0.01

Edds (1993) and Dubey et al. (2012) observed that the environmental variables such as conductivity, DO, pH, alkalinity, and salinity were most intensely correlated with the fish community composition of the Kali Gandaki River Basin, Nepal, and the Ganga River Basin, India. The most important environmental variables forming the fish assemblage in the Seti Gandaki River Basin were depth, width, conductivity, DO, F-CO2, SiO2 and chlorides. Some other variables such as, pH, PO4 3¡, chlorides and NO3–N were also important in structuring the fish communities (Pokhrel et al. 2018). The role of stream order in deciding the number and abundance of organisms has been clarified (Horwitz 1978; Payne 1986; Leveque 1997). Low temperature as well as other stressing physicochemical conditions are also usual in low order streams at high altitude (Bistoni & Hued 2002).

REFERENCES

Ahikari, A., J.H. Limbu & S. Pathak (2021). Fish Diversity and Water Quality Parameters of Mechi River, Jhapa, Province No. 1, Nepal. *Borneo Journal of Resources Science and Technology* 10(2): 24–34. https://doi.org/10.33736/bjrst.2954.2021

APHA (2012). Standard Methods for Examination of Water and Waste water. 22nd Edn. American Public Health Association, Washington DC, USA, 1220

Bhatt, J.P. & M.K. Pandit (2016). Endangered Golden mahseer Tor putitora Hamilton: a review of natural history. *Review in Fish Biology and Fisheries* 26: 25–38. https://doi.org/10.1007/s11160-015-9409-7

Biston, M.A. & A.C. Hued (2002). Patterns of species richness in rivers of the central region of Argentina. *Brazilian Journal of Biology* 62: 753–764. https://doi.org/10.1590/S1519-69842002000500004

Clarke, K.R. (1993). Non-parametric multivariate analyses of changes in community structure. *Australian Journal of Ecology* 18: 117–143. https://doi.org/10.1111/j.1442-9993.1993.tb00438.x

Conversi, A., V. Dakos, A. Gårdmark, S. Ling, C. Folke, J.P. Mumby, C. Greene, M. Edwards, T. Blenckner, M. Casini, A. Pershing, & C. Möllmann (2015). A holistic view of marine regime shifts. *Philosophical Transactions of the Royal Society B Biological Sciences* 370: 1471–2970. https://doi.org/10.1098/rstb.2013.0279

Dudgeon, D, A. H. Arthington, M.O. Gessner, Z.I. Kawabata, D.J. Knowler et al. (2006). Freshwater biodiversity: Importance, threats, status and conservation challenges. *Biological Reviews* 81: 163–182. https://doi.org/10.1017/S1464793105006950

Edds, D.R. (1993). Fish assemblage structure and environmental correlates in Nepal's Gandaki River. *Copeia* 1993 (1): 48–60. https://doi.org/10.2307/1446294

Gerhard, P, R. Maraes & S. Molander (2004). Stream fish communities and their associations to habitat variables in a rain forest reserve in southeastern Brazil. *Environmental Biology of Fishes* 71: 321–330. https://doi.org/10.1007/s10641-004-1260-y

Gorman, O.T. (1988). The dynamics of habitat use in a guild of Ozark minnows. *Ecological Monograph* 58(1): 1–18. https://doi.org/10.2307/1942631

Grossmann, G.D, R.E. Ratajczak, J.M. Crawford & M.C. Freemann (1998). Assemblages organization in stream fishes: effect of environmental variation and interspecific interactions *Ecological Monograph* 68:

395–420. https://doi.org/10.2307/2657245

Harvey, B.C, & A.J. Stewart (1991). Fish size and habitat depth relationship in headwater streams. *Oecologia* 87: 336–342. https://doi.org/10.1007/BF00634588

Hill, M.O. & H.G. Gauch (1980). Detrended correspondence analysis: an improved ordination technique. *Vegetatio* 42: 47–58. https://doi.org/10.1007/BF00048870

Horwitz, R. (1978). Temporal Variability Patterns and the Distributional Patterns of Stream Fishes. *Ecological Monographs* 48(3): 307–321. https://doi.org/10.2307/2937233

Hossain, M.S., N.G. Das, S. Sarker, & M.Z. Rahaman (2012). Fish diversity and habitat relationship with Environmental vriables at Meghna river estuary, Bangladesh. *Egyptian Journal of Aquatic Research* 38: 213–226. https://doi.org/10.1016/j.ejar.2012.12.006

Jayaram, K.C. (2010). *The freshwater fishes of Indian region.* Narendra Publishing House, Delhi, India, 614 pp.

Kadye, W.T., C.H.D. Magadza, N.A.G. Moyo & S. Kativu (2008). Stream fish assemblages in relation to environmental factors on a montane plateau. *Environmental Biology of Fishes* 83: 417–428. https://doi.org/10.1007/s10641-008-9364-4

Legendre, P. & L. Legendre (1998). *Numerical Ecology*. Second Edition. Elsevier, Amsterdam, Netherlands, 853 pp.

Leveque, C. (1997). *Biodiversity dynamics and conservation: the freshwater fishes of tropical Africa.* Cambridge University Press, UK.

Limbu, J.H. & A. Prasad (2020). Environmental variables and fisheries diversity of the Nuwa River, Panchthar, Nepal. *Scientific World* 13: 69–74. https://doi.org/10.3126/sw.v13i13.30542

Limbu, J.H., B. Bhurtel, A. Adhikari, G.C. Punam, M. Maharjan & S. Sunuwar (2020). Fish community structure and environmental correlates in Nepal's Andhi Khola. *Borneo Journal of Resources Science and Technology* 10(2): 85–92. https://doi.org/10.33736/bjrst.2510.2020

Limbu, J.H., G.S. Acharya & O.H. Shrestha (2018). A brief report on ichthyofaunal diversity of Dewmai Khola of Ilam district, Nepal. Journal of Natural History Museum 30: 312–317. https://doi.org/10.3126/jnhm.v30i0.27607

Limbu, J.H., J.K. Gurung, S. Subba, N. Khadka, A. Adhikari & C.B. Baniya (2021b). An Impact Assessment of Betani Irrigation Dam on Fish Diversity of Damak Municipality, Jhapa, Nepal. *Egyptian Journal of Aquatic Biology and Fisheries* 25(2): 163–175. https://doi.org/10.21608/ejabf.2021.161363

Limbu, J.H., S, Subba, J.K. Gurung, J. Tumbahangfe & B.R. Subba (2021a). Correlation of fish assemblages with habitat and environmental variables in the Phewa Khola Stream of Mangsebung Rural Municipality, Ilam, Nepal. *Journal of Animal Diversity* 3(1): 27–36. http://doi.org/10.52547/JAD.2021.3.1.5

Magalhaes, M.F., D.C. Batalha & M.J. CollaresPereora (2002). Gradients in stream fish assemblages across a Mediterranean landscape: contributions of environmental factors and spatial structure. *Freshwater Biology* 47: 1015–1031. https://doi.org/10.1046/j.1365-2427.2002.00830.x

Magurran, A.E. (1988). *Ecological Diversity and its Measurement*. Princeton University Press, Princeton.

McGill, B.J., B.J. Enquist, E. Weiher & M. Westoby (2006). Rebuilding community ecology from functional traits. *Trends in Ecology and Evolution* 21: 178–185. https://doi.org/10.1016/j.tree.2006.02.002

Mishra, A.R. & C.B. Baniya (2017). Ichthyofaunal diversity and physico-chemical factors of Melamchi River, Sind-upalchok, Nepal. *Journal of Institute of Science and Technology* 21(1): 10–18. https://doi.org/10.3126/jist.v21i1.16031

Moyle, P.B. & B. Vondracek (1985). Persistence and structure of the fish assemblage in a small California stream. *Ecology* 66: 1–13. https://doi.org/10.2307/1941301

Ngor, P.B., P. Legendre, T. Oberdorff & S. Lek (2018). Flow alterations by dams shaped fish assemblage dynamics in the complex Mekong-3S river system. *Ecological Indicators* 88: 103–114. https://doi.org/10.1016/j.ecolind.2018.01.023

Payne, A.I. (1986). *The ecology of tropical lakes and rivers.* John Wiley & Sons, Britain.

Perry, L.A., P.J. Low, J.R. Ellis & J.D. Reynolds (2005). Climate change and distribution shifts in marine fishes. *Science* 308(5730): 1912–1915. https://doi.org/10.1126/science.1111322

Pielou, E.C. (1966). The measurement of diversity in different types of biological collections. *Journal of Theoretical Biology* 13: 131-144. https://doi.org/10.1016/0022-5193(66)90013-0

Pokharel, K.K., B.B. Khadga, C.M. Trilok & C.B. Chitra (2018). Correlations between fish assemblage structure and environmental variables of the Seti Gandaki River Basin, Nepal. *Journal of Freshwater Ecology* 33(1): 31–43. https://doi.org/10.1080/02705060.2017.1399170

Pinder, A.C., J.R. Britton, A.J. Harrison, P. Nautiyal, S.D. Bower, S.J. Cooke, S.L.M. Everard, UK.K. Ranjeet, S.W. Andy, N.D. Dahanukar & R. Raghavan (2019). Mahseer (*Tor* spp.) fishes of the world: status, challenges and opportunities for conservation. *Review of Fish Biology and Fisheries* 29: 417–452. https://doi.org/10.1007/s11160-019-09566-y(0123456789

Prasad, A., A. Shrestha, J.H. Limbu & D. Swar (2020). Spatial and temporal variation of fish assemblage structure in Seti Gandaki River, Tanahu, Nepal. *Borneo Journal of Resources Science and Technolog* 10(2): 93–104. https://doi.org/10.33736/bjrst.2048.2020

Punam, G.C. & J.H. Limbu (2019). Spatio-temporal variation of fish assemblages in Babai River of Danag district, Province No. 5, Nepal. *Our Nature* 17(1): 14–25. https://doi.org/10.3126/on.v17i1.33988

Rouyer, T., J.M. Fromentin, F. Me´nard, B. Cazelles, K. Briand, R. Pianet, B. Planque & N.C. Stenseth (2008). Complex interplays among population dynamics, environmental forcing, and exploitation in fisheries. Proceedings of the National Academy of Sciences of the United States of America 105: 5420–5425.

Shah, R.B. (2016). Study of the freshwater fish diversity of Koshi River of Nepal. International Journals of Fauna and Biological Studies, 3(4): 78–81.

Shannon, C.E. & W. Weave (1963). *The Mathematical Theory of Communication*. Urbana, IL: The University of Illinois Press, 117 pp.

Shrestha, J., D.M. Singh & T.B. Saund (2009). Fish diversity of Tamor River and its major tributaries of eastern Himalayan region of Nepal. *Nepal Journal of Science and Technology* 10: 219–223. https://doi.org/10.3126/njst.v10i0.2964

Shrestha, J.N. (2016). Fish diversity of Triyuga River, Udayapur District. *Our Nature* 14(1): 124–134. https://doi.org/10.3126/on.v14i1.16452

Shrestha, T.K. (2019). *Ichthyology of Nepal, a study of fishes of the Himalayan waters.* Prism Color Scanning and Press Supportive Pvt. Ltd, Kathmandu, Nepal.

Spjøtvoll, E. & M.R. Stoline (1973). An extension of the T-Method of multiple comparison to include the cases with unequal sample sizes. *Journal of the American Statistical Association* 68(344): 975–978. https://doi.org/10.1080/01621459.1973.10481458

Subba, B.R., N. Pokharel & M.R. Pandey (2017). Ichthyofaunal diversity of Morang district, Nepal. *Our Nature* 15(12): 55–67. https://doi.org/10.3126/on.v15i1-2.18794

Swar, D.B. & J. Shrestha (1998). Fishery baseline and impact assessment of Dudhkoshi-I hydropower project area. Mediun hydropower study project, NEA.

Swar, D.B. & K.K. Upadhaya (1998). Fisheries baseline and impact assessment of Kabeli "A" hydropower project area. A report submitted to NEA

Talwar, P.K. & A.G. Jhingram (1991). *Inland Fisheries of India and Adjacent Countries*. Volume I and II. Oxford and IBH Publishing Co. India, 1158 pp.

Wu, J., J. Wang, Y. He & W. Cao (2011). Fish assemblage structure in the Chisui River, a protected tributary of the Yangtze River. *Knowledge and Management of Aquatic Ecosystem* 400(11): 1–14. https://doi.org/10.1051/kmae/2011023

Yan, Y., H.E. Shan, C.H.U. Ling, X. Xiuying, J.I.A. Yanju, T.A.O. Juan & C. Yifeng (2010). Spatial and temporal variation of fish assemblages in a subtropical small stream of the Huangshan Mountain. *Current Zoology* 56(6): 670–677. https://doi.org/10.1093/czoolo/56.6.670

Yu, S.L. & T.W. Lee (2002). Habitat preference of the stream fish, *Sinogastromyzon puliensis*. *Zoological Studies* 41: 183–187.

Appendix I. Determined values of environmental variables in different seasons and stations.

Stations	Seasons	pH		WT	FCO2	DO	ALK	CD	WV	TH
A	Winter	7.1		17.6	7	8.6	17	55	1.9	34
B	Winter	7		17.8	6.5	9	18	55	2	32
C	Winter	6.5		17.5	7	8.7	18	56	1.8	31
D	Winter	7		17	5	8	16.5	52	2	29
E	Winter	7.4		17.5	6.5	7.9	16.6	53	2.2	23
F	Winter	7.1		17.8	6	8.2	16.6	52	2.1	27
G	Winter	6.5		17	7	8	15.5	51	1.9	28
A	spring	6.5		17.1	5.9	8.6	15.4	52	1.9	30
B	spring	7		17.6	6	9	15.4	51	2	36
C	spring	7.2		18	6	8.9	17	51.5	1.5	34
D	spring	6.5		19	6.4	8.4	17.5	54	1.8	35
E	spring	7.2		18.6	7	8	17.5	52.4	2	34
F	spring	7.4		18	6	8.4	16	50.1	1.9	36
G	spring	7		18.5	7.5	8.6	17	52.3	2	37
A	Summer	6.5		18.9	7	8.9	17.5	52	1.8	40
B	Summer	7.8		18.4	6	7.9	17.5	53.1	1.7	39
C	Summer	7.7		15.9	6.8	8	16.5	53	1.9	38
D	Summer	7.9		17	6.9	8.3	16.5	52	1.7	39
E	Summer	7.5		19	7	8.6	17	54	1.7	40
F	Summer	7.8		18.9	6.8	8.8	18	52	1.6	41
G	Summer	7.6		19	7	9	18	53	1.9	39
A	autumn	7.5		15	5	8	16	55	2	40
B	autumn	7		17	6	9	19	45	2.3	24
C	autumn	8		17.5	8	7	18	56	2.5	28
D	autumn	6		18	6	8	17	49	2.9	37
E	autumn	7		18.3	9	8	16	53	3	35
F	autumn	7.3		18	6	9	17	60	2.7	39
G	autumn	8		18.5	7	8	15	77	1.6	40

Appendix II. Fish species recorded from the Tamor River.

Stations	Seasons	C1	C2	C3	C4	C5	C6	C7	C8	C9	C10	C11	C12	C13	C14	C15	C16	C17	C18	C19	C20	C21	C22	C23	C24	C25	C26	C27	C28
A	Winter	0	0	5	11	2	8	6	6	0	15	4	10	5	10	3	0	4	20	2	24	0	0	1	0	12	10	0	0
B	Winter	1	0	4	5	5	6	6	5	0	11	6	15	1	9	1	1	0	8	0	11	0	5	0	2	23	9	1	0
C	Winter	0	0	0	10	9	9	6	1	1	18	9	12	0	3	0	3	0	3	8	23	0	4	0	7	11	8	4	0
D	Winter	0	0	3	11	1	4	4	1	0	5	1	0	1	1	0	8	0	25	9	10	0	1	5	5	9	11	2	0
E	Winter	0	0	5	19	0	12	1	2	2	15	0	0	0	21	3	0	0	24	7	35	0	1	6	0	0	0	0	0
F	Winter	0	0	8	3	0	21	4	3	1	2	10	9	3	6	4	0	1	6	13	9	5	0	11	2	0	1	0	0
G	Winter	0	1	1	0	0	0	0	4	0	26	0	22	8	0	2	5	6	8	1	4	4	0	2	0	2	0	2	1
A	spring	0	0	9	24	0	9	9	8	0	28	8	11	2	19	0		0	22	16	19	0	1	0	1	16	15	0	8
B	spring	0	0	3	3	1	12	2	1	0	12	5	16	8	12	1	1	0	13	9	12	0	2	0	6	9	10	3	3
C	spring	0	0	1	7	4	9	14	6	2	9	0	8	6	9	2	6	0	7	13	9	0	0	0	3	12	6	7	12
D	spring	0	0	0	1	1	8	23	3	1	7	0	4	9	5	0	3	0	0	6	16	0	4	1	0	2	3	2	19
E	spring	0	0	3	6	3	1	12	8	0	12	3	8	3	12	0	0	0	12	12	5	0	1	0	0	4	9	0	10
F	spring	0	0	14	10	1	7	9	2	0	1	4	0	1	8	1	0	3	16	9	15	1	0	2	0	1	13	0	6
G	spring	0	0	9	1	1	11	0	3	0	9	2	1	6	9	4	0	1	11	2	9	6	2	6	0	0	25	0	11
A	Summer	0	0	19	13	19	14	25	17	0	13	21	8	20	15	39	29	30	13	27	18	0	8	13	0	11	31	0	13
B	Summer	0	0	24	19	20	12	22	21	0	24	21	12	15	18	23	22	34	12	26	13	0	7	7	0	9	31	0	12
C	Summer	0	0	20	20	20	10	26	20	0	32	23	12	22	25	44	28	37	20	16	18	0	9	15	0	17	31	0	15
D	Summer	0	0	18	19	18	19	25	18	0	24	24	14	20	35	26	22	39	20	22	25	0	12	17	0	21	26	0	18
E	Summer	0	0	20	20	31	15	24	19	0	18	36	8	21	24	55	23	60	9	30	35	0	12	24	0	20	26	0	9
F	Summer	0	0	18	19	35	20	26	15	0	20	30	17	25	22	29	23	33	14	30	32	0	11	26	0	24	24	0	14
G	Summer	0	0	18	18	34	23	24	20	0	24	28	15	22	30	29	14	45	19	36	28	0	9	16	0	17	28	0	7
A	autumn	1	0	9	12	13	12	9	11	0	12	22	15	7	17	17	12	13	14	34	12	0	0	1	0	11	12	0	0
B	autumn	2	0	6	9	5	9	16	9	0	3	9	13	12	12	5	8	4	18	12	9	0	1	2	1	9	11	1	0
C	autumn	0	0	1	4	9	15	6	5	0	8	5	9	9	9	2	3	7	0	9	6	0	0	0	0	3	9	4	9
D	autumn	0	0	2	14	1	23	3	12	0	12	1	18	4	19	0	2	12	1	4	10	0	0	0	0	1	3	0	8
E	autumn	0	0	9	8	1	9	9	19	0	2	0	2	1	12	0	5	2	4	1	8	0	0	3	0	7	2	0	6
F	autumn	0	1	0	0	6	1	11	3	0	13	0	17	9	9	1	0	8	9	0	4	1	0	1	0	4	16	0	5
G	autumn	0	4	2	1	3	2	14	0	0	16	1	9	4	14	8	0	11	12	6	9	0	0	2	0	0	12	0	1

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OPEN ACCESS

COMMUNICATION

Observations on the foraging behavior of Tricoloured Munia *Lonchura malacca* (Linnaeus, 1766) and its interaction with pearl millet fields in Villupuram District, Tamil Nadu, India

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Abstract: Study of foraging behaviour of Tricoloured Munia *Lonchura malacca* and its interaction in pearl millet crop fields was conducted in six villages of Tindivanam taluk, Villupuram district, Tamil Nadu from April to June 2020. A total of six flocks containing 1,640 birds of Tricoloured Munia were enumerated. The number of birds per flock varied from 60 to 800. They never split into small flocks and maintained the same flock size throughout the day. Tricoloured Munias used nine plant species for roosting. Twelve quadrats (0.3 ha) each of 5 m x 5 m size were laid in the pearl millet fields covering six villages. A total of 10,295 spikes were counted in these plots, and of these 3,785 spikes (36.7%) were found damaged by foraging munias. The maximum damage of 99.6% was observed in Thenputhur village. Along with Tricoloured Munia, five other granivorous birds, such as Baya Weaver *Ploceus philippinus*, Indian Silverbill *Euodice malabarica*, Common Babbler *Turdoides caudata*, Rose-ringed Parakeet *Psittacula krameri*, and White-rumped Munia *Lonchura striata* were also found foraging without any inter-specific competition. Farmers adopted various traditional bird repellent techniques such as beating utensils, throwing pebbles/soil on the crop, placing scarecrows, tying multi-coloured ribbons, and hanging bottles to chase the birds away.

Keywords: Bird repellent, flocking behaviour, granivorous birds, inter-specific competition, roosting plants.

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INTRODUCTION

The Tricoloured Munia *Lonchura malacca* (Aves: Passeriformes: Estrildidae) is a small, finch-like, granivorous bird. It is native to India and Sri Lanka and was introduced into Costa Rica, Haiti, Venezuela, Japan, Jamaica, and Portugal (BirdLife International 2018). This species is considered endemic to the Indian subcontinent and distributed in the Peninsula from Gujarat to Sri Lanka (Ali & Ripley 1987; Grimmet et al. 1999; Rasmussen & Anderton 2005). Tricoloured Munia population is adaptable to a wide range of habitats such as open agricultural lands, woodlands, grasslands, and scrub lands. The global population size of this species has not been quantified by BirdLife International. The IUCN Red List classified this species as 'Least Concern' (BirdLife International 2018). Though this species is widely distributed in the dry plains of India, only a few authors have recorded the presence of this species in Carnatic region (Cole & Brown 1840), and recent records of the species is from Karur (Salahudeen et al. 2013; Deepan et al. 2017), Coimbatore (Daniel 2017), Villupuram districts, and a few records are from Rajasthan as well (Jamdar 1998; Sharma 1999; Bhatnagar 2013) (https://ebird.org/species/trimun).

India is a major producer of pearl millet (*Pennisetum glaucum* (L.) R. Br.) and 83% of the country's production occurs in Rajasthan, followed by Uttar Pradesh, Gujarat, and Haryana (www.millets.dactw.nic.in). In Villupuram district of Tamil Nadu is the major producer of pearl millet (Agricultural Times 2016).

Incidents of flocks of *L. malacca* gleaning grains in paddy fields were reported in Colombia (Cubillos *et al*. 2010), Philippines (Llaguno 1975; Reidinger & Libay 1979), and Rajasthan (Bhatnagar et al. 2013). Literature survey revealed that studies are not available on the foraging behaviors of *L. malacca* and its interaction with pearl millet crop fields. Hence, to fill this gap, I decided to take up a study on foraging and roosting behaviors of *L. malacca* and its interaction with pearl millet crop fields in Tindivanam taluk, Villupuram district, Tamil Nadu.

MATERIALS AND METHODS

Study Area

The present study was carried out in six villages viz., Thenputhur, Pathirapuliyur, Elayandapattu, Veedur, Mozhiyanur, and Nedi in Tindivanam taluk in Villupuram district (11.939 N, 79·492 E) of northeastern Tamil Nadu (Figure 1). The district spreads over 3,715 km^2, with a human population of c. 20,90,000 (Figure 1; www.viluppuram.nic.in). Agriculture is the primary occupation of the people. The major crops of the area are paddy *Oryza sativa* L., jowar Sorghum *bicolor* (L.) Moench., pearl millet *Pennisetum glaucum* (L.) R.Br., finger millet *Eleusine coracana* Gaertn., sugarcane *Saccharum officinarum* L., groundnut *Arachis hypogaea* L., and green gram *Vigna radiata* (L.) R.Wilczek. The maximum and minimum temperatures in the district are 36°C and 20°C, respectively and the average annual rainfall is 1,060 mm (www.viluppuram.nic.in).

Methods

Based on information from two persons, suitable habitats were identified, where significant population of Tricoloured Munia persists in six villages of Tindivanam taluk of Villupuram district. These habitats were surveyed from April to June 2020 between 0545 and 1000 h, and again between 1500 and 1800 h, when the birds are usually active during pearl millet cultivation in Villupuram district usually commences, i.e., Chithiraipattam every year sowing in March—April and harvest in May—June. Hence, I have selected this period for study. The number of individual birds on foraging and roosting sites was determined using total count method (Bibby et al. 2000). A total count of individuals of this species was taken when the birds were in foraging and roosting sites. Tricoloured Munia usually live as a flock, roost on nearby vegetation in croplands during night, and move immediately after sunrise around adjacent croplands searching for food. Hence, the number of birds in each flock was counted when they were roosting and foraging. The foraging behaviors, movements of each flock and inter-specific relationships with other granivorous birds were observed in each village continuously for three days using binoculars without causing any disturbance to the birds. The types of trees/shrubs/herbs used by birds for roosting were ascertained. An extent of two-acres of pearl millet crop fields was randomly selected in each of the six villages. A total of twelve acres of pearl millet crop fields were selected for random sampling. Two 5 m x 5 m size quadrats / plots were laid in the selected sites, i.e., two plots per village. Out of the two plots, one was along the edge of crop field and while the other was in the interior of the field. The number of spikes and the number of damaged spikes in each quadrat were manually counted. The time spent by each flock on crop while foraging was measured using the stopwatch feature in smart phones. The exact locations of the croplands where foraging activities of

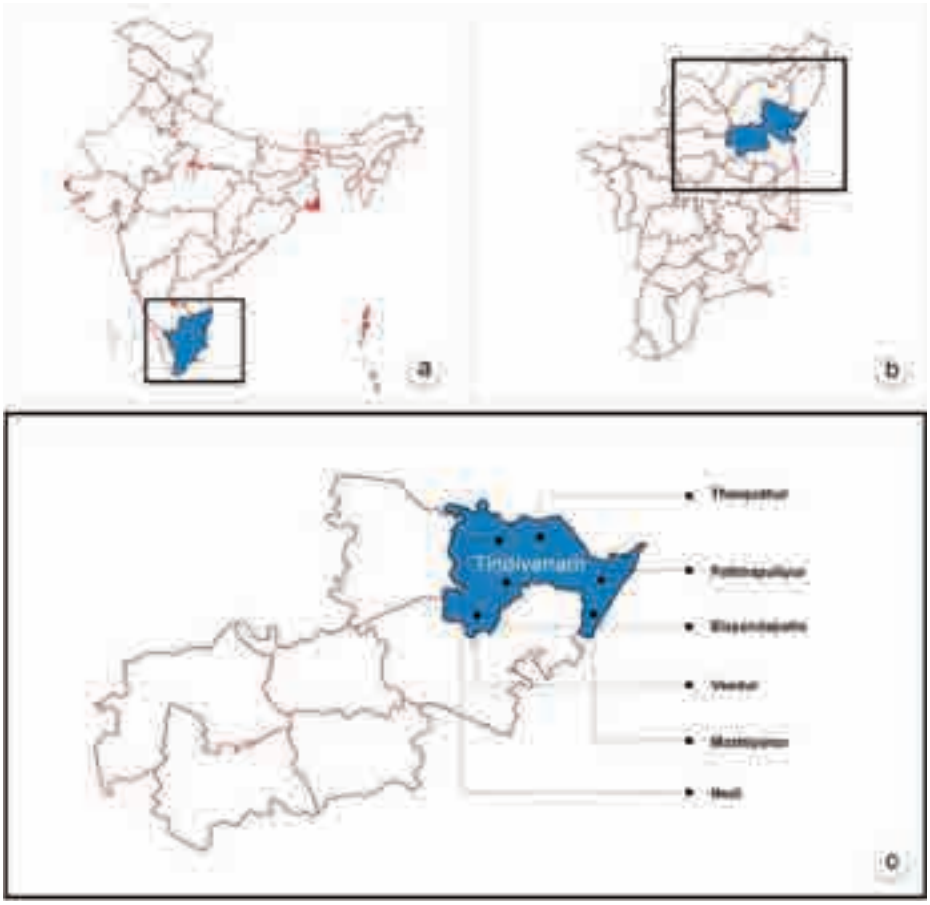

Figure 1. Study area map: a—India map showing Tamil Nadu | b—Tamil Nadu map showing Villupuram district | c—Villupuram district map showing Tindivanam taluk and villages studied. List of villages are (1) Thenputhur (12.177°N, 79.549°E), (2) Pathirapuliyur (12.177°N, 79.549°E), (3) Elayandapattu (12.023°N, 79.604°E), (4) Veedur (12.059°N, 79.598°E), (5) Mozhiyanur (12.148°N, 79.552°E), and (6) Nedi (12.116°N, 79.576°E).

birds occurred were noted using Garmin Etrex 20x GPS device. Photographs and videos were taken using Nikon P1000 digital camera. The bird repellent techniques were recorded by direct observations in the crop fields in six villages. No questionnaire survey was done in this regard. The collected data were tabulated, analyzed and shown as graphical representation.

RESULTS AND DISCUSSION

A total of six flocks of Tricoloured Munia, one each in each village were identified. A total of 1,640 individuals of Tricoloured Munia were enumerated (Table 1). In addition to flocks of Tricoloured Munia, other granivorous species, such as Baya Weaver (240), Indian Silverbill (26), Common Babbler (19), Rose-ringed Parakeet (11), and White-rumped Munia (8) were also found foraging in pearl millet crop fields. The smallest flock size was 60 birds in Nedi village, while the largest of 800 birds was recorded in Thenputhur village (Table 1).

The study on the behavior of the flocks reveals that the individuals of Tricoloured Munia strictly followed communal roosting and foraging. During the entire study period, the existing flocks never split into many smaller groups. They moved as flocks from morning to evening and maintained the flock size throughout the day. The flock size varies from village to village (Table 2). The flocking behavior varies and the birds took various complicated formations to reach pearl millet crops as well as roosting sites. It was observed that the flocks fly in close formations by performing different manoeuvres. They commence their daily foraging between 0545 h and 0615 h and conclude their foraging before 1800 h. No foraging activities were observed between 1130 h and 1500 h, when the flocks moved to adjacent vegetations for roosting. Continuous observations on the movements of the flock in each village consecutively for three days revealed that the birds never go beyond

Table 1. Details of quadrats, number of flocks, number of birds per flock, and damages to spikes of pearl millet in the study area.

	Name of the village	Total Cultivated area (acres) studied	No. of quadrats laid (5m x 5m)	No. of flocks	No. of birds in a flock	Total no. spikes counted	Total no of spikes damaged	Percentage of damaged spikes
1	Thenputhur	2	2	1	800	1596	1564	99.6%
2	Pathirapuliyur	2	2	1	180	1850	298	16.1%
3	Elayandapattu	2	2	1	300	1810	485	26.7%
4	Veedur	2	2	1	200	1560	450	28.8%
5	Mozhiyanur	2	2	1	100	1680	473	28.1%
6	Nedi	2	2	1	60	1795	515	28.6%
Total		12	12	6	1640	10291	3785	36.7%

a 2-km radius from the targeted two-acres pearl millet crop. A total of 104 foraging visits of flocks were studied in the six villages. The mean number of visits to pearl millet crop was 10 in the forenoon (0545–1000 h), and seven in the afternoon (1500–1800 h). The total number of foraging visits to crops per day varies from a minimum of 11 to a maximum of 21. In each foraging visit, they stay on the spikes from 10 sec to 80 sec, glean millets and take sudden flight to adjacent places for temporary roosting. Analysis of the duration over the 104 foraging visits showed that the maximum number of visits fell between two duration segments: 41 to 50, and 51 to 60 sec, which accounted for 43.6% of the total visits. This indicates that the optimum time the birds preferred to spend and forage on the crop fields was around 50 seconds (Table 2; Figure 2).

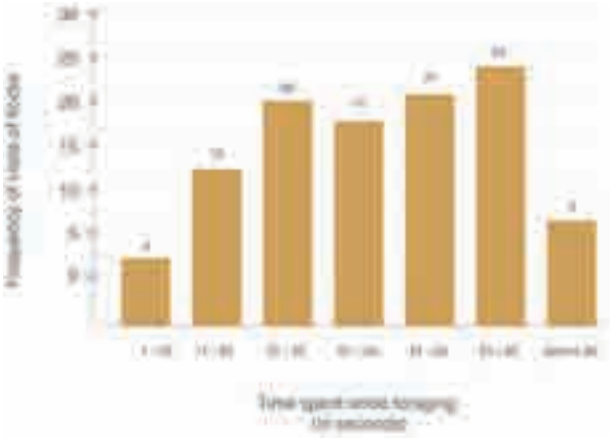

Figure 2. Frequency of foraging visits of flocks and time spent on crops for foraging.

The foraging flocks roost temporarily on powerline cables that cross the crop fields. During non-foraging periods and nights, they use nearby vegetations as roosting sites. This bird uses nine species of plants for roosting. They are: *Prosopis juliflora* (Sw.) DC., *Lantana camara L., Canthium coromandelicum* L., *Pithecellobium dulce* (Roxb.) Benth., *Abutilon indicum* (Link) Sweet., *Azadirachta indica* A.Juss., *Vachellia nilotica* (L.) P.J.H.Hurter & Mabb., *Saccharum officinarum* L., and *Sorghum bicolor* (L.) Moench. The duration of stay of this bird on spikes is short as compared to the duration spent roosting on trees / shrubs / herbs. The reason could be that being habituated to disturbance caused by farmers by banging utensils or other means to chase them away from crops, the birds avoid stay on the crops for long duration while foraging. Threat of prolonged exposure to predators while foraging on open crop fields could be another reason. According to eBird India (www.ebird.org), about 21 avian predators occur in Villupuram district. But the common predators observed during the present study in six villages were House Crow *Corvus splendens*, Large-billed Crow *Corvus macrorhynchos*, Shikra *Accipiter badius*, Sparrowhawk *Accipiter nisus*, White-eyed Buzzard *Butastur teesa*, and Rufous Treepie *Dendrocitta vagabunda*. Gadgil & Ali (1975) stated that the habit of communal roosting helps them to communicate information about source of food and protection from predators. The present observation of huge flock size, communal roosting pattern and foraging enmasse on pearl millet crops probably helps to exchange information about source of food and approach of predators as stated by Gadgil & Ali (1975).

Pearl millet is a 90-day crop and maturing kernels start after 60 days of sowing. The study reveals that the flocks started to visit the spikes after the 65th day when the grains were in milky stage and continued their visit to the crop till harvesting. Frequent attacks on the crops and gleaning of the grains leave the spikes devoid of grains (Image 1). In order to assess the extent of damage to grains in the spikes, a total of 10,295 spikes were sampled in all the 12 quadrats

Table 2. Details of different species of birds, numbers, mean visits and duration of foraging in the study area.

	Name of the village	No. of flock	No. of Tricoloured Munia in the flock	Other granivorous birds					Mean no. of visits to crop per day	Duration of foraging in each visit (seconds)
				No. of White-rumped Munia	No. of Baya Weaver	No. of Rose-ringed Parakeet	No. of Yellow Common Babbler	Indian Silver bill		
1	Thenputhur	1	800	3	40	6	8	7	18	10-70
2	Pathirapuliyur	1	180	2	30	0	0	4	21	10-70
3	Elayandapattu	1	300	0	50	2	5	11	19	20-60
4	Veedur	1	200	0	30	1	6	2	18	20-60
5	Mozhiyanur	1	100	0	60	0	0	0	18	10-60
6	Nedi	1	60	3	30	2	0	2	11	20-80
Total		6	1640	8	240	11	19	26	-	

(0.3 ha) in six villages and among them, 36.7% spikes (n= 3,785) were found damaged by Tricoloured Munia. Out of 12 quadrats, six quadrats were laid towards the margin of the field and another six quadrats were laid in inner side of the field. Analysis reveals that out of a total 36.7% damages to spikes (3,785), more damages to spikes (1,960 spikes; 19%) were found in the inner side and less damages were reported to spikes (1,825 spikes;17.7%) occurred towards the peripheral region. It indicates that the birds avoid perching and foraging on the peripheral parts of the field. The reason could be the frequent visits of farmers along the bunds and roads and chasing the birds using traditional bird repellent techniques. The maximum damage was observed in Thenputhur (99.6%), followed by Veedur (28.8%), Nedi (28.6), Mozhiyanur (28.1%), Elayandapattu (26.7%), and Pathirapuliyur (16.1). Out of the 1,596 spikes counted in two quadrats (total 50m^{2}area) in this village, 1,564 spikes (99.6%) were found damaged. Reason for the greater percentage of damage could be the availability of sugarcane crops in the adjacent land which provide conducive habitat to the flock for roosting during non-foraging periods and to hide when the farmers chase them away from pearl millet crop. On the 90th day, almost all the spikes in the two-acre land in Thenputhur village were found devoid of any grains and hence, the land holder ploughed the land without harvesting the empty spikes. Hence, foraging was found to cause nearly 100% losses of grains in the two-acre crop. According to the Directorate of Millets Development, the yield of pearl millet grains per acre (rainfed land) in India is c.485 to 600 kg (www.millets.dactv.nic.in). The loss of grains in two-acre crop in Thenputhur village would be 1,942 kg to 2,428 kg. But in the remaining five villages the damage to spikes was found to be only between 16.1% and 28.8%. This could be because of the small flock size consisting of birds ranging in number from 60 to 300. Kale et al. (2012) had stated that in India, the damage to pearl millet and sorghum crops by birds is a major concern. The present study on loss of pearl millet grains by granivorous birds matches the findings of Kale et al. (2012) that the loss of pearl millet crop by birds is a major concern.

The study reveals that among the foraging flocks of Tricoloured Munia, a few individuals of other granivorous birds such as Baya Weaver *Ploceus philippinus*, Rose-ringed Parakeet *Psittacula krameri*, Common Babbler *Turdoides caudata*, White-rumped Munia *Lonchura striata*, and Indian Silverbill *Euodice malabarica* were also observed in the pearl millet crops (Image 2a,b,c). Inter-specific competition between Tricoloured Munia and other species during foraging on pearl millet crops was not observed during the study period (Table 2). Rao & Dubey (2006) had stated that Rose-ringed Parakeet, Baya Weaver, Indian Silverbill, Common Babbler, Common Myna (*Acridotheres tristis*), and *Lonchura* spp had caused considerable damage to the pearl millet crops in Gujarat (0.3% to 40%), Andhra Pradesh (1.5% to 9%), Punjab (4% to 5%), and Delhi (60%). In the present study also, it was observed that along with flocks of Tricoloured Munia, other granivorous species such as Baya Weaver (240), Indian Silverbill (26), Common Babbler (19), Rose-ringed Parakeet (11), and White-rumped Munia (8) were also foraging on pearl millet crops and hence this matches the findings of Rao & Dubey (2006). It indicates that all these granivorous species co-exist and forage on targeted crops in the agricultural ecosystem without any inter-specific competitions between them over sharing of food. Further quantitative study in a wider area is required to estimate the exact extent of damage caused to grain production per hectare by these granivorous birds (Image 1; Image 2a,b,c).

Image 1. Pictures of *Lonchura malacca* in pearl millet crop fields: a & b—Flock attacking pearl millet crop | c & e—Flock perched on spikes and gleaning grains | d—Individual bird gleaning grains | f—Spikes devoid of grains. © M. Pandian

Bird repelling techniques adopted by farmers

Techniques used to repel birds from crops in the six villages reveals that farmers had uniformly adopted the practices of beating utensils / iron barrels and throwing pebbles / soil randomly on the crops to chase the birds from morning to evening except the period from 1200 h to 1500 h when the birds were usually non-active. In Nedi village, the farmers tied reflective multi-coloured pieces of cloth on dry twigs and erected them in the fields. In Thenputhur village, empty bottles were hung by strings to make noises when wind causes them to collide with each other. Two scarecrow structures each in the shape of human figures were found fixed in the crop fields in Veedur and Nedi villages. Subramanya (1982) had stated that farmers in India use shining ribbons, noise making devices, and scarecrows to repel birds from crop lands. The present observation of farmers using scarecrows, multi-coloured ribbons, and making noise by beating utensils / iron barrels as bird repellent techniques matches with the observations

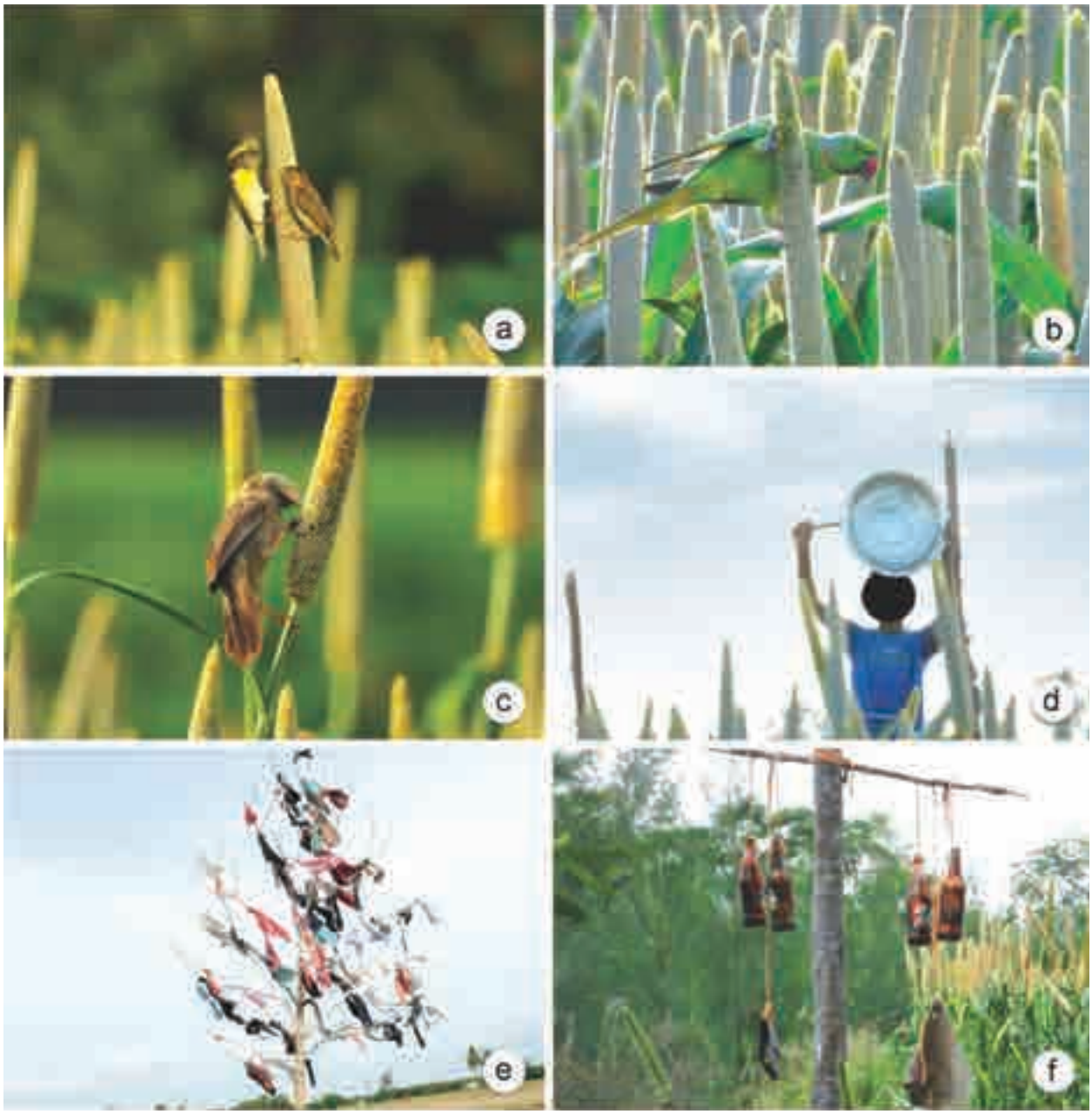

Image 2. Pictures showing forage and bird repellent methods used by farmers: a—Pair of foraging *Ploceus philippinus* | b—Foraging *Psittacula Krameri* individual | c—*Turdoides caudata* pluck grains | d—Beating of utensil | e—Multi-coloured ribbons tied to twigs | h—Hanging empty bottles. © M. Pandian

of Subramanya (1982). Even after adoption of these traditional techniques by farmers, the flocks containing Tricoloured Munia and other granivorous birds had attacked the crops and caused loss of grain productions in the study area (Image 2c,d,e). Hence, a detailed study is required on the impact of various traditional bird repellent techniques on the flocks. No incidents of killing of birds or use of any lethal techniques against granivorous birds were observed in the study area. This shows that even after undergoing economic loss due to the birds, the farmers had eco-friendly attitude by not harming the birds.

CONCLUSION

A total of 1,640 individuals of Tricoloured Munia were counted in six flocks covering six villages.

Tricoloured Munia caused damages to the spikes ranging from 16.1% to 99.6% resulting in economic loss to the farmers. Other granivorous birds such as Baya Weaver, Rose-ringed Parakeet, Common Babbler, White-rumped Munia, and Indian Silverbill were also found foraging along with Tricoloured Munia. This indicates that the region provides a suitable habitat to diverse avifauna. Further quantitative study in a wider area is required to estimate the exact extent of damage caused to grain production per hectare by these granivorous birds. Based on my observations, the following measures are proposed:

(a) Local community, particularly land holders, and agricultural workers should be sensitized to understand the need to preserve the precious populations of avifauna.

(b) A detailed systematic survey on the population status, behavior of flocks and impact of these birds on the pearl millet crops covering the entire state may be carried out to help in drafting an action plan to conserve the avifauna of agro-ecosystem.

(c) Eco-friendly approaches by using traditional and non-lethal techniques have to be adopted for protecting pearl millet crops from depredatory birds.

(d) Efforts must be taken to study birds' habitat and formulate policies to reduce bird-farmer conflicts and promote biodiversity conservation.

REFERENCES

Agriculture Times (2016). Pearl millet price will be static, Estimates, TNAU. www.agritimes.co.in (Accessed on 21 June 2020).

Ali, S. & S.D. Ripley (1987). *Birds of India and Pakistan*. Oxford University Press, New Delhi. 890 pp.

Bhatnagar, C., D.S. Shekhawat & V.K. Kohli (2013). Second record of the Tricolored Munia *Lonchura malacca* from southern Rajasthan. *Journal of the Bombay Natural History Society* 110(1): 76.

Bibby C.J., N.D. Burgess, D.A. Hill & S.H. Mustoe (2000). Bird Census Techniques. Second Edition. Academic Press, London, UK, xvii+302pp.

BirdLife International (2018). *Lonchura malacca*. The IUCN Red List of Threatened Species. Accessed on 09 June 2020. www.iucnredlist.org/species/22719837/131885437

Cole, R. & C.P. Brown (1840). Catalogue of the Birds. *The Madras Journal of Literature and Science* 11: 27.

Cubillos, C.K., D.C. Ayala, R.M.P. Hernandez, M.M. Palacios, C.D. Jaranillo & J.S. Mejia (2010). Feeding biology of the tricolored munia (*Lonchura malacca*, Estrildidae) in the upper Magdalena valley, Colombia. *Ornithologia Colombiana* 9: 25–30.

Daniel, A.J. (2017). Commonly found avifauna of Tamil Nadu Agricultural University, Coimbatore, Tamil Nadu, India. *Journal of Entomology and Zoological Studies* 5 (4): 46–52.

Deepan, R., B. Vikram, B. Harish, B. Ramakrishnan & A. Samson (2017). Occurrence of Tricoloured Munia (*Lonchura malacca*) in Karur district, Tamil Nadu. *Journal of Applied Science and Research* 5(6): 79—80.

Gadgil, M. & S. Ali (1975). Communal Roosting habits of Indian Birds. *Journal of the Bombay Natural History Society* 72(3): 716–726.

Grimmett, R., C. Inskipp & T. Inskipp (1999). Birds of the Indian Subcontinent. Oxford University Press, Delhi, India, 480 pp.

Jamdar, N. (1998). Southern black-headed munia *Lonchura malacca* in Koladeo National Park, Bharatpur, Rajasthan. *Journal of the Bombay Natural History Society* 95(3): 509—510.

Kale, M., B. Balfors, U. Mortberg, P. Bhattacharya & S. Chakane (2012). Damage to agricultural yield due to farmland birds, present repelling techniques and its impacts: an insight from the Indian perspective. *Journal of Agricultural Technology* 8(1): 49–62.

Llaguno, G.V. (1975). Damage potential of three species of Philippine weavers (*Lonchura*), Kaliskaran, Philippines. *Journal of Biology* 4: 141–144.

Rao, V. & O.P. Dubey (2006). Granivorous bird pests and their management. pp 29–61. In: S. Sridhara (Ed.), Vertebrate pests in Agriculture-Indian Scenario. Scientific Publishers, Jodhpur, India.

Rasmussen, P.C. & J.C. Anderton (2005). *The Birds of South Asia: The Ripley Guide*, 2 Volumes, Smithsonian Institute, Washington, D. C. & Lynx Edicions, Barcelona, 1067 pp.

Reidinger, R.F. & J.L. Libay (1979). Perches coated with glue reduce damage in rice field plots. Bird Control Seminars Proceedings, 26. Wildlife Damage Management. University of Nebraska-Lincoln, Nov 1979.

Salahudeen, M., E. Saranya, C. Gunasekaran & C. Vadivalagan (2013). Studies on the abundance and distribution of birds in three different habitats of Karur district, Tamil Nadu, South India. *Journal of the Bombay Natural History Society* 1(3): 57—63.

Sharma, S.K. (1999). Range extension of southern Black-headed Munia *Lonchura* malacca. *Journal of the Bombay Natural History Society* 38(2): 25—27.

Subramanya, S. (1982). Non-random foraging in certain bird pests of field crops. *Journal of Biosciences* 19(4): 369–380.

www.viluppuram.nic.in (2020). Government of Tamil Nadu: Villupuram District wbsite www.viluppursm.nic.in (Accessed on 09 June 2020).

www.viluppursm.nic.in (2020). Directorate of Millet Development, Government of India Website www.viluppursm.nic.in (accessed on 09 June 2020).

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COMMUNICATION

Roosting patterns of House Sparrow *Passer domesticus* Linn., 1758 (Aves: Passeridae) in Bhavnagar, Gujarat, India

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Abstract: The House Sparrow *Passer domesticus* is widely distributed across the world, and local alarming declines in sparrow populations have prompted studies focused on this species. An understanding of fundamental life history aspects such as roosting patterns is necessary for the development of efficient conservation strategies. This study examined House Sparrow roosting patterns in urban, suburban and rural areas of Bhavnagar during 2017–2018. Potential roosting sites were identified, and peak arrival/ departure times and roosting duration of sparrows were recorded. We found that peak arrival and departure times were correlated with solar timings, indicating a strong influence of photoperiod on sparrow behaviour. Little variation was observed in sparrow arrival and departure times across the urban, suburban and rural gradient. However, arrival duration was significantly larger in urban and suburban areas. This may be due to the restricted availability of suitable patches within these habitats, requiring birds to spend more time foraging. House Sparrows mostly preferred thick vegetation for pre-roosting activities and roosting, and the loss of thick vegetation poses a threat to sparrow populations worldwide. In addition to increasing nesting opportunities by providing artificial nest sites, the importance of retaining appropriate habitats should be a major focus of conservation strategies.

Keywords: Arrival & departure pattern, habitat, nesting, Passeriformes, pre-roosting.

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Author contributions: FPP—conception & design of the work, data collection, data analysis and interpretation, drafting the article. PPD—supervisor, critical revision of the article.

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INTRODUCTION

The House Sparrow *Passer domesticus* is one of the most widely distributed avian species on Earth, possibly due to its adaptation to human settlements. Nevertheless, significant declines in its populations have recently been reported from many parts of the world (Gulati 2005). These declines have prompted studies of sparrow breeding biology worldwide (Gokula et al. 2014). However, key habitat needs of the species will not end by finding suitable nest sites only. Understanding of other fundamental life history traits of the species such as the roosting pattern is inevitable, in constructing an efficient frame work for conservation of the species to maintain a healthy sustainable population.

Roosting can be defined as a period of inactivity analogous to human sleep (Ehrlich et al. 1988). Roosting is one of the fundamental life history traits of avian species. Small passerine birds such as sparrows roost communally, which confers many probable advantages as well as disadvantages to the birds. According to Ehrlich et al. (1988) some species change their roosting habits seasonally: male Red-winged Blackbirds *Agelaius phoeniceus*, normally roost solitarily on their territories during the breeding season, but roost in large numbers for the rest of the year. Communal roosting in avian populations probably helps in reducing the cost of thermoregulation and predation risk, and it is also likely to increase foraging efficiency of the individuals (Eiserer 1984; Ydenberg & Prins 1984). According to Ward & Zahavi (1973), roosting forms the centre to exchange information regarding food resources. However, Erwin (1983) opined that enhancement of food location takes place via local enhancement rather than by information exchanged at the roost. Besides, communal roost also provides potential mate selecting opportunities to birds lacking a partner. However, besides possible advantages, communal roost may be energetically costly to territorial species as they need to physically travel to and from roosts (Beauchamp 1999). Further, a large communal roost easily attracts potential predators due to significant vocalization (Beauchamp 1999). Thus, the significances of communal roosting are debatable (Richner & Hebb 1996). The aforementioned studies, stress the importance of investigating the roosting ecology of birds.

In the present study, an attempt has been made to understand the roosting pattern of the sparrow across urban, suburban and rural gradient of Bhavnagar and to identify key habitat requirements of the species. By monitoring roosting patterns of sparrows across different scales of habitat will shed light on understanding corresponding key habitat requirements for healthy and efficient survival of the species. Consequently efficient strategic plans can be framed to fulfil key habitat requirements of the species with respect to its conservation aspects.

Study area

The present study was undertaken in and around Bhavnagar city, Saurashtra region of Gujarat state, India. Bhavnagar is a coastal city, with the Gulf of Khambhat located to its west. A small non perennial river known as Kansara passes through the outer area of the city. Bhavnagar has a hot semi arid climate, with a hot dry summer, wet monsoon, and mild winters. Due to the proximity of Bhavnagar to the gulf, the climate remains fairly humid throughout the year.

To identify differential response of the sparrow towards different scales of habitat, the study area was divided into three gradients, i.e., urban, suburban and rural. After a pilot survey, three potential roosting sites were selected from each gradient by random stratified method. To avoid biases in the data due to population mixture of different sample sites, it was ensured that the selected sample sites were at least 2 km apart from each other – by assuming the sedentary nature of sparrows not migrating more than 2 km (Summers – Smith 1988). This was accomplished by creating 2 × 2 km grids over the study area with the help of Google earth pro software, where each sample site has been cited. Hence, nine study sites were selected to monitor roosting patterns and population of the sparrow throughout the study period. In the current study, within urban gradient (URB) – Barsomahadev (URB1) (21.774N,72.139E), Bharatnagar (URB2) (21.744N, 72.160E) and Anandnagar (URB3) (21.788N, 72.157E) study sites were selected for data collection. Within suburban gradient (SUB) – V P Society (SUB1) (21.759N, 72.170E), Forest colony (SUB2) (21.737N, 72.150E) and Fulsar (SUB3) (21.746N, 72.094E) study sites were selected for data collection. While within rural (RUR) – Akwada (RUR1) (21.739N, 72.180E), Nari (RUR2) (21.783N, 72.077E) and Sidsar (RUR3) (21.721N, 72.110E) study sites were selected (Image 1).

Image 1. Google Earth satellite image of Barsomahadev (URB1), Bharatnagar (URB2), Anandnagar (URB3), V P Society (SUB1), Forest colony (SUB2), Fulsar (SUB3), Akwada (RUR1), Nari (RUR2) and Sidsar (RUR3) study sites of Bhavnagar.

METHODS

The present study was conducted during the year December 2016 to November 2018 (24 months). For convenience, the study period was divided into four seasons, i.e., winter (December–February), summer (March–May), monsoon (June–August), and post monsoon (September–November). These categories aid in understanding seasonal variation in roosting patterns. For precise observation and data collection, instruments like Nikon Aculon A211 8 x 42 binocular and Nikon D500 digital SLR camera were used in the field.

In the year 2016, a pilot survey was carried out across the study area with the aim of identifying sites with a potential number of sparrows. Potential roosting sites were identified during the pilot survey by following flocks of sparrows from foraging grounds in the evening. The potential roosting sites were defined as places where more than a hundred sparrows were found to roost frequently during the pilot survey. Avian species, roosting together with sparrows at the same roosting plant were also recorded. During the study period, in some cases, sparrows left the original roosting site and preferred to roost at a different site – secondary roosting site. In these cases, locations of the secondary roosting place was determined by following the flock of sparrows from the original roosting site or from the foraging ground in the evening. The approximate distance of the secondary roosting site from the original roosting site was determined with the help of Google Earth pro software. Further, roosting plant species used by sparrows were identified with the help of standard field guides as well as experts in Botany. During this study, timings of roosting sounds were also recorded. Further, peak arrival and departure time periods along with arrival & departure durations were recorded during each visit. Here all timings are represented in hh:mm (hour: minutes) format. Sunset and sunrise time was noted by IST (Indian standard time, off set: UTC + 5: 30) from time and date. com website (https://www.timeanddate.com/). To be more precise in finding the relationship between solar movement and arrival as well as departure pattern of House Sparrows from roosting sites, different phases of twilight timings were also considered during the study

period. A total of three twilight timings were considered during this study, which included civil twilight (brightest phase of twilight - enough natural light to carry out most outdoor activities), nautical twilight (the horizon and the brighter stars are generally visible), and astronomical twilight (darkest phase of twilight).

Statistical analysis

Data was analyzed using IBM SPSS v.22.0 for Windows. Variance in peak arrival time, arrival duration, peak departure time, departure duration were analysed by gradients as well as by season using Independent-Samples Kruskal-Wallis Test – non parametric test. Spearman rank – order correlation coefficient test was used to correlate peak arrival and peak departure times with sunset, sun rise and day length respectively. Significance was set at P <0.05 for all statistical tests. For each test, degrees of freedom (df) and significance levels are reported. All results are presented as mean ± standard error (SE). All post hoc test results reported in compact letter display format in table as well as in chart, where groups are represented by superscript alphabetical letter. Groups with the same letter are statistically significantly similar and the others are statistically significantly different. Those groups, which are represented by more than one letter, are similar to groups represented by the same letter.

RESULTS

House Sparrows roost communally. Often large numbers of sparrows aggregate at night shelter and form a significant communal roost which can be easily identified from a distance by pronounced roosting vocalization of the sparrows. In the current study, *Ziziphus xylopyrus*, *Ziziphus jujube*, *Prosopis Juliflora*, *Acasia Senegal*, and *Bambusa vulgaris* were used as roosting plants by sparrows (Image 2). However, sparrows also used *Punica granatum*, *Morus alba*, *Syzygium cumini*, *Ficus religiosa*, and Banyan tree *Ficus benghalensis* for roosting purposes, often in the absence of the aforementioned roosting plant species (Table 1), sparrows often used empty nests for roosting purposes, i.e., roost nest (Image 3E). During the study, it was observed that roosting sparrows often visited or gathered at pre-roosting sites (other than roosting sites) before entering a roosting plant. Various maintenance activities such as sand baths, preening, rubbing bills and fluffing were observed during pre-roosting at all the sites (Image 3B). Sometimes collective motion (murmuration) was observed during aggregation of large numbers of sparrows at roosting sites (Image 3A). Collective motion of sparrows was common at urban and suburban sites, mainly when a large aggregation of sparrows occurred during the post-breeding season.

Table 1. List of different plant species used by House Sparrows for roosting during the study.

Roosting plant species			
	Scientific name	**Common name**	**Family**
1	*Ziziphus xylopyrus*	Moti boradi	Rhamnaceae
2	*Ziziphus jujuba*	Boradi	Rhamnaceae
3	*Prosopis Juliflora*	Gando baval	Fabaceae
4	*Acasia Senegal*	Gorad baval	Fabaceae
5	*Bambusa vulgaris*	Vans	Poaceae
6	*Punica granatum*	Dadam	Lythraceae
7	*Morus alba*	Shetur	Moraceae
8	*Syzygium cumini*	Jambu	Myrtaceae
9	*Ficus religiosa*	Peepal tree	Moraceae
10	*Ficus benghalensis*	Banyan tree	Moraceae

No significant statistical difference was found in mean peak arrival time of sparrows across urban, suburban and rural roosting sites for both the years (Figure 1). Peak arrival time of sparrows at different roosting sites was strongly correlated with sunset time, which was statistically significant, r_s (202)= 0.848, p <0.0001 (Figure 2). Similarly, there was a strong positive correlation between peak arrival time and day length, which was also statistically significant, r_s (202)= 0.819, p <0.0001 (Figure 3). During the observation, the peak numbers of House sparrows were recorded 0.5 h before sunset. House Sparrows arrived at roost sites in different flock size ranging 3–40. In 2017, there was a significant statistical difference in mean arrival duration across urban, suburban and rural gradients (H(2)= 16.99, p <0.0001). The Bonferroni post hoc test revealed that mean arrival duration at rural gradient was statistically significantly lower than urban (p <0.0001) and suburban gradient (p <0.05). There was no statistically significant difference in mean arrival duration between suburban and urban gradient (p >0.05) (Figure 4). Similarly, in 2018, there was a significant statistical difference in mean arrival duration across different gradient (H(2)= 7.05, p <0.05). The Bonferroni post hoc test revealed that mean arrival duration at suburban gradient was statistically significantly higher than urban gradient (p <0.05). There was no significant statistical difference in mean arrival duration between urban – rural gradients and rural –

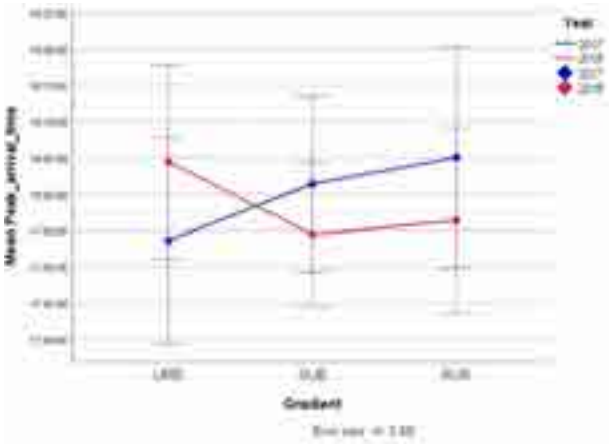

Figure 1. The mean peak arrival time of House Sparrow at different roosting sites across urban (URB), suburban (SUB), and rural (RUR) gradients of Bhavnagar during year 2017 and 2018.

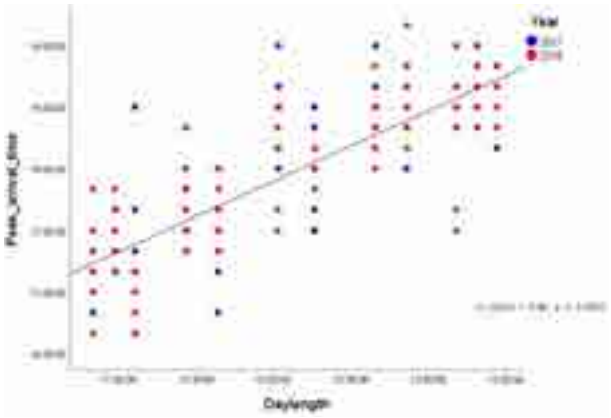

Figure 3. Correlation between peak arrival time of House Sparrow at different roosting sites and day length during study.

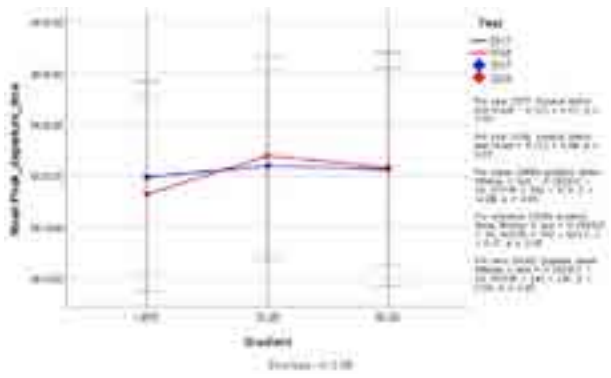

Figure 5. The mean peak departure time of House Sparrow from different roosting sites across urban (URB), suburban (SUB), and rural (RUR) gradients of Bhavnagar during year 2017 and 2018.

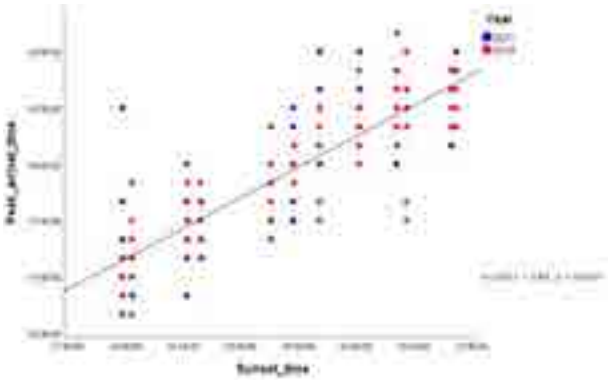

Figure 2. Correlation between peak arrival time of House Sparrows at different roosting sites and sun set time during the study.

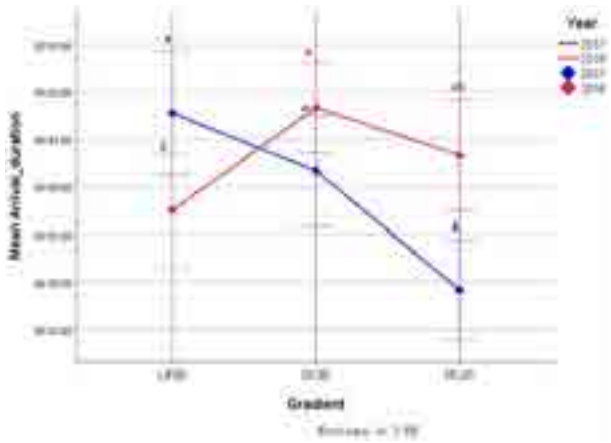

Figure 4. The mean arrival duration of House Sparrow at different sites across urban (URB), suburban (SUB) and rural (RUR) gradients of Bhavnagar during year 2017 and 2018.

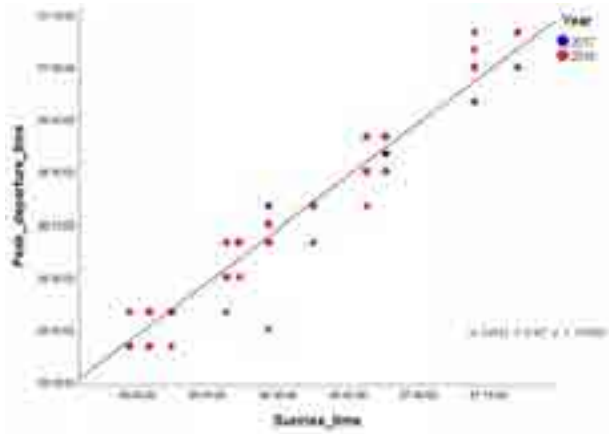

Figure 6. Correlation between peak departure time of House Sparrow from different roosting sites and sun rise time during the study.

Table 2. The mean distance of secondary roosting plant species from original roosting plant across urban, suburban and rural gradients.

Gradient	Distance of secondary roosting plants (km)
Urban (URB)	0.26 ± 0.05
Suburban (SUB)	0.21 ± 0.04
Rural (RUR)	0.17 ± 0.04
Total	0.22 ± 0.03

suburban gradients (Figure 4). Besides, arrival duration varied significantly across the different seasons. Usually, maximum arrival duration was recorded during monsoon and post-monsoon seasons in the current study. House Sparrows presumably spent more time in foraging due to favourable feeding conditions during these seasons, consequently frequent back and forth movements from foraging ground to roosting sites increased arrival duration.

No significant statistical difference was found in mean peak departure time across urban, suburban and rural gradients for both the years (Figure 5). There was a strong positive correlation found between peak departure time and sunrise time, which was statistically significant, $r_s(202)= 0.977$, $p < 0.0001$ (Figure 6). No significant statistical difference was found in mean departure duration across urban, suburban and rural gradients for both years (Figure 7).

The roosting sound started when House sparrows entered into roosting sites and lasted up to the end of nautical twilight. The roosting sound sometimes was interrupted by warning calls resulting in a sudden silence for a fraction of a minute. However, the roosting sound restarted immediately on reoccurrence of favorable conditions. It was observed that unlike the arrival pattern of sparrows, within 30 mins after sunrise, almost the maximum number departed together. Mostly departure occurred in the same direction from where flocks of House sparrows had arrived at the roosting site. Vocalization in the morning generally started during the nautical phase of sunrise and lasted up to approximately 10–15 min after the start of civil twilight. Further, it was observed that the House sparrow easily shares its roosting place with small passerine birds, these individuals may be of the same or different genus, i.e., heterospecific communal roosting.

Under certain circumstances, such as removal of roosting plant species or trimming of corresponding species locally, reduction in foliage density of roosting plants, presence of larger avian species at roost sites, House sparrows often change their roosting sites and opt

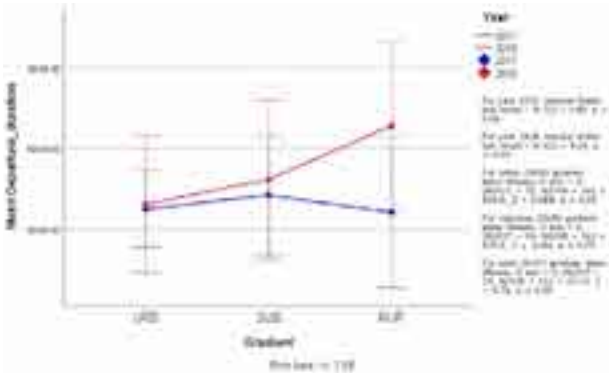

Figure 7. The mean departure time of House Sparrow across urban (URB), suburban (SUB), and rural (RUR) gradients of Bhavnagar during year 2017 and 2018.

for other suitable patches, generally found at a distance of 0.22 ± 0.03 km within the study sites. However, due to restricted availability of suitable patches within urban and suburban gradients, the distance of secondary roosting plants (0.26 ± 0.05 km and 0.21 ± 0.04 km) was relatively higher than in rural gradient (0.17 ± 0.04 km) (Table 2).

DISCUSSION

It was observed during the study that House sparrows mostly prefer to roost in dense bushy vegetation rather than in a tree with dense canopy. According to North (1968), tree height and the density of the foliage, rather than species of the plant are principle criteria for the selection of roosting sites. It was observed that often due to small disturbances sparrows opted for other suitable patches of plants found within the study sites for roosting purpose either temporarily or permanently. However, with the recurrence of favourable conditions part of the population returned to the primary roosting sites. Anderson (2006) opined that sparrows often change roosting sites if sites have less density of foliage. Pre-roosting gathering was also significant at all study sites. Under certain circumstances such as disturbance due to predators at the roosting sites, pre-roosting sites played an important role by providing temporarily better shelter to sparrows. In addition, various maintenance activities such as sand baths, preening, rubbing bills, and fluffing were significant during pre-roosting at all sites (Image 3B). Simmons (1964) considered preening as an essential and significant act performed by birds to maintain their feathers. For removing parasites, birds often shake their body or fluff their feathers. In the current study, sparrows

Image 2. Roosting sites of House Sparrows across different study sites: A—Barsomahadev (URB1) | B—Bharatnagar (URB2) | C—Anandnagar (URB3) | D—V P Society (SUB1) | E—Forest colony (SUB2) | F— Fulsar (SUB3) | G—Akwada (RUR1) | H—Nari (RUR2) | I—Sidsar (RUR3). © Foram P. Patel.

were found to preen their feathers regularly and it was significant during pre-roosting visits. Sand bath was also significant in the House sparrow population at the study area. Many studies have explained the importance of sand/dust bath by birds for removal of parasites, besides the sand bath is also essential as excess amounts of oil that birds daily preen on to their feathers to stay warm and fly is absorbed (Borchelt 1972). This stresses the importance of such characteristic habitats (e.g., sandy surface), where sparrows can efficiently perform various maintenance activities required for a healthy, sustainable life.

It was observed that sparrows arrived at their corresponding roosting sites 1–1.5 h before sunset. This was very similar to Anderson's (2006) observation, where he noted the arrival of sparrows at the roosting site two hours before sunset. No statistical significant difference was found in peak arrival times across different sites of each gradient between 2017 and 2018. However, peak arrival time was strongly correlated with sunset time, this indicated that the arrival of the House sparrows at the roosting site is totally influenced by photoperiod. However, presumably, various factors such as illumination (direct sun light), presence of raptors, and other larger avian species at the roosting site might play an important role in delaying arrival time at roosting sites. Variances in arrival duration of sparrows at roosting sites across urban, suburban and rural gradient could be explained as birds spent more time for last moment foraging. Statistically significant larger arrival duration in urban and suburban gradient was due to prevalence of restricted suitable patches across such gradients, where birds could spend more time for foraging. In 2018, the amount of suitable patches was significantly reduced at suburban sites such as V P Society (SUB1) and Forest colony (SUB2). Sometimes attacks by raptors such as Shikra *Accipiter badius* on sparrows during arrival at roosting sites made a pause in the arrival and increased the arrival duration. The peak departure time and departure duration of sparrows from roosting sites did not vary significantly across urban, suburban and rural gradients during the study period. In the evening,

Image 3. Pre-roosting activities and roosting of House Sparrows: A—Collective motion of House Sparrow (during arrival at roost site) | B—House Sparrows taking sand bath | C—Roosting House Sparrows | D—House Sparrows at roosting plant | E—Roost nest. © A–C—Foram P. Patel | D–E—Kajal R. Tadha.

the roosting vocalization of sparrows was distinct and significant at all sites through which communal roosting sites of sparrows could be located from a distance. However, sometimes on warning calls, the roosting sound was interrupted for a fraction of time which began again on the return of favourable conditions. Daanje (1941) reported that House Sparrows have social warning calls through which the whole colony quickly learns of the presence of an enemy in the vicinity.

It was observed that the departure of sparrows from different roosting sites started by sunrise; 0.5 h to 1 h after sunrise a maximum number of sparrows departed from roosting sites. Departure duration recorded in the current study was a bit longer than recorded by North (1968). However, peak departure occurred within 30 min after sunrise during the current study too. It was observed that unlike the arrival pattern of sparrows, within 30 min after sunrise, almost the maximum number of the population departed together. Mostly departure occurred in the same direction from where the flocks of sparrows arrived at the roosting site. North (1968) noted the beginning of vocalization of the sparrows about 30 min before sunrise, and they usually departed from the roost within 30 min after sunrise. These observations of North (1968) are also supported by the current study where during the nautical phase of sunrise vocalization started and lasted up to approximately 10–15 min after the start of civil twilight.

Heterospecific communal roosting was witnessed in the current study too, where House sparrows roosted with other small passerine birds on the same roosting plant. Heterospecific communal roosts of House sparrows with different avian species are reported across the globe. House sparrows were found to share roosting sites with European Starlings in Poland (Gorska 1975), with Spanish Sparrows in Spain (Alonso 1986), with European Starlings and Eurasian Tree Sparrows in North America (North 1968; Anderson 2006). In India, Rana (1989) observed communal roosts of House sparrows with Jungle Babblers *Turdoides striatus* and Common Mynas *Acridotheres tristis*. The above mentioned study supports the observation of the current study, where a

communal roost of House Sparrows has been observed with Large Grey Babbler *Turdoides malcolmi*, however, a record of sharing roosting sites with Common Myna *Acridotheres tristis* was lacking in the current study. Mahabal & Bastawade (1985) reported communal roosting of House sparrows near the communal roosting site of the Black Kite (*Milvus migrans govinda*). However, it was observed in the current study, that the presence of larger avian species such as Alexandrine Parakeet *Psittacula eupatria* forced House sparrows to roost on other plant species. Further, the opportunistic presence of larger avian species at the study site also influenced House Sparrows' behavioral patterns. Like, when Painted Stork *Mycteria leucocephala* was present at roosting sites—for collecting corresponding nest materials from the site—sparrows swiftly entered the roosting plant, without murmuration and without producing any roosting calls, thus indicating that larger avian species negatively influence roosting House Sparrows.

CONCLUSION

During the study, peak arrival and peak departure times of the House Sparrow did not vary significantly across urban, suburban and rural gradients of Bhavnagar. While arrival duration was significantly larger in urban and suburban gradients, such variation in the arrival duration could be explained by multiple factors such as restricted availability of suitable patches, lack of suitable foraging grounds near roost sites, and the presence of raptor birds. In the present study, dense bushy vegetation was found to be the most preferred habitat of the House sparrow for roosting and pre roosting purposes across urban, suburban and rural gradients of Bhavnagar. Besides providing better night shelter, bushy vegetation forms an ideal habitat with reference to maintenance activities of the House Sparrow such as sand baths. During the study it was observed that bushy vegetation was significantly reduced across urban and suburban sites which resulted in a drastic reduction of suitable habitat patches for the House Sparrow. Hence, conservative initiatives should not be restricted to complement nesting opportunities by providing artificial nest sites, but attention should also be given to preserving suitable habitats required for the species.

REFERENCES

Alonso, J.C. (1986). Ecological segregation between sympatric Spanish Sparrows (*Passer hispaniolensis* Temm.) and House Sparrows (*Passer domesticus* [L.]) during winter. *Ekologia Polska* 34: 63–73.

Anderson, T. (2006). *Biology of the Ubiquitous House Sparrow: From Genes to Populations*. Oxford University Press, New York. https://doi.org/10.1093/acprof:oso/9780195304114.001.0001

Beauchamp, G. (1999). The evolution of communal roosting in birds: origin and secondary losses. *Behavioral Ecology* 10(6): 675–687. https://doi.org/10.1093/beheco/10.6.675

Blanco, G. & J.L. Tella (1999). Temporal, spatial and social segregation of red-billed choughs between two types of communal roost: a role for mating and territory acquisition. *Animal Behaviour* 57 (6): 1219–1227. https://doi.org/10.1006/anbe.1999.1103.PMID10373254.S2CID7254376

Borchelt, P.L. (1972). Dust bathing in Bobwhite Quail (*Colinus virginianus*): A regulatory model. PhD Thesis, Michigan State University.

Daanje, A. (1941). Uber der Verhalten des Haussperlings (*Passer d. domesticus* [L.]). *Ardea* 50: 1–42.

Ehrlich, P.R., D.S. Dobkin & D. Wheye (1988). Communal roosting. Accessed on 10/02/2019. https://web.stanford.edu/group/stanfordbirds/text/essays/Communal_Roosting.html

Eiserer, L.A. (1984). Communal roosting in birds. *Bird Behavior 5*(2–3): 61–80.

Erwin, R.M. (1983). Feeding habitats of nesting wading birds: spatial use and social influences. *Auk* 100: 960–970.

Gokula, V., S. Palanivel & B. Sivagamy (2014) Nesting ecology of house sparrow *Passer domesticus* (Linnaeus 1758) in Punavasipatty and Kuthoor, Tamil Nadu, India. *Journal of Scientific Transactions in Environment and Technovation* 7(4): 193–200

Gorska, E. (1975). The investigations on the common roostings of the sparrow, *Passer domesticus* (L.) and starling, *Sturnus vulgaris* L. in Poznan in winters 1970/71 and 1971/72. *Przeglad Zoologiczny* 19: 230–238.

Gulati, V. (2005). House Sparrow on Verge of Extinction**,** Tribune News Service, Chandigarh. Accessed on 30.ix.2013.

Mahabal, A. & D.B. Bastawade (1985). Population ecology and communal roosting behaviour of pariah kite *Milvus migrans govinda* in Pune (Maharashtra). *Journal of the Bombay Natural History Society* 82: 337–346.

North, C.A. (1968). *A study of house sparrow populations and their movements in the vicinity of Stillwater, Oklahoma*. PhD Thesis. Oklahoma State University, Stillwater.

Rana, B.D. (1989). Population ecology of *Passer domesticus* in the Indian arid zone. *International Studies on Sparrows* 16: 1–7.

Richner, H. & P. Heeb (1996). Communal life: Honest signaling and the recruitment center hypothesis. *Behavioral Ecology* 7(1): 115–118. https://doi.org/10.1093/beheco/7.1.115

Simmons, K.E.L. (1964). Feather maintenance, pp. 101–105. In: Campbell B. & E. Lack (eds.). *A New Dictionary of Birds*. Buteo Books, Vermillion, South Dakota.

Summers-Smith, J.D. (1988). *The Sparrows*. T. & A.D. Poyser, Calton, UK.

Ward, P. & A. Zahavi (1973). The important of certain assemblages of birds as "Information Centers" for food- feeding. *Ibis* 115: 517–534.

Ydenberg, R.C. & H.H.T. Prins (1984). Why do birds roost communally in winter? Pp. 123–139. In: Evans, P.R., J.D.G. Custard & W.G. Hale (eds.). *Coastal Waders and Wildfowl in Winter*. Cambridge University Press, Cambridge.

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REVIEW

Comprehensive checklist of algal class Chlorophyceae (sensu Fritsch, 1935) for Uttar Pradesh, India, with updated taxonomic status

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Abstract: Uttar Pradesh is an active center for algal research in India, but regional checklists are not available. Checklists of algae reported from class Chlorophyceae (sensu Fritsch, 1935) are presented here, with taxonomic status updated per AlgaeBase. The checklist covers algae from 17 types of habitats and includes 749 species, 166 varities and six forma, belonging to four phyla, 11 classes, 26 orders, 64 families and 161 genera. Charophyta is the dominant phylum with 519 infrageneric taxa (species, varities, forma), while Chlorophyta is represented by 389 taxa. Zygnematophyceae is the dominant class with 465 infrageneric taxa under two orders, six families and 29 genera. Chlorophyceae has 305 infrageneric taxa under five orders, 33 families, and 76 genera. *Cosmarium* is the most speciose genus with 163 taxa, followed by *Oedogonium* (79), *Spirogyra* (72), and *Closterium* (54). Our study revealed that of 75 districts in Uttar Pradesh only 40 are explored for algae, with Prayagraj and Lucknow recording 266 and 144 taxa respectively.

Keywords: Asia, aquatic organism, biodiversity, enumeration, gangatic plains, green algae.

उत्तरप्रदेश, भारत में शैवाल अनुसंधान का एक सक्रिय केंद्र है| इसके बावजूद इस प्रदेश के शैवालों का चेकलिस्ट उपलब्ध नहीं है| वर्ग क्लोरोफैसी (सेंसु फ़्रिश, १९३५) की चेकलिस्ट जो कि आधुनिक वर्गीकरण एल्गीबेस पर आधारित है, यहाँ प्रस्तुत की गयी है| प्रस्तुत चेकलिस्ट में शैवालों की ७४९ प्रजातियाँ, १६६ वराईटी और ०६ फ़ोर्मा एक साथ समाग्रहीत की गयी है, जो १६१ जाति, ६४ वंश, २६ आर्डर, ११ वर्ग तथा ४ फ़ाइला के अंतर्गत आते हैं| ये सभी प्रजातियाँ कुल १७ विभिन्न प्राकृतिक आवास से प्रतिवेदित की गयी हैं| फाइलम कारोफाइटा अधिकतम पाये गए हैं| जिसमें ५१९ इन्फ्रा जेनेरिक प्रजातियाँ (प्रजाति, वराईटी, फ़ोर्मा) है | जबकि क्लोरोफाइटा में ३८९ प्रजातियाँ दर्ज की गई हैं | शैवाल वर्ग में वर्ग जिग्नीमिटेसी अधिक संख्या में हैं, जिसमें सर्वाधिक ४६५ इन्फ्रा जेनेरिक प्रजातियाँ है, जो कि २९ जातियां, ३३ वंश तथा ०२ आर्डर में वर्गीकृत है| जबकि वर्ग क्लोरोफाइसी में ३०५ इन्फ्रा जेनेरिक प्रजातियाँ सम्मिलित है जो ७६ जातियाँ, ३३ वंश तथा ५ आर्डर में वर्गीकृत है| सर्वाधिक रूप से कोसमेरियम प्रजातियां पायी गयी हैं, जिसकी कुल १६३ प्रजातियाँ हैं| इसके पश्चात ऊडोगोनियम ७९, स्पाईरोगाइरा ७२ तथा क्लोस्टेरियम ५४ प्रजातियाँ दर्ज की गयी हैं | प्रस्तुत अध्ययन से ज्ञात होता है, कि उत्तर प्रदेश के कुल ७५ जिलों में से केवल ४० जिलों से शैवाल की खोज की गयी है| जिसमें प्रयागराज से २६६ तथा लखनऊ से १४४ शैवाल की प्रजातियाँ हैं|

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Author contributions: SV and KT collected and compiled information on algae. Further, SV drafted the manuscript while KT authenticated the identities of several taxa. SN conceptualized the study, updated the current taxonomic status algae and improved the manuscript.

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INTRODUCTION

Algae are defined as "oxygenic photosynthesisers other than embryophyte land plants" by Cavalier-Smith (2016). They are predominantly aquatic photosynthetic organisms, and are the major primary producers. Algae are ubiquitous in distribution and occur in a wide variety of shapes and sizes. Fristch (1935) classified algae into 11 classes under the plant kingdom, mostly based on the pigments, reserve food and flagella. Modern classification uses few kingdoms and several phyla (Ruggiero et al. 2015). Although Fristch's classification is obsolete, it is still popular and followed by many authors. AlgaeBase (www.algaebase.org, Guiry & Guiry 2019) currently lists 155,155 species and infraspecific taxa, under 15 phyla and 54 classes. According to Guiry (2012) there are 72,500 species of algae in the world, of which >20,000 are diatoms. From India so far 7,411 taxa of algae are known, which is 15% of the total Indian flora (Mao & Dash 2019).

Freshwater algal studies in India date back 170 years, when Griffith (1849) first reported species of *Chara* from West Bengal. Several workers thereafter explored the algal flora of different water bodies across India. Uttar Pradesh, the fourth largest and most populous state of India, lies between the geo-coordinates 23.866–30.416N and 77.05–84.15E. The state covers a geographical area of 2,40,9228 km^2 and is divided into 75 districts. Himalayan foothills form the northern border, and the state is largely covered by plains characterized by hard rock strata and plateaus. About 7% (16,826 km^2) of the geographical area is covered by forests, which include tropical thorn forest, deciduous and semi-evergreen. A total of 5,712 km^2 is protected under 24 wildlife sanctuaries, three tiger reserves and one national park. The Ganga, Yamuna, Ramganga, Gomti, Ghaghara, Gandak, Chambal, Betwa, Ken, and Son are some of the major rivers flowing through Uttar Pradesh. The state has at least 36 prominent lakes and numerous ponds. It is notable that 11 wetlands of the state are declared as wildlife sanctuaries of which eight are recognized as Ramsar sites. Uttar Pradesh has a humid subtropical climate with four seasons; temperature ranges from 42°C in summer to 7°C in winter. Annual rainfall ranges from 650 to 1,000 mm. The state has been an active center of algal research in India for nine decades, indicated by numerous publications and descriptions of several novel taxa. However, the algal enumerations published from Uttar Pradesh are scattered and a compiled list is not yet available. The aim of the present study is to prepare comprehensive checklist of algal flora for Uttar Pradesh state. Since a large number of studies are available with total taxa exceeding 2,000, the checklist is split in to several publications. Class Chlorophyceae (sensu Fritsch 1935) is presented here, with updated taxonomic status of all taxa.

Uttar Pradesh state has been explored extensively for green algae, and major works include Rao 1937, 1948; Singh 1938, 1939, 1941, 1945; Randhawa 1946; Mitra 1947; Gupta & Pandey 1950a,b, 1951a,b; Gupta 1956a,b; Venkataraman 1957, 1959; Sarma 1962, 1963; Lakshminarayana 1963; Prasad 1964, 1965, 1978; Prasad & Srivastava 1964; Pandey 1966, 1969; Ahmed 1967; Hortobagyi 1969; Prasad & Dutta 1970a,b; Shukla 1971; Khan & Rawat 1972; Prasad et al. 1973; Sarma & Shyam 1974; Bendre & Kumar 1975; Chaturvedi 1975; Kumar 1975; Prasad & Asthana 1975a,b; Rai & Kumar 1976; Chadha & Pandey 1977; Pal 1977; Chadha & Pandey 1978; Prasad & Jain 1978; Gupta & Pandey 1979; Pandey & Chaturvedi 1979; Prasad & Kumari 1979; Tiwari et al. 1979; Pandey et al. 1981; Prasad & Fatima 1981a,b,c. Gupta (2012) in his checklist included a total of 622 taxa under class Chlorophyceae from Uttar Pradesh while Suseela et al. (2015) could compile only 301 taxa including some taxa already mentioned by Gupta (2012). These numbers indicate the ambiguity regarding species richness of Chlorophyceae in the state. Moreover, there are several districts, remains unexplored to present accurate data on the algal diversity of Uttar Pradesh. Present study not only provides number of chlorophycean species but also help in identifying lacuna and potential areas for future exploration.

MATERIALS & METHODS

The present checklist is based on an extensive review of literature involving over 126 research papers, 10 books, monographs and chapters, 18 dissertations and Ph.D. theses deposited at various universities and research institutes. The entire list is appended as a bibliography. Taxa identified up to species, variety or forma level are included. Taxonomic identities of the taxa were checked on AlgaeBase (www.algaebase.org). Taxa are arranged alphabetically (Table 1) and their heirarchial position is provided separately (Table 2). AlgaeBase is followed for arranging taxa as per their hierarchy, which in turn mostly follows the classification system proposed by Ruggiero et al. (2015). A map of Uttar Pradesh indicating the districts explored for Chlorophyceae is provided in Figure 1.

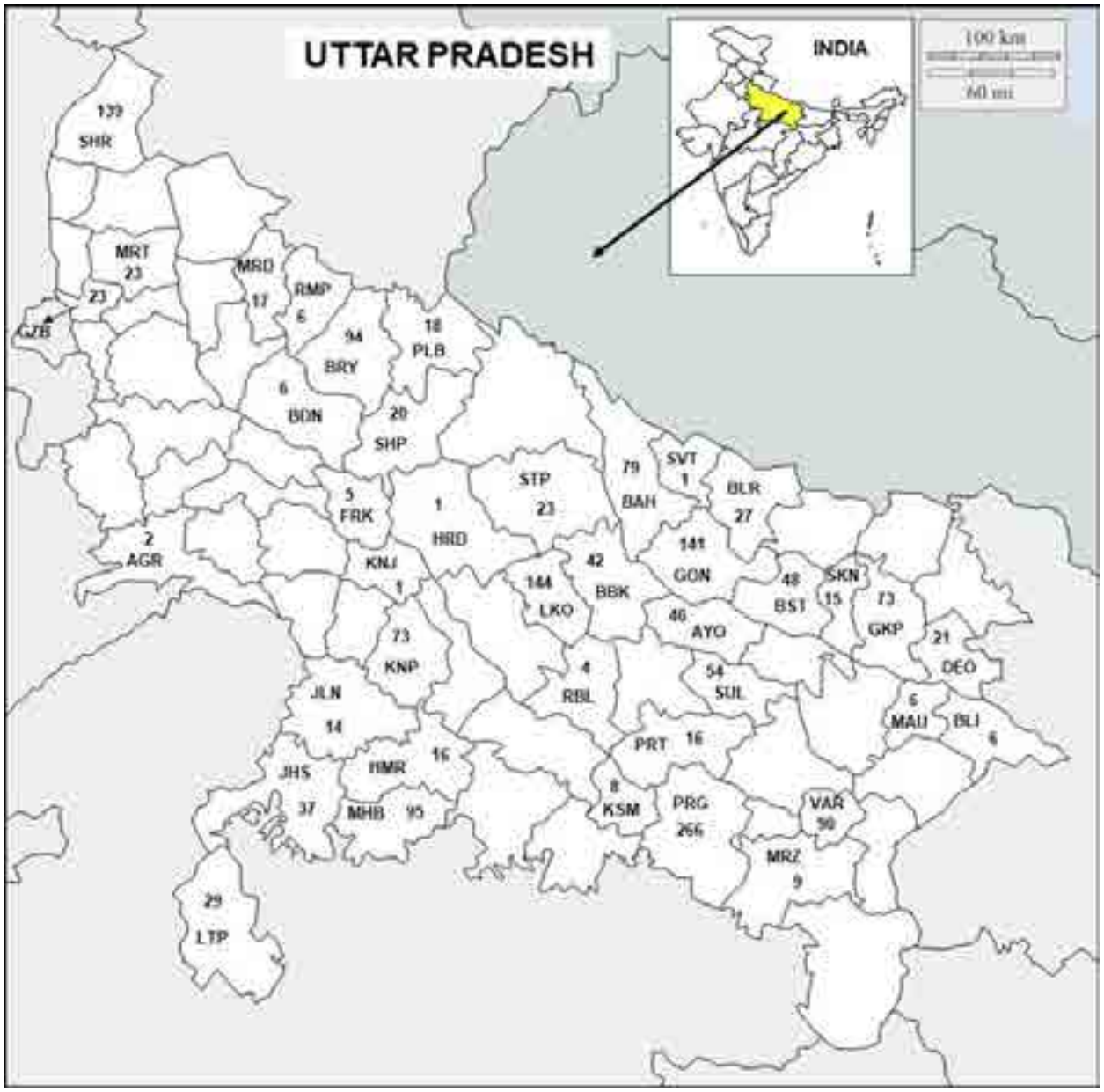

Figure 1. Map of Uttar Pradesh showing districts with reports of Chlorophycean algae. The numbers inside districts indicate totals of infarageneric taxa recorded: AGR—Agra | AYO—Ayodhya | BAH—Bahraich | BBK—Barabanki | BDN—Badaun | BLI—Ballia | BLR—Balrampur | BRY—Bareilly | BST—Basti | DEO—Deoria | FRK—Farrukhabad | GKP—Gorakhpur | GON—Gonda | GZB—Ghaziabad | HMP—Hamirpur | HRD—Hardoi | JHS—Jhansi | JLN—Jalaun | KNJ—Kannauj | KNP—Kanpur | KSM—Kaushambi | LKO—Lucknow | LTP—Lalitpur | MHB—Mahoba | MAU—Mau | MRD—Moradabad | MRT—Meerut | MRZ—Mirzapur | PLB—Pilibhit | PRG—Prayagraj | PRT—Pratapgarh | RBL—Raebareli | RMP—Rampur | SHP—Shahjahanpur | SHR—Saharanpur | SKN—Sant Kabir Nagar | STP—Sitapur | SVT—Shravasti | SUL—Sultanpur | VRN—Varanasi. Map modified from d-maps.com.

RESULTS

The compilation of available literature resulted in 979 taxa, reduced to 921 after considering synonyms and deleting unverifiable names. It is notable that Class Chlorophyceae of Fritsch (1935) now falls under four phyla: Charophyta, Chlorophyta, Glaucophyta and Ochrophyta. 921 taxa are distributed under these four phyla, 11 classes, 26 orders, 64 families and 161 genera, 749 species, 166 varities, and six forma (Table 1). Five names are excluded from the list, as their status were could not be ascertained from Algaebase (pers. com. with Guiry MDR): *Arnoldiella glomerata* Fritsch; *Cladophora furotosa* (Griff) Harvey; *Draparnaldia indica* J.P.Sinha &

Noor; *Spirogyra hyalina* var. *gracilis* (Hassall) Kützing; and *S. reservoiraensis* R.N.Singh. The study revealed that phylum Charophyta is most dominant in Uttar Pradesh with 519 infrageneric taxa (species, varieties, forma) under four classes, six orders, 10 families, and 37 genera. Whereas Chlorophyceae is the most diverse phylum with 389 infrageneric taxa under four classes, 17 orders, 51 families, and 120 genera (Table 2). Among the 11 classes Ulvophyceae of phylum Chlorophyta is diverse with six orders followed by Chlorophyceae and Trebouxiophyceae with five orders each. However, Zygnematophyceae of phylum Charophyta is the most dominant class with maximum infrageneric taxa totaling up to 465 under two orders, six families, and 29 genera. It is followed by Chlorophyceae with 305 infrageneric taxa under five orders, 33 families, and 76 genera. Order Chlamydomonadales of phylum Chlorophyta is the most diverse in the state with 17 families, 27 genera, and 61 species and varieties, followed by Sphaeropleales with nine families, 33 genera, and 112 species and varities. Desmidiaceae (phylum Charophyta) is the diverse family with 16 genera and 277 species and varieties, followed by Hydrodictyaceae with nine genera and 21 taxa, and Chaetophoraceae with seven genera and 29 species and varieties. *Cosmarium* is the most speciose genera with 163 taxa followed by *Oedogonium* (79), *Spirogyra* (72), *Closterium* (54) while several genera had less than five taxa.

It is observed that algal samples were collected from as many as 17 habitats including ditches, tanks to river. Among them maximum number of Chlorophycean algae belonged to ponds with 621 taxa, followed by lakes (394 taxa) and river (236 taxa). The study revealed that out of 75 districts in Uttar Pradesh, algal exploration has been carried out only in 40 districts (Figure 1). The district Prayagraj (= Allahabad) recorded the maximum number of taxa (266 nos.) followed by Lucknow (144 nos.), Gonda (141 nos.), and Saharanpur (139 nos.). The species, variety or forma epithet of following taxa are based on the prominent localities in the state - *Bulbochaete allahabadensis, Cosmarium awadhense, Oedogonium areolatum* var. *gorakhporense, Pleurotaenium varanasiense, Scenedesmus arcuatus* var. *allahabadensis, Spirogyra chakiaensis* var. *lucknowensis*, *S. daedalea* f. *oudhensis, S. oudhensis, Volvox rousseletii* var. *lucknowensis, Zygnema gorakhporense*, and *Z. oudhense.*

It is clear from the study that 35 districts of Uttar Pradesh are either unexplored or the literature unavailable. The major algal research centres in Uttar Pradesh are mostly located in Banaras Hindu University, Varanasi; University of Allahabad, Allahabad; University of Lucknow and CSIR-NBRI, Lucknow. Therefore, much attention was paid to easily accessible region in and around Allahabad, Lucknow, and Prayagraj while other districts are neglected. Among unexplored districts Lakhimpur, Siddarth Nagar, and Maharajganj are in the Tarai region of the state, which are wetter regions due to mansoon flooding. The district Sonbhadra located in the south-east of Uttar Pradesh is a biodiversity rich part of the state but so far no records of algae available from here. The south-western part of Uttar Pradesh can be considered as potential region under explored for algal flora. This region consists of districts such as Agra, Eath, Etawah, and Kannauj with wetlands declared as protected areas such as Patna Wildlife Sanctuary, Sarasai Nawar Wetland, Lakh Bahosi Sanctuary, National Chambal Wildlife Sanctuary, and Sursarovar Sanctuary. Currently, one each species is reported from Agra and Kannauj districts.

CONCLUSION

The enumeration of 921 taxa under phylum Chlorophyta covering only 40 districts of Uttar Pradesh in the present study is certainly remarkable indicating the presence of rich diversity of this phylum in the state. It can be noted that earlier studies by Gupta et al. (2012) and Suseela et al. (2015) have estimated low number of algae from the state. This rich diversity may be due to the presence of numerous small and large water bodies with diverse physico-chemical characteristics and seasonal variations. Floristic exploration in the unexplored areas of the state could be an important step towards unraveling the true representation of the algal wealth in the state.

REFERENCES

Ahmed, M.R. (1967). Algal flora of some ponds of Kanpur. *Hydrobiologia* 29(1–2): 156–164. https://doi.org/10.1007/BF00142061

Bendre, A.M., S. Kumar & S.K. Sharma (1975). Zygnemataceae of Meerut, Gurukul Kangri Vishwavidyalaya. *Journal of Science and Research* 6(1): 35–41.

Chadha, A. & D.C. Pandey (1977). Additions to the algal flora of Allahabad I, genus *Scenedesmus*. *Phykos* 16(1–2): 69–75.

Chadha, A. & D.C. Pandey (1978). Additions to the algal flora of Allahabad II, (Chlorophyta, Chlorococcales). *Phykos* 17(1–2): 73–80.

Chaturvedi, U.K. (1975). A list of green algae from Rohilkhand division, UP, India III. *Phykos* 14(1–2): 449–452.

Cavalier-Smith, T. (2016). Higher classification and phylogeny of Euglenozoa. *European Journal of Protistology* 56: 250–276. https://doi.org/10.1016/j.ejop.2016.09.003

Fritsch, F.E. (1935). *The Structure and Reproduction of the Algae,* Vol 1.

Table 1. Checklist of Chlorophycean (sensu Fritsch, 1935) taxa recorded from Uttar Pradesh. The names in the brackets are originally annotated names which are now synonyms: Habitat: A—Canal | B—Dam | C—Ditch | D—Lake | E—Paddy Field | F—Pond | G—Pool | H—Puddle | I—Reservoir | J—River | K—River Bank | L—Sewage | M—Soil | N—Stone | O—Stream | P—Tank | Q—Water Fall. Localities: AGR—Agra | AYO—Ayodhya | BAH—Bahraich | BBK—Barabanki | BDN—Badaun | BLI—Ballia | BLR—Balrampur | BRY—Bareilly | BST—Basti | DEO—Deoria | FRK—Farrukhabad | GKP—Gorakhpur | GON—Gonda | GZB—Ghaziabad | HMP—Hamirpur | HRD—Hardoi | JHS—Jhansi | JLN—Jalaun | KNJ—Kannauj | KNP—Kanpur | KSM—Kaushambi | LKO—Lucknow | LTP—Lalitpur | MHB—Mahoba | MAU—Mau | MRD—Moradabad | MRT—Meerut | MRZ—Mirzapur | PLB—Pilibhit | PRG—Prayagraj | PRT—Pratapgarh | RBL—Raebareli | RMP—Rampur | SHP—Shahjahanpur | SHR—Saharanpur | SKN—Sant Kabir Nagar | STP—Sitapur | SVT—Shravasti | SUL—Sultanpur | VRN—Varanasi.

	Currently accepted name	Habitat	Localities
1	***Actinastrum*** *fluviatile* (J.L.B. Schröder) Fott (=*Actinastrum hantzschii* var. *fluviatile* J.B.L. Schroder)	F	HMR
2	*A. hantzschii* Lagerheim	F, D, J	BDN, BLR, MHB, MRD, RMP, SHP, FRK
3	***Actinotaenium*** *colpopelta* (Brébisson ex W. Archer) Compère (=*Cosmarium viride* Joshua)	D, F	PRG
4	*A. cucurbitinum* (Bisset) Teiling (=*Cosmarium cucurbitinum* (Bisset) Lütkemüller)	D, F	PRG
5	*A. globosum* (Bulnheim) Kurt Förster ex Compère (=*Cosmarium globosum* Bulnheim)	D, F	PRG
6	*A. inconspicuum* (West & G.S. West) Teiling	G	BRY
7	*A. turgidum* (Brébisson ex Ralfs) Teiling (=*Cosmarium turgidum* Brébisson ex Ralfs)	F, K, D, J	BBK, BRY, JLN
8	***Acutodesmus*** *acutiformis* (Schröder) Tsarenko & D.M. John (=*Scenedesmus acutiformis* Schroder)	B, D, F, J	KNP, LKO, SHR
9	***Aegagropila*** *calcicola* (F.E. Fritsch) C. Boedeker (=*Cladophorella calcicola* Fritsch)	A, D, F, H	BLR
10	*A. linnaei* Kützing (=*Cladophora aegagropila* (Linnaeus) Trevisan; *Cladophora profunda* var. *nordstedtiana* Brand)	A, D, F, H	BLR, PRG
11	***Aegagropilopsis*** *clavuligera* (Grunow) Boedeker (=*Cladophora clavuligera* Grunow)	A, D, F, H	BLR
12	***Ankistrodesmus*** *densus* Korshikov (=*Ankistrodesmus spiralis* var. *fasciculatus* G.M. Smith)	D, J, F, K, I	MHB, SHR
13	*A. falcatus* (Corda) Ralfs	I, F, M	PRG, JLN, LKO, LTP, MHB, SHR
14	*A. falcatus* var. *radiatus Lemmermann*	M	PRG, BBK, JLN, KSM, KNP, LKO, SUL, VRN
15	*A. sigmoideus* (Rabenhorst) Brühl & Biswas	D	LTP
16	*A. spiralis* (W.B. Turner) Lemmermann	J, F, K, I	BAH, LKO, LTP, MHB, SHR
17	***Aphanochaete*** *magnum* Godward	F	KNP, LKO
18	*A. polychaete* (Hansgirg) F.E. Fritch	F	DEO, GKP
19	*A. repens* A. Braun	F	PRG, HMR, LKO, VRN,
20	***Arnoldiella*** *chelonum* (Collins) C. Boedeker (=*Basicladia chelonum* (Collins) W.E. Hoffmann & Tilden)	J	KNP
21	***Arthrodesmus*** *arcuatus* var. *minus* Scott & Prescott	F, D	LKO
22	***Asterococcus*** *limneticus* G.M. Smith	K	BAH
23	***Balticola*** *droebakensis* (Wollenweber) Droop (=*Haematococcus droebakensis* Wollenweber)	F, J	VRN
24	***Botryococcus*** *braunii* Kützing	I, F	PRG, BAH, LKO, SHR, STP
25	***Bulbochaete*** *affinis* Hirn	D	PRT
26	*B. allahabadensis* G.L. Tiwari	A, C	PRG
27	*B. indica* P. Sarma (=*Bulbochaete pseudoareolata* Kargupta)	A, K, J	BAH, GON
28	*B. intermedia* De Bary ex Hirn	D	PRT
29	*B. lagoensis* Wittrock ex Hirn	D	PRT
30	*B. nana* Wittrock ex Hirn	F	PRG
31	*B. polyandria* Cleve ex Hirn	D	PRT
32	*B. rectangularis* Wittrock ex Hirn	D	PRT
33	*B. repanda* Wittrock ex Hirn	D	PRT
34	*B. reticulata* Nordstedt	D	PRT
35	*B. triangularis* C.-C. Jao	D	PRT
36	*B. varians* Wittrock ex Hirn	C, D	PRT, RBL

	Currently accepted name	Habitat	Localities
37	*B. nordstedtii* Wittrock ex Hirn	F, A, P	BAH, GON
38	***Carteria*** *intermedia* A.K. Mitra	E, F	PRG
39	*C. lunzensis* Pascher & Jahoda	E, J	PRG
40	***Cephaleuros*** *virescens* Kunze ex E.M. Fries	J	LKO
41	***Chaetopeltis*** *orbicularis* Berthold	A, J	MHB
42	***Chaetophora*** *lobata* Schrank (=*Chaetophora incrassata* Hazen)	B, F	DEO, GKP
43	***Chaetophoropsis*** *attenuata* (Hazen) B. Wen Liu, Qian Xiong, X. Dong Liu, Z. Yu Hu & G. Xiang Liu (=*Chaetophora attenuata* Hazen)	F	PRG, BAH, DEO, GKP, LKO
44	*C. elegans* (Roth) B. Wen Liu, Qian Xiong, X. Dong Liu, Z. Yu Hu & G. Xiang Liu (=*Chaetophora elegans* (Roth) C. Agardh)	F, K	PRG, BBK, HRD, MAU, RBL, BRY, SUL, VRN
45	*C. pisiformis* (Roth) B. Wen Liu, Qian Xiong, X. Dong Liu, Z. Yu Hu & G. Xiang Liu (=*Chaetophora pisiformis* (Roth) C. Agardh)	K, D, P	KNP, LKO, MHB
46	*C. pisiformis* var. *hamata* (C.-C. Jao) B. Wen Liu, Qian Xiong, X. Dong Liu, Z. Yu Hu & G. Xiang Liu (=*Chaetophora pisiformis* var. *hamata* C.-C. Jao)	K, F, D, P	DEO, GKP
47	***Chaetosphaeridium*** *globosum* (Nordstedt) Klebahn	F, J	MHB
48	*C. ovalis* G.M. Smith	F, J	MHB
49	*C. pringsheimii* Klebahn	F	DEO, GKP
50	***Chara*** *bharadwajae* Y.S.R.K. Sarma & M. Khan	D, F, O, J	SUL
51	*C. braunii* C.C. Gmelin	D, F, O, J	BRY
52	*C. contraria* A. Braun ex Kützing	D, F, O, J	BRY
53	*C. corallina* Klein ex C.L. Willdenow	D, F, O	SUL
54	*C. diaphana* (F.J.F. Meyen) R.D. Wood (=*Chara zeylanica* var. *diaphana* (F. Meyen) R.D. Wood)	D, F, O, J	BRY
55	*C. fibrosa* C. Agardh ex Bruzelius	A, D, F, O, J	BRY, SUL
56	*C. globularis* Thuiller	D, F, O, J	BRY, SUL
57	*C. hookeri* A. Braun (=*Chara fibrosa* var. *hookeri* (A. Braun) R.D. Wood)	D, F, J	SUL
58	*C. hydropithys* Reichenbach (=*Chara fibrosa* var. *hydropithys* (Reiscenbach) R.D. Wood)	B, D, F, O, J	BRY, SUL
59	*C. nuda* B.S. Pal	D, O, J	BRY
60	*C. setosa* Klein ex C.L. Willdenow	D, F, O, J	BRY
61	*C. vulgaris* Linnaueus	D, F, O, J	BRY, SUL
62	*C. zeylanica* Willdenow	D, O, J	BRY, MRD, SUL
63	***Characiellopsis*** *anophelesi* (M.O.P. Iyengar & M.O.T. Iyengar) M.O.P. Iyengar (=*Characium anopheles* M.O.P. Iyengar)	A, O	PRG
64	***Characium*** *acuminatum* A. Braun	F, J, O	PRG
65	*C. orissicum* Philipose	A, O	PRG
66	*C. pringsheimii* A. Braun	J, P	KNP
67	***Chlamydocapsa*** *planctonica* (West & G.S. West) Fott (=*Gloeocystis gigas* (Kützing) Lagerheim; *Gloeocystis planctonica* (West & G.S. West) Lemmermann)	D, F, P	KSM, LKO, MHB
68	***Chlamydomonas*** *angulosa* E.O. Dill	E, F, H	PRG
69	*C. debaryana* var. *atactogama* (Korshikov) Gerloff (= *Chlamydomonas atactogama* Korshikov)	A, J, F, L	KNP
70	*C. globosa* J.W. Snow	J, F, D	LKO, VRN
71	*C. gloeogama* Korshikov	F	PRG
72	*C. grandistigma* A.K. Mitra	E, J, F	PRG
73	*C. indica* A.K. Mitra	E, F, A	PRG
74	*C. intermedia* Chodat	E, J	PRG
75	*C. iyengarii* A.K. Mitra	D	PRG
76	*C. pertusa* Chodat	C, F, J	KNP
77	*C. reinhardtii* P.A. Dangeard	F, L	KNP
78	*C. sphagnicola* (F.E.Fritsch) F.E. Fritsch & H. Takeda	D, F	KNP

	Currently accepted name	Habitat	Localities
79	*C. sphagnophila* Pascher	F, J	SUL
80	*C. sphagnophila* var. *indica* (A.K. Mitra) Ettl (=*Chlamydomonas eugamatos* var. *indica* Mitra)	E, F	PRG
81	***Chlorella*** *vulgaris* Beyerinck [Beijerinck]	F, K, J	PRG, JHS, JLN
82	***Chlorochytrium*** *lemnae* Cohn (=*Chlorochytrium limnanthemum* (D.D. Cunningham) G.S. West)	J	PRG
83	***Chlorococcum*** *infusionum* (Schrank) Meneghini (=*Chlorococcum humicola* (Nägeli) Rabenhorst)	D, F, J, K	BAH, JLN, PRG, AYO, MHB
84	*C. vitiosum* Printz	K	FRK
85	***Chlorogonium*** *elongatum* (P.A. Dangeard) France	F, H	MRZ
86	*C. spirales* Scherffel & Pascher	J	VRN
87	***Choricystis*** *parasitica* (K. Brandt) Pröschold & Darienko (=*Chlorella parasitica* (F. Brandt) Beijerinck)	F	PRG
88	***Cladophora*** *cristata* Kützing	A, D, F, H, J	PRG, BLR, SUL
89	*C. crystallina* (Roth) Kützing	A, D, F, H	BLR
90	*C. flexuosa* (O.F. Müller) Kützing	J	BLR
91	*C. fracta* (O.F. Müller ex Vahl) Kützing	J	PRG, JLN, VRN
92	*C. glomerata* (Linnaeus) Kützing	J, F, A	PRG, BDN, BRY, BAH, BLR, SHP, SUL, VRN
93	*C. gracilis* Kützing	A, D, F, H, J	BLR
94	*C. intermedia* Foslie	A, D, F, H	BLR
95	*C. rivularis* (Linnaeus) Kuntze (=*Cladophora insignis* (C. Agardh) Kützing; *Cladophora oligoclona* (Kützing) Kützing)	A, C, D, F, H, P	PRG, LKO, VRN, BLR
96	***Closteriopsis*** *longissima* (Lemmermann) Lemmermann (=*Closterium didymotocum* var. *tropicum* West & G.S. West)	F	PRG
97	***Closterium*** *acerosum* Ehrenberg ex Ralfs	K, J, F, D	PRG, BAH, LTP, LKO, PLB, MRT, VRN
98	*C. acerosum* var. *elongatum* West	D, E, F, J	PRG
99	*C. acutum* Brébisson	C, F	GZB, PLB, SHP
100	*C. baillyanum* (Brébisson ex Ralfs) Brébisson	F	BRY
101	*C. braunii* Reinsch	F	PLB
102	*C. calosporum* var. *maius* (West & G.S. West) Willi Krieger	D, B, K, J	PRG, BAH, LTP, LKO
103	*C. calosporum* Wittrock	D, B, K, F, J	PRG, BAH, LTP, LKO
104	*C. closterioides* (Ralfs) A. Louis & Peeters (=*Closterium libellula* Focke ex Nordstedt)	E	PRG
105	*C. cornu* Ehrenberg ex Ralfs	F	BRY
106	*C. cornu* var. *javanicum* Gutwinski	F	BRY
107	*C. croasdaleae* A.K.M.N. Islam	D	BRY
108	*C. delpontei* (Klebs) Wolle	J, D	BRY
109	*C. dianae* Ehrenberg ex Ralfs	F, D	PRG, BAH, BRY, MHB
110	*C. dianae* var. *arcuatum* (Brebisson ex Ralfs) Rabenhorst (=*Closterium arcuatum* Brébisson ex Ralfs)	A	BBK
111	*C. dianae* var. *minus* F. Ducellier	F, D	MHB
112	*C. dianae* var. *pseudodianae* (J. Roy) Willi Krieger (=*Closterium pseudodianae* J. Roy)	D, F	MHB
113	*C. ehrenbergii* Meneghini ex Ralfs	D, F	PRG, BAH, BBK, GZB, VRN
114	*C. gracile* Brébisson ex Ralfs	C, D, F	MHB
115	*C. incurvum* Brébisson	B, I, F	SHR
116	*C. intermedium* Ralfs	F, D	BRY
117	*C. intermedium* var. *erectum* Grönblad	F, D	BRY
118	*C. jenneri* var. *cynthia* (De Notaris) Petlovany (=*Closterium cynthia* De Notaris)	K, F	BBK, BRY, PLB
119	*C. kuetzingii* Brébisson	F, B, K	PRG, MFB, LTP, LKO
120	*C. lagoense* Nordstedt	F, A	BRY

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121	*C. lanceolatum* Kützing ex Ralfs	B, K, J	LKO
122	*C. lanceolatum* var. *parvum* West & West	B, K, J	LKO
123	*C. leibleinii* Kützing ex Ralfs	K, D, F, F	PRG, GON, GKP
124	*C. lineatum* Ehrenberg ex Ralfs	F	BAH
125	*C. littorale* F. Gay	D, B, K, F, J	GON, JHS, LKO
126	*C. longissima* var. *tropica* West & G.S. West	F	PRG
127	*C. lunula* Ehrenberg & Hemprich ex Ralfs	J	LKO
128	*C. lunula* var. *biconvexum* Schimidle	J	BRY
129	*C. lunula* var. *massartii* (De Wild.) Willi Krieger	J	BRY
130	*C. moniliferum* Ehrenberg ex Ralfs	K, A, D, F, J	PRG, GZB, GKP, MHB, BRY, BDN, RMP, SHP
131	*C. navicula* (Brébisson) Lütkemüller	H	SUL
132	*C. nematodes* var. *tumidum* G.S. West	F, J	SHP
133	*C. parvulum* Nägeli	D, J, P	GON, KNP, LKO, VRN,
134	*C. parvulum* var. *angustum* West & G.S. West	D, P	GON, KNP, LKO
135	*C. peracerosum* F. Gay	D, K, B	JHS, LKO, SKN
136	*C. pleurodermatum* West & G.S. West	J	BRY
137	*C. porrectum* Nordetedt	F, P	BBK, BRY, KNP
138	*C. porrectum* var. *angustatum* West & G.S. West	F, P	LKO
139	*C. praelongum* Brébisson	F, H	BRY
140	*C. pritchardianum* W. Archer	D, F, J, K	GZB, GKP, JHS, LKO
141	*C. pusillum* Hantzsch (=*Closterium pusillum* var. *monolithum* Wittrock)	J, M	BRY, VRN
142	*C. ralfsii* Brébisson ex Ralfs	F	BRY
143	*C. ralfsii* var. *hybridum* Rabenhorst	F	BRY
144	*C. rectimarginatum* A.M. Scott & Prescott	D, J	LKO
145	*C. rectimarginatum* var. *maius* N.D. Kamat	D, J	JHS, MHB
146	*C. recurvum* Prescott	D	GON
147	*C. strigosum* Brébisson	F, H, D	BRY
148	*C. tumidum* L.N. Johnson	K	PRG, GON, VRN
149	*C. turgidum* Ehrenberg ex Ralfs	F, J	BAH, JHS
150	*C. venus* Kützing ex Ralfs	K, F	PRG, LKO
151	***Coccomyxa*** *subsphaerica* Chodat & Jaag	F	PRG
152	*C. subsphaerica* var. *terrestre* A. Mitra	F	PRG
153	***Coelastrum*** *astroideum* De Notaris	F	SHR
154	*C. cambricum* var. *intermedium* (Bohlin) G.S. West	B, D, J	JHS, LTP, MHB, SHR
155	*C. cambricum* W. Archer	D	AGR, BST, KSM, LTP, MHB, SHR
156	*C. microporum* Nägeli	F	PRG, GZB, JHS, KNP
157	*C. proboscideum* Bohlin	K, F, D, P	JHS, LKO
158	*C. verrucosum* (Reinsch) Reinsch (=*Coelastrum morus* West & G.S. West)	I, F	SHR
159	***Coenocystis*** *asymmetrica* Komárek	I	SHR
160	***Coleochaete*** *conchata* K. Möbius	F	DEO, GKP
161	*C. irregularis* Pringsheim	A	PRG, BBK
162	*C. nitellarum* Jost	J	MHB
163	*C. orbicularis* E.G. Pringsheim	J, A, F	PRG, LKO
164	*C. pseudosoluta* Gauthier-Lièvre	D, P	BBK, MHB
165	*C. pulvinata* A. Braun	D, F	DEO, GKP

	Currently accepted name	Habitat	Localities
166	*C. pulvinata* var. *minor* A. Braun	F	DEO, GKP
167	*C. scutata* Brébisson	F	BAH, GKP, KNP, MHB, SUL
168	*C. soluta* (Brébisson) Pringsheim	D	BRY, GON, MHB
169	*C. soluta* var. *minor* Hansgirg	D, F	DEO, GKP
170	***Comasiella*** *arcuata* var. *platydisca* (G.M. Smith) E. Hegewald & M. Wolf (=*Scenedesmus arcuatus* var. *platydiscus* G.M. Smith)	J	KNP
171	***Conochaete*** *comosa* Klebahn	F, J	PRT
172	***Cosmarium*** *abbreviatum* Raciborski	B	LTP
173	*C. amoenum* Brebisson ex Ralfs	F	PRG
174	*C. amoenum* var. *mediolaeve* Nordstedt	D, F	PRG
175	*C. anceps* P. Lundell	F, J	BRY, PLB
176	*C. angulatum* (Perty) Rabenhorst	D	PRG
177	*C. angulosum* Brébisson	F, D, J, K	PRG
178	*C. angulosum* var. *concinnum* (Rabenhorst) West & G.S. A673West	F, D, K	BST, LTP, SKN
179	*C. angulosum* var. *euastroides* (Delponte) Krieger & Gerloff	D	PRG
180	*C. askenasyi* Schmidle	D, J	GON, SHR
181	*C. auriculatum* Reinsch	D, P	PRG, BAH, GON, LKO
182	*C. auriculatum* var. *bogoriense* C. Bernard (=*Cosmarium subauriculatum* (C. Bernard) Bourrelly; *Cosmarium subauriculatum* var. *bogoriense* (C. Bernard) Bourrelly)	D	PRG
183	*C. awadhense* B.N. Prasad & R.K. Mehrotra	F, J	GZB, GON, JHS, LKO, SKN
184	*C. baileyi* Wolle (=Cosmarium depressum Bailey)	B, D, F, J	PRG, BBK, GKP, LKO
185	*C. bengalense* W.B. Turner	D, F, J	PRG
186	*C. bioculatum* Brébisson ex Ralfs	D, F	PRG
187	*C. bioculatum* var. *hians* West and G.S. West	F	PRG
188	*C. biretum* Brébisson ex Ralfs	F, D	PRG
189	*C. bituberculatum* F.E. Fritsch & Rich	D, J	PRG, SHP
190	*C. blytii* Wille	J	PRG, BST, MAU, DEO
191	*C. botrytis* Meneghini ex Ralfs	J	BBK
192	*C. botrytis* var. *mediolaeve* West	I, J	SHR
193	*C. botrytis* var. *paxillosporum* West & G.S. West	D	PRG
194	*C. braunii* Reinsch	F, J	BRY
195	*C. broomei* Thwaites ex Ralfs	J, I	PRG, HMR
196	*C. circulare* Reinsch (=*Cosmarium lundellii* var. *circulare* (Reinsch) Willi Krieger)	A, D, F	GKP, PRG, MRT, PLB
197	*C. connatum* Brébisson ex Ralfs	D, J	PRG, LKO, SHP
198	*C. connatum* var. *depressum* Irenee-Marie	D	PRG
199	*C. conspersum* Ralfs	F	PRG
200	*C. conspersum* var. *latum* (Brebisson) West & G.S. West	D, F	PRG
201	*C. conspersum* var. *scottii* Crosdale & A.M. Scott	F	PRG
202	*C. constrictum* Delponte	D	PRG
203	*C. contractum* O. Kirchner	F, J	KNP
204	*C. contractum* var. *minutum* (Delponte) Coesel	J	SHP
205	*C. contractum* var. *pachydermum* A.M. Scott & Prescott	F, J	JHS
206	*C. crenatum* Ralfs ex Ralfs (=*Cosmarium ordinatum* E. Larsen; Euastrum sinuosum Kützing)	C, F	BST, PRG, SHR
207	*C. cucumis* Corda ex Ralfs	F, D	GKP
208	*C. cucurbitinum* var. *truncatum* Willi Krieger	D, F	BST, JHS
209	*C. cuneatum* Joshua	D, F	BRY

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210	*C. cyclicum* P. Lundell	C, D	SHR
211	*C. cyclicum* var. *nordstedtianum* (Reinsch) West	D, J	BRY
212	*C. decoratum* West & G.S. West	I, D, F	BST, GON, SHR, SKN
213	*C. depressum* var. *apertum* (W.B. Turner) M. Hirano	J, H, B	JHS
214	*C. difficile* Lütkemüller	F	SHR
215	*C. divergens* Krieger	D, F, J	PRG
216	*C. dubium* O. Borge	F	MHB
217	*C. formosulum* Hoff	F, D	PRG, GON
218	*C. formosulum* var. *nathorstii* (Boldt) West & G.S. West	F, D	GKP
219	*C. furcatospermum* West & G.S. West	J, K	BBK
220	*C. garrolense* J. Roy & Bisset	F	SHR
221	*C. gonioides* West & G.S. West	B, F	GZB, MRD
222	*C. granatum* Brébisson ex Ralfs	K, D, J	PRG, BRY, HMR, LKO
223	*C. granatum* var. *nordstedtii* Hansgirg	H	MRD
224	*C. granatum* var. *ocellatum* West & G.S. West	K, D, J	PRG
225	*C. granatum* var. *rotundatum* Willi Krieger	B, F	SHR
226	*C. hammeri* Reinsch	F	PRG, GKP, BRY, MAU, DEO
227	*C. hammeri* var. *homalodermum* (Nordstedt) West & G.S. West	A, F	BAH
228	*C. hammeri* var. *Schmidlei* Grönblad & A.M. Scott	F	PRG, GKP
229	*C. humile* (Nordstedt) De Toni	B, F	BBK
230	*C. impressulum* Elfving	B, K, D, F	PRG, BAH, SHR
231	*C. isthmochondrum* Nordstedt	B, F	BRY
232	*C. javanicum* Nordstedt (=*Cosmarium maculatum* W.B. Turner)	K, D, J	GKP, HMR, STP
233	*C. laeve* Rabenhorst	D, J	PRG, SHR
234	*C. logiense* Bisset	D, B	PRG
235	*C. lundellii* Delponte	D, F	PRG, GZB, LTP, PRT
236	*C. lundellii* var. *corruptum* (W.B. Turner) West & G.S. West (=*Cosmarium corruptum* W.B. Turner)	F, J	LKO, MHB, PRG
237	*C. lundellii* var. *ellipticum* West & G.S. West	D	PRG, LKO
238	*C. lundellii* var. *subellipticum* Messikommer	D, F	PRG, BST, BBK, GKP, LKO
239	*C. margaritatum* (P. Lundell) J. Roy & Bisset	K, D, F	PRG, LKO
240	*C. medioscrobiculatum* var. *egranulatum* Gutwinsk	D	PRG
241	*C. meneghinii* Brébisson ex Ralfs	C, D	PRG, SHP
242	*C. miniata* B.N. Prasad & R.K. Mehrotra	D	MHB
243	*C. miscellum* Skuja	K, F	BAH
244	*C. moniliforme* Ralfs	D, F	PRG, GZB, LKO, MHB, SKN
245	*C. moniliforme* var. *indentatum* A.M. Scott & Grönblad	D	PRG
246	*C. nitidulum* De Notaris	A, D, F	BAH, GKP, JHS
247	*C. nitidulum* var. *minutum* Prescott	D	PRG
248	*C. norimbergense* Reinsch	K, D, F	PRG, BAH
249	*C. notabile* Brébisson	F	BRY
250	*C. notabile* var. *medium* (Gutwinski) Willi Krieger & Gerloff	F	BRY
251	*C. nymannianum* Grunow	F	PLB
252	*C. obsoletum* (Hantzsch) Reinsch	A, K, D, F	PRG, BAH
253	*C. obsoletum* var. *sitvense* Gutwinski	A, K, F, J	PRG, BAH
254	*C. obtusatum* (Schmidle) Schmidle	D, F	PRG

	Currently accepted name	Habitat	Localities
255	*C. obtusatum* var. *undulatum* Fritsch & M.F. Rich	D	PRG
256	*C. ordinatum* var. *borgei* Scott & Grönblad	B, F	LTP
257	*C. pachydermum* P. Lundell	D, J	PRG
258	*C. pachydermum* var. *aethiopicum* (West & G.S. West) West & G.S. West	D, J	BST, BAH, HMR, LKO
259	*C. pachydermum* var. *minus* Noestedt	D	PRG
260	*C. perfissum* G.S. West	D	BBK
261	*C. phaseolus* Brébisson ex Ralfs	D	PRG
262	*C. phaseolus* var. *omphalum* (Schaarschmidt) Raciborski	D	SHR
263	*C. phaseolus* var. *subbireme* Raciborski	F	BRY
264	*C. polygonum* (Nägeli) W. Archer	D, F	BST, LKO, MHB
265	*C. porteanum* var. *majus* Scott & Prescott	D, F	BST
266	*C. porteanum* var. *nephroideum* Wittrock	D, F	BST, JHS, SKN
267	*C. porteanum* W. Archer	D, F	PRG, BST, MHB
268	*C. pseudobiremum* Boldt	D, J	PRG
269	*C. pseudobroomei* var. *compressum* G.S. West	D, J	PRG
270	*C. pseudobroomei* var. *madagascariense* West and G.S. West	D, J	PRG
271	*C. pseudobroomei* Wolle	F, J	BAH, BST, LKO
272	*C. pseudoconnatum* Nordstedt	D, F, J	PRG, SHR
273	*C. pseudogranatum* Nordstedt	F	LKO, SHR
274	*C. pseudopachydermum* Nordstedt	F	STP
275	*C. pseudopachydermum* var. *incrassatum* Fritsch & M.F. Rich	F	STP
276	*C. pseudoprotuberans* O. Kirchner	D, F	PRG
277	*C. pseudoprotuberans* var. *angustius* Nordstedt	D, F	PRG
278	*C. pseudopyramidatum* P. Lundell	C, D	BST
279	*C. pseudopyramidatum* var. *lentiferum* W.R. Taylor	D	SHR
280	*C. punctulatum* Brébisson	K, D	BAH, BST, MHB, MRZ, SKN
281	*C. pyramidatum* Brébisson ex Ralfs	C, K, F, D	BAH, BST, JHS
282	*C. quadratum* Ralfs ex Ralfs	D, F	SHR
283	*C. quadrifarium* P. Lundell	D, H	BRY
284	*C. quadrum* P. Lundell	D, F	BST, GKP, PLB, SKN
285	*C. quadrum* var. *sublatum* (Nordstedt) West & G.S. West (=*Cosmarium margaritatum* var. *sublatum* (Nordestedt) Krieger)	K, D, F	SHR
286	*C. quinarium* P. Lundell	D, F, J	PRG, BST
287	*C. radiosum* Wolle	A, D, F	MRT, PLB
288	*C. ralfsii* Brébisson ex Ralfs	A	BRY
289	*C. regnellii* Wille	F	BRY
290	*C. reniforme* (Ralfs) W. Archer	D, F, J	PRG, BAH, BST, SKN
291	*C. reniforme* var. *compressum* Nordstedt	D	PRG
292	*C. reniforme* var. *elevatum* West & G.S. West	A, K, D	BAH, GZB
293	*C. repandum* Nordstedt	F, J	SHR
294	*C. retusiforme* (Wille) Gutwinski	K, F	BAH
295	*C. scabrum* W.B. Turner	D, F	PRG, PLB
296	*C. seelyanum* Wolle	K, I, F	SHR
297	*C. sexangulare* P. Lundell	K, F	PRG, BAH
298	*C. sexnotatum* Gutwinski	K, J, F	JHS, PLB
299	*C. speciosum* P. Lundell	F, J	BST, GON, PLB

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300	*C. striolatum* (Nägeli) W. Archer	D	PRG
301	*C. subalatum* West & G.S. West	B, D, F	JHS, JLN, LKO
302	*C. subauriculatum* var. *truncatum* West & G.S. West	D	PRG
303	*C. subcostatum* Nordstedt	B, D	PRG, LKO
304	*C. subcrenatum* Hanzsch	D, F	PRG, BST, LKO, MHB
305	*C. subimpressulum* Borge	D, F	PRG
306	*C. subprotumidum* Nordstedt	D, F	PRG, PLB
307	*C. subspeciosum* Nordstedt	D, F	PRG
308	*C. subtransiens* Croasdale	F, H	BRY
309	*C. subtumidum* Nordstedt	D	PRG
310	*C. subtumidum* var. *klebsii* (Gutwinski) West & G.S. West	D	PRG
311	*C. tenue* W. Archer	F, J	JLN, MHB
312	*C. tinctum* Ralfs	D, F	BRY
313	*C. tinctum* var. *intermedium* Nordstedt	D, F	BRY
314	*C. tinctum* var. *subretusum* Nordstedt	F	BRY
315	*C. trachypleurum* P. Lundell	D, F	PRG
316	*C. trilobulatum* Reinsch	D, F, J	PRG, SHR
317	*C. tumidum* P. Lundell	D	GKP
318	*C. turpinii* Brébisson	D, F	MHB, SKN, STP
319	*C. undulatum* Corda ex Ralfs	F	PRG
320	*C. undulatum* var. *minutum* Wittrock	D, F	PRG
321	*C. venustum* (Brébisson) W. Archer	D	PRG
322	*C. vermae* B.N. Prasad & R.K. Mehrotra	F	BST
323	*C. vexatum* (Schidmidle) Migula	D	PRG
324	*C. viride* var. *compressum* Taft	F	PRG
325	*C. vitiosum* Scott & Grönblad	D	BBK
326	*C. vitiosum* var. *orientale* A.M. Scott and Grönblad	D	LKO
327	*C. westii* C.Bernard (=*Cosmarium turgidum* var. *westii* (C. Bernard) Krieger & Gerloff)	B	PRG, BAH
328	*C. blyttii* var. *novae-sylvae* West & G.S. West	B, D, J	PRG, LTP
329	*C. impressulum* var. *crenulatum* (Nägeli) Willi Krieger & Gerloff	B, K, F	BAH
330	*C. medioscrobiculatum* West & G.S. West	D	PRG
331	*C. ochthodes* Nordstedt	J	BST, SHR
332	*C. quadrum* var. *andamanicum* B.N. Prasad & P.K. Misra	D	BBK, BST, HMR
333	*C. subspeciosum* var. *validius* Nordstedt	D, F	PRG
334	*C. subturgidum* f. *minus* Schmidle (=*Cosmarium turgidum* var. *minus* (Reinsch) Schmidle)	F	VRN
335	***Cosmocladium*** *constrictum* (W. Archer) W. Archer ex Joshua	D	LKO
336	***Crucigenia*** *fenestrata* (Schmidle) Schmidle	F	GZB, MRT, SHR
337	*C. mitrii* G.L. Tiwari & D.C. Pandey	F, L	PRG
338	*C. quadrata* Morren	D, J	PRG, LKO
339	*C. tetrapedia* (Kirchner) Kuntze	D, F, J	LKO, LTP, SHR
340	***Ctenocladus*** *circinnatus* Borzì (=*Gongrosira circinnata* (Borzi) Schmidle)	F	LKO
341	***Cylindrocapsa*** *geminella* var. *minor* Hansgirg	F	SHR
342	*C. geminella* Wolle	D, F, P	PRG, MHB
343	*C. involuta* Rein	F	PRG
344	*C. oedogonioides* M.S. Randhawa	D, F	BLR

	Currently accepted name	Habitat	Localities
345	***Cylindrocystis*** *brebissonii* (Ralfs) De Bary	D, F	STP
346	***Desmidium*** *baileyi* (Ralfs) Nordstedt	I, F, J	PRG, BAH, SHR
347	*D. suboccidentale* A.M. Scott & Prescott	D, F, P	PRG, MHB
348	*D. swartzii* C. Agardh ex Ralfs	D, F	MHB
349	***Desmococcus*** *olivaceus* (Persoon ex Acharius) J.R. Laundon (=*Pleurococcus naegelii* Chodat)	F	PRG
350	***Desmodesmus*** *abundans* (Kirchner) E.H. Hegewald (=*Scenedesmus abundans* (O. Kirchner) Chodat; *Scenedesmus quadricauda* var. *parvus* G.M. Smith; *Scenedesmus quadricauda* var. *quadrispina* G.M. Smith)	B, F, J, P	KNP, PRG, SHR, STP
351	*D. abundans* var. *brevicauda* (G.M. Smith) Taskin & Alp (=*Scenedesmus abundans* var. *brevicauda* G.M. Smith)	J	KNP
352	*D. aculeolatus* (Reinsch) P.M. Tsarenko (=*Scenedesmus aculeolatus* Reinsch)	F	LTP
353	*D. armatus* (Chodat) E.H. Hegewald (=*Scenedesmus armatus* (Chodat) Chodat)	D, F, J	PRG, KNP, LKO
354	*D. armatus* var. *asymetricus* (Philipose) Taşkin & Alp (=*Scenedesmus armatus* var. *asymmetricus* Philipose)	D, F	MHB
355	*D. armatus* var. *longispina* (Chodat) E. Hegewald (=*Scenedesmus armatus* var. *asymmetricus* Philipose)	F, J	PRG, JHS, KNP, MHB
356	*D. asymmetricus* (Schröder) E. Hegewald (=*Scenedesmus abundans* var. *asymmetricus* (Schroeder) G.M. Smith)	B, J	JHS, SHR
357	*D. bicellularis* (Chodat) S.S. An, T. Friedl & E. Hegewald (=*Scenedesmus bijugatus* var. *bicellularis* (Chodat) Philipose)	B, I, D, ,F J	PRG, JHS, MHB
358	*D. brasiliensis* (Bohlin) E. Hegewald (=*Scenedesmus brasiliensis* Bohlin)	I, J	GZB, KNP, MRT, SHR
359	*D. denticulatus* (Lagerheim) S.S. An, T. Friedl & E. Hegewald (=*Scenedesmus denticulatus* Lagerheim)	D	PRG, BRY, BST
360	*D. denticulatus* var. *linearis* (Hansgirg) Hegewald (= *Scenedesmus denticulatus* var. *linearis* Hansgirg)	D, F, J	PRG, BRY, BST
361	*D. dispa* (Brébisson) E. Hegewald (=*Scenedesmus dispar* Brébisson)	K, D, F, J	BST, LKO
362	*D. granulatus* (West & G.S. West) Tsarenko (=*Scenedesmus granulatus* West & G.S. West)	K, J	LKO
363	*D. hystrix* (Lagerheim) E. Hegewald (=*Scenedesmus hystrix* Lagerheim)	D, F	MHB
364	*D. lefevrei* (Deflandre) S.S. An, T. Friedl & E.H. Hegewald (=*Scenedesmus lefevrei* Deflandre)	I	GZB, MRT, SHR
365	*D. maximus* (West & G.S. West) Hegewald (=*Scenedesmus quadricauda* var. *maximus* West & G.S. West)	A, B, D, J, P	SHR
366	*D. opoliensis* (P.G. Richter) E. Hegewald (=*Scenedesmus opoliensis* P.G. Richter)	I	LKO, SHR
367	*D. opoliensis* var. *carinatus* (Lemmermann) E. Hegewald (=*Scenedesmus carinatus* (Lemmermann) Chodat)	D	PRG, GZB, MRT, SHR
368	*D. opoliensis* var. *mononensis* (Chodat) E. Hegewald (=*Scenedesmus opoliensis* var. *mononensis* Chodat)	I	PRG, GZB, MRT, SHR
369	***Dichotomosiphon*** *tuberosus* (A. Braun ex Kützing) A. Ernst	M	SUL
370	***Dictyosphaerium*** *ehrenbergianum* Nägeli	F	VRN
371	*D. indicum* M.O.P. Iyengar & Ramanathan	F, P	GON
372	*D. pulchellum* var. *minutum* Deflandre	F	BBK, MHB
373	***Dimorphococcus*** *lunatus* A. Braun	I, D	MHB, SHR
374	***Diplosphaera*** *chodatii* Bialosuknia (=*Stichococcus chodatii* (Bialosuknia) Heering)	F	PRG, LKO
375	***Docidium*** *baculum* Brébisson ex Ralfs	F	BAH
376	***Draparnaldia*** *acuta* (C. Agardh) Kützing	D, P	PRG, LKO
377	*D. champlainensis* P.W. Cook	E	PRG
378	*D. desikacharyi* R.N. Yadava	E, F	PRG
379	*D. indica* (Y. Bharadwaja) Manasi Mandal & D. Maity (=*Draparnaldia indica* Bharadwaja)	F	PRG, KNP
380	*D. iyengarii* G.L. Tiwari, D.C. Pandey & R.S. Pandey	E	PRG
381	*D. mutabilis* (Roth) Bory (=Draparnaldia plumosa (Vaucher) C. Agardh)	E	PRG
382	***Elongatocystis*** *ecballocystiformis* (Iyengar) L. Krienitz & C. Bock (=*Oocystis ecballocystiformis* M.O.P. Iyengar)	K, I, F, J	JHS
383	***Enteromorpha*** *flexuosa* subsp. *pilifera* (Kützing) Bliding (=*Enteromorpha intermedia* C.B. Bliding)	D, J	LKO

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384	***Epibolium*** *polysporum* Duringer	D, F	DEO, GKP
385	***Eremosphaera*** *gigas* (W. Archer) Fott & Kalina (=*Oocystis gigas* W. Archer)	D, F, J, P	JHS, MHB, SHR
386	***Euastrum*** *amoenum* F. Gay (=*Euastrum denticulatum* F. Gay)	D, F	PRG
387	*E. bidentatum* f. *bidentatum* Nägeli (=*Euastrum rostratum* Ralfs ex Ralfs)	F	BRY
388	*E. bidentatum* Nägeli	F, J	SHR
389	*E. binale* Ehrenberg ex Ralfs	F	PRG
390	*E. binale* var. *juvae* Croasdale	D, F	PRG
391	*E. binale* var. *unicorne* W.B. Turner	F	PRG
392	*E. ceylanicum* (West & G.S. West) Willi Krieger (=*Euastrum sinuosum* var. *ceylanicum* West & G.S. West)	A, B, D, F, J, K	BAH, PRG, BST
393	*E. denticulatum* var. *rectangulare* West & G.S. West	D, F	PRG, MHB, SHR
394	*E. divergens* Joshua	A, F, J	GKP, SHR
395	*E. elegans* Ralfs	D	GKP, LKO
396	*E. elegans* var. *planum* W.B. Turner	D, F	LKO, SHR
397	*E. evolutum* (Nordstedt) West & G.S. West	F, H	MRD
398	*E. evolutum* var. *glaziovii* (G.S. West) W. Krieger	F	MRD
399	*E. insulare* (Wittrock) J. Roy (=*Euastrum binale* var. *insulare* Wittrock)	D, F	MHB, PRG, SHR
400	*E. johnsonii* West & G.S. West	D	MHB
401	*E. platycerum* Reinsch	D, F	MHB, SHR
402	*E. quadriceps* Nordstedt	D, F	BRY
403	*E. quadriceps* var. *minus* Fritsch & M.F. Rich	D, F	BRY
404	*E. radiatum* W.B. Turner	F	BRY, MRD
405	*E. rostratum* var. *bioculatum* A.M. Scott & Prescott	F	BRY
406	*E. sinuosum* Lenormand ex W. Archer (=*Euastrum sinuosum* var. *reductum* West & G.S. West)	D, F, J	SKN
407	*E. solum* (Nordstedt) Grönblad & A.M. Scott	D, F	BRY
408	*E. sphyroides* Nordstedt	K, F, J	BBK, BST, MHB
409	*E. sphyroides* var. *intermedium* Lütkemüller	D, F	BRY, MHB
410	*E. spinulosum* Delponte	D, F, J	PRG, BAH, BBK, BST, HMR, MHB, PLB, SHR
411	*E. spinulosum* var. *bellum* A.M. Scott & Prescott	D, F, J	LTP
412	*E. spinulosum* var. *burmense* (West & G.S. West) Willi Krieger (=*Euastrum inermius* var. *burmense* West & G.S. West)	D, F	MHB, PRG
413	*E. spinulosum* var. *inermius* (Nordstedt) C. Bernard	B, D, F	GKP
414	*E. spinulosum* var. *vaasii* A.M. Scott & Prescott	C, I, D, F	GON, PRT
415	*E. subalpinum* Messikommer	F	BRY
416	*E. subhexalobum* var. *scrobiculatum* Grönblad	F	BRY
417	*E. subhexalobum* West & G.S. West	F	BRY
418	*E. sublobatum* Brebisson ex Ralfs	D	LKO, MHB
419	*E. sublobatum* var. *sumatranum* A.M. Scott & Prescott	D	LKO, MHB
420	*E. subspinosum* W.B. Turner	D, F, P	MHB
421	*Euastrum substellatum* Nordstedt	D	MHB
422	*E. urniforme* (West & G.S. West) Y. Okada (=*Xanthidium urniforme* (West & G.S. West) A.M. Scott & Croasdale)	F	SHP
423	*E. verrucosum* Ehrenberg ex Ralfs	F	PRG
424	*E. verrucosum* var. *alpinum* (Huber-Pestalozzi) Willi Krieger (=*Euastrum verrucosum* var. *vallesiacum* L. Viret)	D, F	PRG
425	***Eudorina*** *elegans* Ehrenberg	D, F, J	LKO, SHR, VRN
426	***Fritschiella*** *tuberosa* M.O.P. Iyengar	F	PRG

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427	***Geminella*** *interrupta* Turpin	F	PRG
428	***Glaucocystis*** *cingulata* Bohlin	J	SHR
429	*G. nostochinearum* Itzigsohn	D	LKO, MHB
430	*G. reniformis* B.N. Prasad & P.K. Misra	D	MHB
431	***Gloeocystis*** *major* Gerneck ex Lemmermann	K	MHB
432	*G. vesiculosa* Nägeli	D	GON
433	***Gloeotaenium*** *loitlesbergereanum* Hansgirg	D	BAH, BBK, GON, MHB, SHR
434	***Gloeotilopsis*** *planctonica* M.O.P. Iyengar & Philipose	F	SUL
435	***Gonatozygon*** *aculeatum* W.N. Hastings	D, F	PRG
436	***Goniochloris*** *mutica* (A. Braun) Fott (=*Tetraedron muticum* (A. Braun) Hansgirg)	K, D, F	KNP
437	***Gonium*** *compactum* M.O.P. Iyengar	D, F	LKO
438	*G. pectorale* O.F. Müller	D, F	VRN
439	***Haematococcus*** *droebakensis* var. *fastigiatus* Wollenweber	F, J	VRN
440	***Hariotina*** *reticulata* P.A. Dangeard (=*Coelastrum reticulatum* (P.A. Dangeard) Senn)	D	MHB
441	***Hyalotheca*** *burmensis* West & G.W. West	I	SHR
442	*H. dissiliens* Brébisson ex Ralfs	K, D	MHB
443	***Hydrodictyon*** *reticulatum* (Linnaeus) Bory	A, D, J, P	PRG, JLN, KNP, LKO, LTP, MRT, SHR
444	***Iwanoffia*** *terrestris* (Iwanoff) Pascher	F	LKO
445	***Kirchneriella*** *dianae* (Bohlin) Comas (=*Kirchneriella lunaris* var. *dianae* Bohlin)	I, D, F	SHR
446	*K. lunaris* (Kirchner) Möbius	I, D, F	LKO, SHR, VRN
447	*K. obesa* (West) West & G.S. West (=*Selenastrum bibraianum obesum* West)	F, K, D, J	BAH, MHB, VRN
448	***Klebsormidium*** *rivulare* (Kützing) M.O. Morison & Sheath (=*Hormidium rivulare* Kützing)	C, F, J	KNP
449	*K. subtile* (Kützing) Mikhailyuk, Glaser, Holzinger & Karsten	M	PRG
450	***Lacunastrum*** *gracillimum* (West & G.S. West) H. McManus (=*Pediastrum duplex* var. *gracillimum* West & G.S. West)	F	PRG
451	***Lemmermannia*** *triangularis* (Chodat) C. Bock & Krienitz (=*Crucigenia triangularis* (Chodat) Schmidle)	A, K, D, F	PRG
452	***Leptosiropsis*** *torulosa* C.-C. Jao	F	DEO, GKP
453	***Lychaete*** *pellucida* (Hudson) M.J. Wynne (=*Cladophora pellucida* (Hudson) Kützing)	A, D, F, H	BLR
454	***Messastrum*** *gracile* (Reinsch) T.S. Garcia (=*Selenastrum bibraianum gracile* Reinsch; *Selenastrum bibraianum* var. *gracile* (Reinsch) Tiffany & Ahlstrom)	D, F, I, P	PRG, BBK, GON, JHS, KNP, SHR, LKO, MHB
455	*M. gracile* var. *westii* (G.M. Smith) L. Täuscher (=*Selenastrum bibraianum westii* G.M. Smith)	F	JHS
456	***Micractinium*** *pusillum* Fresenius	F	PRG
457	***Micrasterias*** *elegans* (W. West & G.S. West) Coesel & Van Geest	I, F	BST, KNP
458	*M. foliacea* Bailey ex Ralfs	D, E	BST, LKO, MHB
459	*M. mahabaleshwarensis* J. Hobson	A, D, F, J, I	BAH, LKO, MHB, SHR
460	*M. mahabuleshwarensis* var. *chauliodon* A.M. Scott & Prescott	D, F, J	BAH, LKO, MHB, SHR
461	*M. pinnatifida* Ralfs	D, F, J	PRG, BAH, LKO, SHR
462	*M. radians* var. *bogoriensis* (C. Bernard) Willi Krieger	A, F	BST, MHB
463	*M. radians* W.B. Turner	A, D, F	BST, LKO, MHB, SHR
464	*M. tropica* Nordstedt	F	MAU, DEO
465	*M. zeylanica* F.E. Fritsch	K, F	BAH
466	***Microglena*** *braunii* (Goroschankin) Demchenko, Mikhailyuk & Proschold (=*Chlamydomonas braunii* Goroschankin [Gorozhankin])	A, F	BLI, STP
467	*M. monadina* Ehrenberg (=*Chlamydomonas monadina* (Ehrenberg) F. Stein)	F, K, J	SUL
468	***Microspora*** *amoena* (Kützing) Rabenhorst	K, F	BAH, GON, KNP, SVT
469	*M. floccosa* (Vaucher) Thuret	C, F	KNP

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470	*M. tumidula* Hazen	F	PRG
471	*M. willeana* Lagerheim	F	PRG
472	*M. wittrockii* (Wille) Lagerheim	K, F	BAH, KNP
473	***Microthamnion*** *curvatum* West & G.S. West	F	LKO
474	*M. kuetzingianum* Nägeli ex Kützing	F	PRG
475	*M. strictissimum* Rabenhorst	F	PRG
476	***Monactinus*** *simplex* (Meyen) Corda (=*Pediastrum simplex* Meyen)	D, F, J	GZB, JHS, JLN
477	***Monoraphidium*** *minutum* (Nägeli) Komárková-Legnerová (=*Selenastrum bibraianum minutum* (Nägeli) Collins)	D, F	MHB
478	***Mougeotia*** *genuflexa* (Roth) C. Agardh	A, K, P	STP
479	*M. gotlandica* (Cleve) Wittrrock	C, P	AYO
480	*M. indica* Randhawa	D	AYO
481	*M. quadrata* Randhawa	F	AYO
482	*M. recurva* (Hassall) De Toni	D, F	AYO, KSM, GKP, STP
483	*M. scalaris* Hassall	F	AYO
484	*M. sinensis* L.C. Li	D, F, P	LKO, SUL
485	*M. sphaerocarpa* Wolle	K, F	BBK, BRY, AYO, MRZ, SHP
486	*M. transeaui* Collins	C	BLR, KNP
487	*M. varians* (Wittrock) Czurda	D, P	KNP, LKO
488	*M. floridana* Transeau	F	AYO
489	***Mucidosphaerium*** *pulchellum* (H.C. Wood) C. Bock, Proschold & Krienitz (=*Dictyosphaerium pulchellum* H.C. Wood)	D, F	MHB
490	***Neglectella*** *solitaria* (Wittrock) Stenclová & Kastovsky (=*Oocystis crassa* Wittrock; *Oocystis solitaria* Wittrock)	C, K, F, J	JHS, PRG, BRY, RBL
491	***Nephrocytium*** *agardhianum* Nägeli	I, P	SHR
492	*N. lunatum* West	D	SHR
493	***Netrium*** *digitus* (Brébisson ex Ralfs) Itzigsohn & Rothe	D, J	LKO
494	***Nitella*** *acuminata* A. Braun	D, F, P	BRY, KNP
495	*N. agharkarii* Kundu	D, F, P	VRN
496	*N. axillaris* A. Braun	D, F	MRD
497	*N. confervacea* (Brébisson) A. Braun ex Leonhardi (=*Nitella gracilis* var. *confervacea* Brébisson)	D, F, P	SUL, VRN
498	*N. dualis* Nordstedt	D	BRY
499	*N. flagellifera* var. *patula* (J. Groves & G.O. Allen) Raam (=*Nitella patula* J. Groves & G.O. Allen)	D, F, O	MRD
500	*N. flagelliformis* A. Braun	D, F, P	VRN
501	*N. furcata* (C. Roxburgh ex Bruzelius) C. Agardh	D, F	BRY
502	*N. furcata* f. *polycarpa* (B.P. Pal) R.D. Wood (=*Nitella polycarpa* B.P. Pal)	D, F	MRD
503	*N. gracilis* (J.E. Smith) C. Agardh	D, F, O	SUL, VRN
504	*N. hyalina* (De Candolle) C. Agardh	D, F, P	PRG, BRY
505	*N. leptodactyla* J. Groves (=*Nitella pseudoflabellata* var. *leptodactyla* (J. Groves) R.D. Wood)	D, F, J	MRD
506	*N. microcarpa* A. Braun	D, F, P	SUL
507	*N. microcarpa* var. *sieberi* (A. Braun) Raam (=*Nitella furcata* var. *sieberi* (A. Braun) R.D. Wood)	F	BRY
508	*N. mirabilis* Nordstedt ex Groves	D, F, P	BRY
509	*N. mucronata* (A. Braun) F. Miquel	D, F	MRD
510	*N. oligospira* A. Braun	D, F, P	MRD
511	*N. opaca* (C. Agardh ex Bruzelius) C. Agardh	D, F, P	VRN
512	*N. pseudoflabellata* A. Braun	D, F, P	MRD

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513	*N. pulchella* T.F. Allen (=*Nitella dualis* var. *pulchella* (T.F. Allen) R.D. Wood)	D	BRY
514	*N. superba* B.P. Pal	D, F	SUL
515	*N. tenuissima* (Desvaux) Kützing	D, F	BRY
516	*N. translucens* (Persoon) C. Agardh	D, F, P	BRY
517	***Oedocladium*** *prescottii* Islam	P	BRY
518	***Oedogonium*** *acmandrium* Elifving ex Hirn	K, J	PRG, BBK, VRN
519	*O. acrosporum* De Bary ex Hirn	J	BLI
520	*O. acrosporum* var. *floridense* Wolle ex Hirn	J	BLI
521	*O. alterans* Wittrock & P. Lundell	I	BAH
522	*O. areolatum* (Singh) Mrozinska	J	GKP
523	*O. areolatum* var. *gorakhporense* (R.H. Singh) Gonzalves (=*Oedogonium gorakhporense* R.H. Singh)	B, D, K	GKP
524	*O. armigerum* Hirn	F	GKP
525	*O. bharuchae* N.D. Kamat	C, F	VRN
526	*O. borisianum* var. *crassa* R.H. Singh	A, K, I, F	BAH, GKP
527	*O. borisianum* Wittrock ex Hirn	K, J, I	BAH, GKP
528	*O. boscii* Wittrock ex Hirn	D	PRT
529	*O. calosporum* C.-C. Jao (=*Oedogonium asiaticum* Gonzalves; *Oedogonium asiaticum* var. *majus* Gonzalves)	C, F	GZB
530	*O. calvum* Wittrock	F	PRG
531	*O. capilliforme* Kützing ex Hirn	F	GKP, LKO
532	*O. cardiacum* Wittrock ex Hirn	D	LKO
533	*O. crassiusculum* var. *indica* Venkataraman	D	AYO
534	*O. crassiusculum* Wittrock ex Hirn	A	AYO
535	*O. crassum* f. *amplum* Hirn (=*Oedogonium amplum* Magnus & N. Wille)	K	GON
536	*O. crispum* var. *gracilescens* Wittrock ex Hirn	F	VRN
537	*O. crispum* Wittrock ex Hirn	F	VRN
538	*O. cryptoporum* Wittrock ex Hirn (=*Oedogonium vulgare* (Wittrock) L.H. Tiffany)	F	PRG
539	*O. curvum* Pringsheim ex Hirn	F	AYO
540	*O. cymatosporum* Wittrock & Norstedt	F	PRG
541	*O. ellipsosporum* R.N. Singh	F	GKP
542	*O. epiphyticum* Transeau & Tiffany	D	LKO
543	*O. franklinianum* Wittrock ex Hirn	F	GKP
544	*O. globosum* Nordstedt ex Hirn	F, J, M	MRT
545	*O. globosum* var. *nanyohense* C.-C. Jao	F, J, M	MRT
546	*O. gracillimum* Wittrock & P. Lundell ex Hirn	D, F, J	RBL
547	*O. grande* Kützing ex Hirn	D	PRT
548	*O. hians* Nordstedt & Hirn	F	VRN
549	*O. hindustanense* Kamat	F	PRG
550	*O. hirnii* Gutwinski ex Hirn	J	VRN
551	*O. howardii* var. *formosum* (Kamat) Mrozinska (=*Oedogonium howardii* G.S. West)	F	GKP
552	*O. idioandrosporum* Nordstedt & Wittrock ex Hirn	K	SUL
553	*O. idioandrosporum* var. *minus* Tiffany	K	BBK
554	*O. inerme* Hirn	K, F, J	BAH
555	*O. intermedium* Wittrock ex Hirn	F	BST, GKP, MRZ, VRN
556	*O. irregulare* var. *condensatum* (Hallas) Hirn	F	AYO

	Currently accepted name	Habitat	Localities
557	*O. irregulare* var. *tenuis* Venkataraman	F	VRN
558	*O. irregulare* Wittrock ex Hirn	F	AYO
559	*O. kirtikari* N.D. Kamat	F	VRN
560	*O. kushmiense* R.N. Singh	F	GKP
561	*O. landsboroughii* var. *norvegicum* Wittrock ex Hirn	D, F	DEO, MAU
562	*O. landsboroughii* Wittrock ex Hirn	D, F	DEO, MAU
563	*O. lautumniarum* Wittrock ex Hirn	F	VRN
564	*O. longatum* Kützing ex Hirn	F	VRN
565	*O. mexicanum* Wittrock ex Hirn	D	PRT
566	*O. minus* Wittrock ex Hirn	D	AYO
567	*O. mirandrium* Skuja	F, D	GKP
568	*O. mitratum* Hirn	F	GKP
569	*O. mitratum* var. *minus* R.N. Singh	K, I	GKP
570	*O. nanum* Wittrock ex Hirn	F	PRG, BRY, SHP, VRN
571	*O. oblongum* Wittrock ex Hirn	D, F, J	PRG, HMR, LKO, SHR, VRN
572	*O. oboviforme* Wittrock ex Hirn	A	BBK
573	*O. obtruncatum* var. *completum* Hirn (=*Oedogonium completum* (Hirn) Tiffany)	K, D, F	GON
574	*O. obtruncatum* Wittrock ex Hirn	K, I, F, J	GON
575	*O. oviforme* var. *minus* (Pandey) Mrozinska (=*Oedogonium patulum* var. *minus* Pandey)	J	BLI
576	*O. patulum* Tiffany	J	BLI
577	*O. peipingense* C.-C. Jao	J	BAH
578	*O. praelongum* Hallas	D	PRT
579	*O. pringsheimii* C.E. Cramer ex Hirn	C	BBK
580	*O. pringsheimii* var. *nordstedtii* Wittrock ex Hirn	C	BBK
581	*O. pseudaureum* C.-C. Jao	J	BRY, SHP
582	*O. punctatostriatum* De Bary ex Hirn	F	SHR
583	*O. punctatum* Wittrock ex Hirn	C	BBK
584	*O. pusillum* Kirchner	F	PRG
585	*O. rufescens* f. *exiguum* Hirn (=*Oedogonium rufescens* var. *exiguum* (Hirn) Tiffany)	F	VRN
586	*O. rufescens* Wittrock ex Hirn	D, F	LKO, VRN
587	*O. silvaticum* Hall	F	GKP
588	*O. silvaticum* var. *idioandrosporum* R.N. Singh	F	GKP
589	*O. sociale* var. *kanwaense* R.N. Singh	F	VRN
590	*O. sociale* Wittrock ex Hirn	F	VRN
591	*O. terrestre* Randhawa	M	AYO
592	*O. tungarense* Gonzalves & S.C. Jain	F	PRG
593	*O. varians* Wittrock & Lundell ex Hirn	A, F, J, M	PRG, BAH
594	*O. vaucheri* A. Braun ex Hirn (=*Oedogonium vaucheri* var. *parvum* Gonzalves & Sonnad)	K, D	GON
595	*O. inconspicuum* Hirn	F	BLI
596	*O. plurisporum* Arnoldi & Y.V. Roll	H	BAH
597	***Oocystaenium*** *elegans* Gonzales & Mehra	P	PRG
598	***Oocystis*** *bispora* Komárek	I, F	SHR
599	*O. borgei* J.W. Snow	D, F	PRG, BAH, KNP, LKO, MHB
600	*O. elegans* Gonzalves & K.R. Mehra	F	VRN
601	*O. elliptica* W. West	A, F, J	PRG, LKO, MHB

	Currently accepted name	Habitat	Localities
602	*O. irregularis* (Petkoff) Printz	A, K, F, P	PRG, SHR
603	*O. naegelii* A. Braun	K, I, F	KNP, MRT, SHR
604	*O. pusilla* Hansgirg	A	HMR
605	***Oogamochlamys*** *gigantea* (O. Dill) Proschold, B. Marin, U.W. Schlosser & Melkonian (=*Chlamydomonas capensis* Pocock)	C	PRG
606	***Oonephris*** *obesa* (West & G.S. West) Fott (=*Nephrocytium obesum* West & G.S. West)	F, P, D, J	PRG, KNP
607	***Palmella*** *miniata* Leiblein	K, F, J	LKO
608	*P. mucosa* Kützing	P	BAH
609	***Pandorina*** *cylindricum* M.O.P. Iyengar	D	GON
610	*P. morum* (O.F. Müller) Bory	K, D, J	KNP, LKO, LTP, MHB, SHR STP, VRN
611	***Papenfussiomonas*** *cordata* (Pascher & Jahoda) Desikachary	C	VRN, MRZ
612	***Parapediastrum*** *biradiatum* (Meyen) E. Hegewald (=*Pediastrum biradiatum* Meyen)	C, F	MHB
613	***Pediastrum*** *angulosum* Ehrenberg ex Meneghini (=*Pediastrum araneosum* (Raciborski) G.M. Smith)	K, D, F, J, P	GKP, MHB, SHR
614	*P. angulosum* var. *laevigatum* Raciborski	D, J	MRT, SHR
615	*P. cornutum* (Raciborski) Troitskaya	D, F	GKP
616	P. duplex Meyen (=*Pediastrum duplex* var. *genuinum* (A. Braun) Hansgirg; *Pediastrum duplex* var. *reticulatum* Lagerheim)	A, C, K, I, D, F, J	GZB, LKO, PRG, AYO, KNP MRT, LTP, SHR
617	*P. duplex* var. *regulosum* Raciborski	A, C, K, I, D, F, J	JHS
618	*P. simplex* Meyen (=*Pediastrum simplex* var. *duodenarium* (Bailey) Rabenhorst)	A, J	LKO
619	*P. subgranulatum* (Raciborski) J. Komárek & V. Jankovsk (=*Pediastrum duplex* var. *subgranulatum* Raciborski)	A, C, K, I, D, F, J	BAH, MHB
620	***Penium*** *cucurbitinum* var. *subpolymorphum* Nordstedt (=*Cosmarium cucurbitinum* var. *subpolymorphum* (Nordstedt) Lütkemüller)	F, J	BST, SHR
621	*P. margaritaceum* Brébisson	D	PRG
622	***Phacotus*** *lenticularis* (Ehrenberg) Diesing	F	STP
623	*P. lenticularis* var. *undulata* R. Shyam & Y.S.R.K. Sarma	F	VRN
624	***Pithophora*** *roettleri* (Roth) Wittrock (=*Pithophora cleveana* Wittrock; *Pithophora mooreana* Collins; *Pithophora oedogonia* (Montagne) Wittrock; *Pithophora polymorpha* Wittrock; *Pithophora sumatrana* (Wittrock) Mont; *Pithophora varia* Wille)	A, C, D, F, H, K, J, P	AYO, BAH, BLR, KNP, LKO, PRG, SUL, STP, VRN
625	***Pleodorina*** *indica* (Iyengar) H. Nozaki (= *Eudorina indica* M.O.P. Iyengar)	D, F	GON
626	***Pleurastrum*** *terricola* (Bristol) D.M. John (=*Gongrosira terricola* Bristol; *Pleurastrum terrestre* F.E. Fritsch & R.P. John)	M	LKO, PRG
627	***Pleurotaenium*** *baculoides* (J. Roy & Bisset) Playfair	D, F	PRG
628	*P. caldense* var. *cristatum* (W.B. Turner) Willi Krieger (=*Pleurotaenium cristatum* (W.B. Turner) O. Borge)	D, F	LKO
629	*P. coronatum* (Brébisson) Robenhorst	F	PRG
630	*P. coronatum* var. *fluctuatum* West	D, F	PRG, VRN
631	*P. cylindricum* (W.B. Turner) Schmidle	D, F	BBK, BRY
632	*P. ehrenbergii* (Ralfs) De Bary	D, F	PRG, BBK, GON, JHS, SHR
633	*P. ehrenbergii* var. *undulatum* Schaarschmidt	D, F	PRG, BBK, GON, JHS, SHR
634	*P. elatum* O. Borge	F	PRG
635	*P. eugeneum* (W.B. Turner) West & G.S. West	K, D	BRY, GON
636	*P. indicum* (Grunow) P. Lundell	F	BRY
637	*P. nodulosum* (Brébisson ex Ralfs) Rabenhorst (=*Pleurotaenium coronatum* var. *nodulosum* (Brébisson ex Ralfs) West)	D	PRG
638	*P. subcoronulatum* (W.B. Turner) West & G.S. West	K, D	LKO
639	*P. trabecula* Nägeli	K, D, F	PRG, BAH, BST, JHS, PLB
640	*P. varanasiense* Lakshminarasimhan	F	VRN
641	*P. cylindricum* var. *stuhlmannii* (Hieronymus) Willi Krieger	D, F	BBK
642	***Protosiphon*** *botryoides* (Kützing) Klebs	F	SUL

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643	***Pseudagloë*** *polychloris* (Pascher) K.I. Meyer (= *Carteria polychloris* Pascher)	E, J	PRG
644	***Pseudopediastrum*** *boryanum* (Turpin) E. Hegewald (=*Pediastrum boryanum* (Turpin) Meneghini)	K, D, J	PRG, GZB, KNP, LKO, STP
645	*P. boryanum* var. *longicorne* (Reinsch) Tsarenko (=*Pediastrum boryanum* var. *longicorne* Reinsch)	K, D, J	GZB
646	***Pseudorhizoclonium*** *africanum* (Kützing) Boedeker (=*Rhizoclonium hookeri* Kützing)	A, C, D, F, J	PRG
647	***Pseudostaurastrum*** *limneticum* (Borge) Couté & Rousselin (=*Tetraëdron limneticum* O. Borge)	J	PRG, VRN
648	***Pseudulvella*** *americana* (J.W. Snow) Wille	F	DEO, GKP, LKO, MHB
649	*P. americana* var. *indica* Philipose	F	DEO, GKP
650	***Pyrobotrys*** *acuminata* Y.S.R.K. Sarma & R. Shyam	F	VRN
651	*P. casinoensis* (Playfair) P.C. Silva (=*Pyrobotrys gracilis* (Korshikov) Korshikov)	F, L	KNP, VRN
652	*P. casinoensis* var. *intermedius* Y.S.R.K. Sarma & R. Shyam	C, F	VRN
653	*P. desikacharyi* Y.S.R.K. Sarma & R. Shyam	C, F	VRN
654	*P. korschikoffi* (L.A. Schkorbatov) Korshikov	K, H	VRN
655	*P. stellatus* (Korshikov) Korshikov	F	VRN
656	***Radiofilum*** *flavescens* G.S. West	A, F	SUL
657	***Raphidocelis*** *danubiana* (Hindák) Marvan, Komárek & Comas (=*Kirchneriella contorta* (Schmidle) Bohlin)	K, D	MHB
658	***Rhizoclonium*** *crassipellitum* West & G.S. West	D, F	BST, BLR, SKN
659	*R. hieroglyphicum* (C. Agardh) Kützing	A, C, D, F, J	BRY, BDN, BLR, FRK, KNP, LKO, MRD, RMP, SHP, STP, SUL, VRN
660	*R. pachydermum* Kjeillmann	A, D, F, H	BLR
661	*R. profundum* Brand	F	PRG
662	*R. tortuosum* Dillwy	A, D, F, H	BLR
663	***Scenedesmus*** *abundans* var. *longicauda* G.M. Smith	J	KNP
664	*S. apiculatus* (West & G.S. West) Chodat	K, P	LTP
665	*S. apiculatus* var. *indicus* (Hortobagyi) Hortobagyi	K, P	HMR
666	*S. arcuatus* (Lemmermann) Lemmermann	D, F, J	PRG, BAH, KNP, LTP, MHB
667	*S. arcuatus* var. *allahabadensis* Chadha & D.C. Pandey	D, F, J	PRG
668	*S. brevispina* (G.M. Smith) Chodat	D, F, J	SHR
669	*S. denticulatus* var. *australis* Playfair	D, F, J	SHR
670	*S. ellipticus* Corda (=*Scenedesmus linearis* Komárek)	D	SHR
671	*S. irregularis* Roll	K, I, F, J	BST, GKP, SKN
672	*S. lefevrei* var. *manguinii* Lefevre & Bourrelly	I	JHS
673	*S. magnus* Meyen (=*Scenedesmus longus* Meyen)	P, J	PRG, KNP
674	*S. maximus* (West & G.S. West) Chodat (=*Scenedesmus quadricauda* var. *westii* G.M. Smith)	F	PRG, JHS, STP
675	*S. monomorphus* Chadha & D.C. Pandey	F	PRG
676	*S. naegelii* Brébisson (=*Scenedesmus longus* var. *naegelii* (Brébisson) G.M. Smith)	P, J	PRG, KNP
677	*S. obtusus* Meyen (=*Scenedesmus bijugatus* var. *alternans* (Reinsch) Hansgirg; *Scenedesmus ovalternus* Brébisson)	B, I, D, F, J	LKO, LTP, SHR
678	*S. philiposei* Chadha & D.C. Pandey	A, B, C, K, I, D	PRG, LKO
679	*S. platydiscus* (G.M. Smith) Chodat	F, J	SHR
680	*S. prismaticus* Brühl & Biswas	D, P	PRG, BST
681	*S. quadricauda* (Turpin) Brébisson	F, J	PRG, HMR, JLN, KNP, LKO, MHB, SHR
682	*S. quadricauda* var. *bicaudatus* Hansgirg	F	PRG
683	*S. quadricauda* var. *eualternans* C.N. Proschkina-Lavrenko	F	PRG
684	*S. raciborskii* Woloszynska (=*Scenedesmus arcuatus* var. *capitatus* G.M. Smith; *Scenedesmus incrassatulus* var. *mononae* G.M. Smith)	D, F, J	KNP, LKO, LTP

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685	*S. semicristatus* Uherkovich	P	LTP
686	*S. smithii* Chodat	J	LKO
687	***Schizomeris** irregularis* Fritsch and Rich	F	PRG
688	*S. leibleinii* Kützing	B, C, F	BAH, BLR, AYO, JHS, LKO
689	***Schroederia** indica* Philipose	N	MHB
690	***Scotinosphaera** paradoxa* Klebs (=*Kentrosphaera bristoliae* G.M. Smith)	F	PRG
691	***Selenastrum** bibraianum* Reinsch (=*Ankistrodesmus bibraianus* (Reinsch) Korshikov)	D, I, F	MHB SHR
692	***Sirocladium** kumaoense* Randhawa	D, F	SUL
693	***Sirogonium** ceylanicum* Wittrock	F	SHR
694	*S. indicum* Singh	F	GKP
695	*S. melanoporum* (Randhawa) Transeau	F	AYO
696	*S. reticulatum* Randhawa	F	SHR SUL
697	*S. sticticum* (Smith) Kützing	D, F	SHR SUL
698	*S. stictium* (Smith) Kützing	F	PRG SUL VRN
699	*S. vandalurense* M.O.P. Iyengar	F, P	SHR SUL
700	*S. ventersicum* Transeau	D, F	GKP SHR
701	***Sorastrum** spinulosum* Nägeli	F, P	PRG, BAH, SHR, VRN
702	***Sphaerellocystis** ampla* (Kützing) Nováková (=*Gloeocystis ampla* (Kützing) Rabenhorst)	F, J	SHR
703	***Sphaerocystis** schroeteri* Chodat	B, D, F	KNP, SHR
704	***Sphaeroplea** annulina* (Roth) C. Agardh	B, A, D, F	GZB, KNP, MRT, SHR
705	***Sphaerozosma** laeve* (Nordstedt) Thomasson (=*Onychonema laeve* Nordstedt)	I, F	SHR
706	*S. laeve* var. *micracantha* (Nordstedt) Thomasson (=*Onychonema laeve* var. *micracanthum* Grönblad)	I, F	GON
707	*S. nitens* (Wallich) De Toni (=*Spondylosium nitens* (G.C. Wallich) Lundell)	C, K, D	PRG, BAH
708	*S. wallichii* var. *borgei* Grönblad	F	PRG
709	***Spirogyra** acanthophora* (Skuja) Czurda	F	SHR
710	*S. affinis* (Hassall) Petit	F	SHR
711	*S. africana* (F.E. Fritsh) Czurda	J	BRY, BDN, FRK, MRD, RMP, SHP
712	*S. anomala* Bhashyakarla Rao	F	PRG, AYO, KNP, MHB, KSM, SHR, VRN
713	*S. azygospora* R.N. Singh	F	GKP, SHR
714	*S. baileyi* Schmidle	F	SHR
715	*S. bichromatophora* (Randhawa) Transeau	C, F, J	BAH, AYO
716	*S. biformis* C.-C. Jao	F	BAH, AYO, GKP, LKO
717	*S. borgeana* Transeau	F	SHR
718	*S. brunnea* Czurda	F	SHR
719	*S. bullata* C.-C. Jao	F	SHR
720	*S. cataeniformi* (Hassall) Kützing	F, J	SHR
721	*S. chakiaensis* (Bhashyakarla Rao) Wille Krieger	F	SHR, VRN
722	*S. chakiaensis* var. *lucknowensis* B.N. Prasad & S. Dutta	F	SHR
723	*S. circumlineata* Transeau	F, J	HMR, LKO
724	*S. communis* (Hassall) Kützing	J	BLR, GKP, JLN, SHR, SUL
725	*S. condensata* (Vaucher) Dumortier	C, F, J	BLR, JLN, SHR
726	*S. crassa* (Kützing) Kützing	F	LKO, STP
727	*S. crenulata* R.N. Singh	F	GKP
728	*S. cylindrica* Czurda	D, F	SUL

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729	*S. daedalea* f. *oudhensis* (Randhawa) V. Poljansky (=*Spirogyra oudhensis* Randhawa)	F	AYO, SHR
730	*S. daedalea* Lagerheim	F	AYO
731	*S. decimina* (O.F. Müller) Dumortier	D	GKP, LKO
732	*S. decimina* var. *juergensii* (Kützing) Petlovany (=*Spirogyra juergensii* Kützing)	F	GKP, SHR
733	*S. diluta* H.C. Wood	C	BLR
734	*S. dubia* Kützing	F	BRY, MRT, SHP, VRN
735	*S. ellipsospora* Transeau	D	GKP
736	*S. elliptica* C.-C. Jao	B, D	MRT, SUL
737	*S. emilianensis* Bonhomme	F, J	SUL
738	*S. flavescen* (Hassall) Kützing	F	SHR, VRN
739	*S. fluviatilis* Hilse	J, O	SHR, VRN
740	*S. foveolata* (Transeau) Czurda	D, F	AYO
741	*S. gangaensis* Lakshminarasimhan	D	VRN
742	*S. ghosei* R.N. Singh	B	GKP
743	*S. gibberosa* C.-C. Jao	F	SHR
744	*S. gracilis* Kützing	F	SHR
745	*S. hassallii* (Jenn) Petit	F	SHR
746	*S. hatillensis* Transeau	K, F	LKO, KNP
747	*S. hyalina* Cleve	F	LKO
748	*S. hymerae* Britton & B.H. Smith	F	AYO, LKO, MRT
749	*S. irregularis* Nägeli ex Kützing	F	SHR
750	*S. jaoensis* Randhawa	F, J	AYO
751	*S. lagerheimii* Wittrock	J	SHR
752	*S. lambertiana* Transeau	J	AYO
753	*S. macrospora* (C.B. Rao) Krieger	F	SHR
754	*S. manoramae* Randhawa	F	BRY, BST
755	*S. margaritata* Wollny	F	GKP, VRN
756	*S. neglecta* (Hassal) Kützing	F	BLR, KNP, VRN
757	*S. neglecta* var. *fuellerbornei* (Schmidle) Petlovany (=*Spirogyra fuellebornei* Schmidle)	D	VRN
758	*S. nitida* (O.F. Müller) Leiblein	F, P	KNP, VRN
759	*S. paradoxa* Rao	G, P	VRN
760	*S. parvula* (Transeau) Czurda (=*Spirogyra cateniformis* var. *parvula* Transeau)	F, J, K	BAH, SHR
761	*S. perforans* Transeau	J	SHR
762	*S. plena* (West & G.S. West) Czurda	D, F	GKP
763	*S. pratensis* Transeau	P	VRN
764	*S. puncticulata* C.-C. Jao	F	SHR
765	*S. randhawae* Krieger	F	BLR, GON
766	*S. reticuliana* Randhawa	J	AYO
767	*S. rhizobrachialis* C.-C. Jao	B, D, F	SHR
768	*S. rivularis* (Hassall) Rabenhorst	F, J	MRT, SHR
769	*S. setiformis* Kützing	B, J	SHR
770	*S. singularis* Nordstedt (=*Spirogyra silvicola* M.E. Britton)	A, F	PRG, SHR, SUL, VRN
771	*S. skujae* Randhawa	F	AYO
772	*S. submaxima* Transeau	F	PRG, BRY
773	*S. subsalina* Cedercreutz	F	SHR

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774	*S. subsalsa* Kützing	F	SHR
775	*S. szechwanensis* C.-C. Jao	F	GKP, RLB, SUL
776	*S. tandae* Randhawa	F	AYO
777	*S. unduliseptum* Randhawa	F	AYO
778	*S. varians* (Hassall) Kützing	F	SHR, VRN
779	*S. velata* Nordstedt	J	SHR
780	*S. rhizoides* Randhawa	F	AYO
781	***Spirotaenia*** *condensata* Brébisson	C, F, J	KNP
782	***Spondylosium*** *planum* (Wolle) West & G.S. West	I, D	MHB
783	*S. pygmaeum* Cooke	I	SHR
784	***Staurastrum*** *alternans* Brébisson ex Ralfs	D, F	PRG
785	*S. anatinoides* A.M. Scott & Prescott	K, I, F	SHR
786	*S. bieneanum* Rabenhorst	F, J	LKO
787	*S. columbetoides* West & G.S. West	D, F	BRY
788	*S. dilatatum* Ehrenberg ex Ralfs	D, F	PRG
789	*S. gracile* Ralfs ex Ralfs	D, F, J	PRG, HMR
790	*S. gracile* var. *coronulatum* Boldt	F	PRG, BST, VRN
791	*S. hexacerum* Wittrock	D, F	PRG
792	*S. lapponicum* var. *ellipticum* (Wille) Grönblad (=*Staurastrum bieneanum* var. *ellipticum* Wille)	F, J	BAH, LKO, SHR
793	*S. oxyacanthum* W. Archer	I, D	SHR
794	*S. pachyrhynchum* Nordstedt	D	BBK, VRN
795	*S. paradoxum* var. *parvum* (West) N. Carter	F	BRY
796	*S. perundulatum* Grönblad	C, J	LKO
797	*S. pinnatum* var. *subpinnatum* (Schmidle) West & G.S. West	I, F	PLB
798	*S. pinnatum* W.B. Turner	I, F	PLB
799	*S. pseudotetracerum* (Nordstedt) West & G.S. West	I, D	SHR
800	*S. sebaldi* Reinsch	D, F	PRG
801	*S. sebaldi* var. *ventriverrucosum* A.M. Scott & Prescott	F	PRG
802	*S. setigerum* Cleve	D, F	PRG
803	*S. sexangulare* (Bulnheim) Rabenhorst	K	GON
804	*S. sexangulare* var. *productum* Nordstedt	K	GON
805	*S. tetracerum* Ralfs ex Ralfs	D, F	PRG
806	*S. wildemanii* Gutwinski	F	PRG
807	*S. wildemanii* var. *horizontale* A.M. Scott & Prescott	D, F	PRG
808	*S. zonatum* Børgesen	D	BST
809	*S. zonatum* var. *majus* A.M. Scott & Prescott	C, D	BST
810	*S. cyclacanthum* West & G.S. West	D, F	PRG
811	***Stauridium*** *tetras* (Ehrenberg) E. Hegewald (=*Pediastrum tetras* (Ehrenberg) Ralfs)	A, K, F, J	PRG, JLN, KNP, LKO, LTP, MRT
812	*S. tetras* var. *tetraodon* (Corda) J.D. Hall & Karol (=*Pediastrum tetraodon* (Corda) A. Braun; *Pediastrum tetras* var. *excisum* (A. Braun) Hansgirg*; Pediastrum tetras* var. *tetraodon* (Corda) Hansgirg)	F, J	BBK, BST, GZB, KNP, LKO, LTP
813	***Staurodesmus*** *arcuatus* (Joshua) Teiling (=*Arthrodesmus arcuatus* Joshua)	F, D	LKO
814	*S. convergens* (Ehrenberg ex Ralfs) S. Lillieroth (=*Arthrodesmus convergens* Ehrenberg ex Ralfs)	F, D	LKO
815	*S. curvatus* (W.B. Turner) Coesel & Van Geest (=*Arthrodesmus curvatus* W.B. Turner)	F, K	LKO
816	*S. pachyrhynchus* var. *pseudopachyrhynchus* (Wolle) Teiling (=*Staurastrum pseudopachyrhynchum* Wolle)	F	PLB

	Currently accepted name	Habitat	Localities
817	***Stigeoclonium*** *aestivale* (Hazen) Collins	F	GKP
818	*S. amoenum* Kützing	F, J	DEO, GKP, SUL
819	*S. attenuatum* (Hazen) Collins	F	LKO
820	*S. elongatum* (Hassal) Kützing	F	LKO
821	*S. farctum* Berthold	D	PRG, BAH, AYO, JHS
822	*S. fasciculare* Kützing	D, F	DEO, GKP
823	*S. fasciculare* var. *glomeratum* (Hazen) A.K.M. Islam (=*Stigeoclonium glomeratum* (Hazen) Collins)	F, P	KNJ, KNP, LKO
824	*S. flagelliferum* Kützing	F	LKO
825	*S. lubricum* (Dillwyn) Kützing	C	BRY, MNB, SHP
826	*S. nanum* (Dillwyn) Kützing	J	LKO
827	*S. nudiusculum* (Kützing) Rabenhorst	F	LKO
828	*S. polymorphum* (Franke) Heering	K, D	GKP, HMR, STP
829	*S. stagnatile* (Hazen) Collins	I, J	BAH
830	*S. subsecundum* (Kützing) Kützing	F	PRG
831	*S. tenue* (C. Agardh) Kützing	F	PRG, BAH, BLR, DEO, GKP, JHS, MRT
832	***Teilingia*** *granulata* (J. Roy & Bisset) Bourrelly (=*Sphaerozosma granulatum* J. Roy & Bisset)	A, B, D, F	PRG, STP
833	*T. wallichii* (J.P. Jacobsen) Bourrelly (=*Sphaerozosma wallichii* J.P. Jacobsen)	D, F	PRG
834	***Temnogametum*** *heterosporum* West & G.S. West	F	SUL
835	***Tetrabaena*** *socialis* (Dujardin) H. Nozaki & M. Itoh (=*Gonium sociale* (Dujardin) Warming)	D	STP
836	***Tetradesmus*** *bernardii* (G.M. Smith) M.J. Wynne (=*Scenedesmus bernardii* G.M. Smith)	J	HMR, LKO
837	*T. dimorphus* (Turpin) M.J. Wynne (=*Scenedesmus dimorphus* (Turpin) Kützing)	D, J	PRG, BAH, JHS, KNP, LKO, MHB, MRT
838	*T. incrassatulus* (Bohlin) M.J. Wynne (=*Scenedesmus incrassatulus* Bohlin)	D, F, J	BST
839	*T. lagerheimii* M.J. Wynne & Guiry (=*Scenedesmus acuminatus* (Lagerheim) Chodat)	J	KNP
840	*T. obliquus* (Turpin) M.J. Wynne (=*Scenedesmus bijugatus* Kützing; *Scenedesmus obliquus* (Turpin) Kützing)	B, I, D, F, J	BAH, GZB, PRG, KNP, LKO, MHB, MRT, VRN
841	***Tetraedron*** *bifurcatum* (Wille) Lagerheim	F	BBK
842	*T. caudatum* (Corda) Hansgirg	C, F	BBK
843	*T. gracile* (Reinsch) Hansgirg	F	BBK
844	*T. lunula* (Reinsch) Hansgirg (=*Closteridium lunula* Reinsch)	A	KSM
845	*T. trigonum* (Nägeli) Hansgirg	F	PRG, BBK
846	*T. tumidulum* (Reinsch) Hansgirg	J	BBK
847	***Tetrallantos*** *lagerheimii* Teiling	D, P	KNP, MHB, STP
848	***Tetraselmis*** *cordiformis* (H.J. Carter) F. Stein (=*Carteria cordiformis* (H.J. Carter) Diesing)	C, F, J	KNP
849	***Tetraspora*** *lubrica* (Roth) C. Agardh	D	MHB
850	*T. apiocystioides* Chowdary, Suryanarayan & Y.S.R.K. Sarma	F	KNP
851	*T. gelatinosa* (Vaucher) Desvaux	F, P	KNP, STP
852	***Tolypella*** *glomerata* (Desvaux) Leonhardi (=*Tolypella nidifica* var. *glomerata* (Desvaux) R.D. Wood)	D, F	BRY, LKO
853	*T. nidifica* (O.F. Müller) Leonhardi	F	BRY
854	***Transeauina*** *costata* (Rahdhawa) Guiry (=*Debarya costata* Randhawa)	A, F, D	AYO, KNP, MHB, SUL
855	***Trebouxia*** *arboricola* Puymaly (=*Trebouxia humicola* G.S. West & F.E. Fritsch)	J	LKO
856	***Trentepohlia*** *aurea* (Linnaeus) C. Martius	F	LKO
857	*T. umbrina* (Kützing) Bornet	F	LKO
858	***Ulothrix*** *aequalis* Kützing	F	BRY, SHP

	Currently accepted name	Habitat	Localities
859	*U. albicans* Kützing (=*Ulothrix moniliformis* (Kützing) Kützing)	F, P	KNP
860	*U. bipyrenoidosa* F.E. Fritsch & M.F. Rich	K, I	BAH
861	*U. fimbriata* Bold	K	BAH
862	*U. gigas* (Vischer) K.R. Mattox & Bold (=*Uronema gigas* Vischer)	F	PRG, BST, GON, GKP, AYO, LKO, MHB, SUL
863	*U. oscillarina* Kützing	F	BAH
864	*U. tenerrima* (Kützing) Kützing (=*Ulothrix variabilis* (Kützing) Kützing)	F, J	AGR, BDN, BRY, FRK, MRD, RMP, SHP, VRN
865	*U. tenuissima* Kützing	C, F	GON
866	*U. zonata* (F. Weber & Mohr) Kützing	F, P	BAH, GON, KNP, STP
867	***Ulva** flexuosa* Wulfen (=*Enteromorpha tubulosa* (Kützing) Kützing	F	PRG
868	*U. prolifera* O.F. Müller (=*Enteromorpha prolifera* (O.F. Müller) J. Agardh)	J	PRG
869	***Uronema** confervicola* Lagerheim	D, F	LKO, MHB, KNP
870	***Vaucheria** amphibia* Randhawa	E	VRN
871	*V. aversa* Hassall	A	VRN
872	*V. borealis* Hirn	F	VRN
873	*V. bursata* (O.F. Müller) C. Agardh (=*Vaucheria sessilis* (Vaucher) De Candolle)	M	VRN
874	*V. bursata* var. *major* (B.H. Smith) Q.X. Wang & W.-M. Bao (=*Vaucheria sessilis* var. *major* (B.H. Smith) Ventkataraman)	M	VRN
875	*V. cruciata* (Vaucher) De Candolle (=*Vaucheria debaryana* Woronin)	K, D, J	KSM, LTP, MAU, MRZ
876	*V. geminata* (Vaucher) De Candolle	A, F, M	BRY, MRZ
877	*V. geminata* var. *verticillata* (Meneghini) Rabenhorst	A	SUL
878	*V. hamata* (Vaucher) De Candolle	K	VRN
879	*V. nasuta* W.R. Taylor & Bornatowicz	A	SUL, VRN
880	*V. uncinata* Kützing	A	VRN
881	*V. undulata* C.-C. Jao	M	VRN
882	***Volvox** africanus* G.S. West	C, F, G, P, Q	LKO, MRZ
883	*V. aureus* Ehrenberg	F	LKO, LTP, SHP
884	*V. carteri* F. Stein	C, F, G, P, Q	LKO, MRZ
885	*V. globator* Linnaeus	C, F	BBK, LKO, VRN
886	*V. merrillii* W.R. Shaw	F	LKO
887	*V. rousseletii* G.S. West	F	LKO
888	*V. rousseletii* var. *lucknowensis* M.O.P. Iyengar	F	LKO
889	*V. spermatosphaera* J.H. Powers	F	AYO
890	***Willea** apiculata* (Lemmermann) D.M. John, M.J. Wynne & P.M. Tsarenko (=*Crucigenia apiculata* (Lemmermann) Schmidle)	D, F	MHB
891	*W. crucifera* (Wolle) D.M. John, M.J. Wynne & P.M. Tsarenko (=*Crucigenia crucifera* (Wolle) O. Kuntze)	D, F	MHB
892	*W. rectangularis* (A. Braun) D.M. John, M.J. Wynne & P.M. Tsarenko (=*Crucigenia rectangularis* (Nägeli) Komárek)	F	PRG
893	***Wittrockiella** sundarbanensis* (A.K. Islam) C. Boedeker (=*Cladophorella sundarbanensis* A.K. Islam)	A, D, F, H	BLR
894	***Xanthidium** antilopaeum* Kützing	D, N	PRG
895	***Zygnema** chalybeospermum* Hansgirg (=*Zygnema melanosporum* Lagerheim)	D, F	KSM, KNP, MHB, PRG
896	*Z. collinsianum* Transeau	F	AYO
897	*Z. cylindricum* Transeau	K, J	MHB, LKO
898	*Z. cylindrosporum* Czurda	F	PRG
899	*Z. czurdae* Randhawa	F	PRG
900	*Z. gangeticum* Bhashyakarla Rao	F	SHR, VRN
901	*Z. globosum* Czurda	F	GKP

	Currently accepted name	Habitat	Localities
902	*Z. gorakhporense* R.N. Singh	F	GKP, SHR
903	*Z. inconspicuum* Czurda	J, M	SHR
904	*Z. indicum* J.N. Misra	D, F, J	KNP, LKO, SKN
905	*Z. insigne* (Hassall) Kützing	F	BAH, KNP, SHR, SKN
906	*Z. mucigena* Randhawa	F	AYO
907	*Z. normanii* Taft	F	VRN
908	*Z. oudhense* Randhawa	F	GON
909	*Z. stellinum* (O.F. Müller) C. Agardh	F	SHR
910	*Z. terrestre* Randhawa	F, M	AYO, SUL
911	*Z. vaucheri* C. Agardh	F	BBK, GON
912	***Zygnemopsis*** *globosa* Randhawa (= *Zygnemopsis globosum* Czurda)	F	GKP
913	*Z. gracilis* Randhawa	M, O	AYO
914	*Z. indica* (Randhawa) Randhawa	M	PRG, SUL
915	*Z. iyengarii* (Randhawa) Randhawa	C	SUL
916	*Z. lamellata* Randhawa	M	AYO
917	*Z. minuta* Randhawa	M	AYO
918	*Z. sphaerospora* Randhawa	F, M	AYO
919	*Z. splendens* Randhawa	F	AYO, RMP
920	*Z. transeauana* Randhawa	F	AYO
921	*Z. vermaii* B.N. Prasad & V. Kumari	M	LKO

Cambridge University Press, London, 791pp.

Griffith, W. (1849). Notulae and Plantas. *Asiaticans* 2: 275–284.

Guiry, M.D. (2012). How many species of algae are there? *Journal Phycology* 48: 105–1063. https://doi.org/10.1111/j.1529-8817.2012.01222.x

Guiry, M.D. & G.M. Guiry (2019). *Algaebase*. Worldwide electronic publication, National University of Ireland, Galway (http://www.algaebase.org). Accessed on 19.vii.2020.

Gupta, A.B. (1956a). A contribution to the algal flora of the Allahabad district. *The Journal of Research* 3(1): 76–81.

Gupta, A.B. (1956b). The algal flora of some paddy fields and its importance in soil economy. *The Journal of Research* 4(1): 1–24.

Gupta, M. & D.C. Pandey (1979). A study on the alkaline (usar) soil algae. *Nova Hedwigia* 63: 297–324.

Gupta, R.K. (2012). *A Checklist of Chlorophyceae, Xanthophyceae, Chrysophyceae and Euglenophyceae II*. Botanical Survey of India, Kolkata, 428pp.

Hortobagyi, T. (1969). Phytoplankton organisms from three reservoirs of Jamuna River India. Acta *Botanica Academiae Scientiarum Hungarica* 148: 1–80.

Khan, M. & R.S. Rawat (1972). Studies on the algal flora of Golatappar swamp (A piliminary Report). *Phykos* 11(1–2): 67–70.

Kumar, H. (1975). A checklist of *Spirogyra* from Meerut. *Phykos* 14(1–2): 11.

Lakshminarayana, J.S.S. (1963). Algal flora of Uttar Pradesh IV, Chlorophyceae, Conjugales, Siphonales and Charales. *Environmental Health* 5: 1–5.

Mao, A.A. & S.S. Dash (2019). Plant Discoveries 2018. Botanical Survey of India, Kolkata.

Mitra, A.K. (1947). On the structure and reproduction of *Uronema terrestre* n. sp. *Annals Botany* 11(43): 349–361.

Mitra, A.K. (1950a). A peculiar method of sexual reproduction in certain new members of the Chlamydomonadaceae. *Hydrobiologia* 2(3):209–216. https://doi.org/10.1007/BF00046556

Mitra, A.K. (1950b). Two new algae from Indian soils. *Annals of Botany* 14(56): 457–464.

Mitra, A.K. (1951a). The algae of certain Indian soils. *Indian Journal of Agriculture Science* 31(4): 357–373.

Mitra, A.K. (1951b). Certain new members of the Volvocaceae from Indian soils. *Phytomorphology* 1(1–22): 58–64.

Pal, S. (1977). A preliminary list of Zygnemaceae of Saharanpur, UP, India. *Phykos* 16(1–2): 43–45.

Pandey, D.C. (1966). A study on the algae from paddy field soils of Ballia and Ghazipur districts of Uttar Pradesh, India 11 (B). *Nova Hedwigia* 11: 75–88.

Pandey, S.N. (1969). Studies on planktonic algae of Kanpur. *Journal Science and Technology India* 7B(2): 63–167.

Pandey, U.C. & U.K. Chaturvedi (1979). Algae of Rohilkhand division Uttar Pradesh, India-V. *Phykos* 18(1–2): 37–43.

Pandey, U.C., G.L. Tiwari & D.C. Pandey (1981). Addition to the algal flora of Allahabad-VII, Chlorophyta, Chlorococcales. *Proceedings of Indian National Society Academy* 47(2): 255–259.

Prasad, B.N. (1964–1965). On the algal flora of river Varuna in Varanasi district. *Journal Science Research* 15(1): 142–151.

Prasad, B.N. & D.K. Asthana (1975a). Genus *Chaetopeltis* Berthold in India. *Current Science* 444(21): 781.

Prasad, B.N. & D.K. Asthana (1975b). Genus *spongioplastidium* Visher in India. *New Botanist* 2(3–4): 18–50.

Prasad, B.N. & D.K. Asthana (1978). *Coleochaete pseudosoluta*-New addition to the Indian flora. *Current Science* 44(5): 176.

Prasad, B.N. & S. Dutta (1970a). Abnormal conjugations in *Spirogyra*. *Current Science* 39 (19): 444–445.

Prasad, B.N. & S. Dutta (1970b). Two new taxa of *Spirogyra*. *Hydrobiologia* 36(1): 27–31. https://doi.org/10.1007/BF00751280

Prasad, B.N., S. Dutta & V. Jain (1973). Cytological studies in the genus *Rhizoclonium*. *Phykos* 1(1–2): 106–113.

Prasad, B.N. & T. Fatima (1981a). *Chaetosphaeridium pringsheimii*-A new addition to the algal flora of India. *Current Science* 50: 187–188.

Prasad, B.N. & T. Fatima (1981b). *Stigeoclonium nudiuscullum* (Kuetz.) Kuetz. An addition to the Indian flora. *Current Science* 50: 187–188.

Table 2. Current taxonomic position of various taxa after segregation of Fritsch's class Chlorophyceae in Uttar Pradesh.

Phylum	Class	Order	Family	Genera
Charophyta	Charophyceae	Charales	Characeae	*Chara (13), Nitella (23), Tolypella (2)*
	Coleochaetophyceae	Chaetosphaeridiales	Chaetosphaeridiaceae	*Chaetosphaeridium (3)*
		Coleochaetales	Coleochaetaceae	*Coleochaete (10), Conochaete (1)*
	Klebsormidiophyceae	Klebsormidiales	Klebsormidiaceae	*Klebsormidium (2)*
	Zygnematophyceae	Desmidiales	Closteriaceae	*Closterium (54)*
			Desmidiaceae	*Actinotaenium (5), Arthrodesmus (1), Cosmarium (163), Cosmocladium (1), Desmidium (3), Docidium (1), Euastrum (39), Hyalotheca (2), Micrasterias (9), Pleurotaenium (15), Sphaerozosma (4), Spondylosium (2), Staurastrum (27), Staurodesmus (4), Teilingia (2), Xanthidium (1)*
			Gonatozygaceae	*Gonatozygon (1)*
			Peniaceae	*Penium (1)*
		Zygnematales	Mesotaeniaceae	*Cylindrocystis (1), Netrium (1), Spirotaenia (1)*
			Zygnemataceae	*Mougeotia (11), Sirocladium (9), Sirogonium (8), Spirogyra (72), Temnogametum (1), Transeauina (1), Zygnema (17), Zygnemopsis (10)*
Chlorophyta	Chlorodendrophyceae	Chlorodendrales	Chlorodendraceae	*Tetraselmis (1)*
	Chlorophyceae	Chaetopeltidales	Chaetopeltidaceae	*Chaetopeltis (1), Pseudulvella (2)*
		Chaetophorales	Aphanochaetaceae	*Aphanochaete (3)*
			Chaetophoraceae	*Chaetophora (1), Chaetophoropsis (4), Draparnaldia (6), Epibolium (1), Iwanoffia (1), Leptosiropsis (1), Stigeoclonium (15)*
			Fritschiellaceae	*Fritschiella (1)*
			Schizomeridaceae	*Schizomeris (2)*
			Uronemataceae	*Uronema (1)*
		Chlamydomonadales	Carteriaceae	*Pseudagloë (1)*
			Chlamydomonadaceae	*Carteria (2), Chlamydomonas (13), Microglena (2) Oogamochlamys (1)*
			Chlorochytriaceae	*Chlorochytrium (1)*
			Chlorococcaceae	*Chlorococcum (2)*
			Dunaliellaceae	*Papenfussiomonas (1)*
			Goniaceae	*Gonium (2)*
			Haematococcaceae	*Balticola (1), Chlorogonium (2), Haematococcus (1)*
			Palmellaceae	*Palmella (2)*
			Palmellopsidaceae	*Asterococcus (1), Chlamydocapsa (1), Sphaerellocystis (1)*
			Phacotaceae	*Phacotus (2)*
			Pleurastraceae	*Pleurastrum (1)*
			Protosiphonaceae	*Protosiphon (1)*
			Spondylomoraceae	*Pyrobotrys (6)*
			Sphaerocystidaceae	*Sphaerocystis (1)*
			Tetrabaenaceae	*Tetrabaena (1)*
			Tetrasporaceae	*Tetraspora (3)*
			Volvocaceae	*Eudorina (1), Pandorina (2), Pleodorina (1), Volvox (8)*

		Oedogoniales	Oedogoniaceae	*Bulbochaete (13), Oedocladium (1), Oedogonium (79)*
		Sphaeropleales	Characiaceae	*Characiellopsis (1), Characium (3)*
			Cylindrocapsaceae	*Cylindrocapsa (4)*
			Hydrodictyaceae	*Hydrodictyon (1), Lacunastrum (1), Monactinus (1), Parapediastrum (1), Pediastrum (7), Pseudopediastrum (2), Sorastrum (1), Stauridium (1), Tetraedron (6)*
			Radiococcaceae	*Coenocystis (1), Gloeocystis (2)*
			Scenedesmaceae	*Acutodesmus (1), Coelastrum (6), Comasiella (1), Desmodesmus (19), Dimorphococcus (1), Hariotina (1), Scenedesmus (24), Tetradesmus (5), Tetrallantos (1)*
			Microsporaceae	*Microspora (5)*
			Selenastraceae	*Ankistrodesmus (5), Kirchneriella (3), Messastrum (2), Monoraphidium (1), Raphidocelis (1), Selenastrum (1)*
			Sphaeropleaceae	*Radiofilum (1), Sphaeroplea (1)*
			Schroederiaceae	*Schroederia (1)*
	Trebouxiophyceae	Chlorellales	Chlorellaceae	*Actinastrum (2), Chlorella (1), Closteriopsis (1), Dictyosphaerium (3), Geminella (1), Micractinium (1), Mucidosphaerium (1)*
			Eremosphaeraceae	*Neglectella (1)*
			Oocystaceae	*Elongatocystis (1), Eremosphaera (1), Gloeotaenium (1), Nephrocytium (2), Oocystaenium (1), Oocystis (7), Oonephris (1), Willea (3)*
		Microthamniales	Microthamniaceae	*Microthamnion (3)*
		Prasiolales	Stichococcaceae	*Diplosphaera (1), Desmococcus (1)*
		Trebouxiales	Botryococcaceae	*Botryococcus (1)*
			Trebouxiaceae	*Trebouxia (1)*
		Trebouxiophyceae ordo incertae sedis	Coccomyxaceae	*Choricystis (1), Coccomyxa (2)*
			Trebouxiophyceae fam. incertae sedis	*Crucigenia (4), Lemmermannia (1)*
	Ulvophyceae	Bryopsidales	Dichotomosiphonaceae	*Dichotomosiphon (1)*
		Cladophorales	Cladophoraceae	*Cladophora (8), Lychaete (1), Pseudorhizoclonium (1), Rhizoclonium (5)*
			Pithophoraceae	*Aegagropila (2), Aegagropilopsis (1), Arnoldiella (1), Pithophora (1), Wittrockiella (1)*
		Scotinosphaerales	Scotinosphaeraceae	*Scotinosphaera (1)*
		Trentepohliales	Trentepohliaceae	*Cephaleuros (1), Trentepohlia (2)*
		Ulotrichales	Ulotrichaceae	*Gloeotilopsis (1), Ulothrix (9)*
		Ulvales	Ctenocladaceae	*Ctenocladus (1)*
			Ulvaceae	*Enteromorpha (1), Ulva (2)*
Glaucophyta	Glaucophyceae	Glaucocystales	Glaucocystaceae	*Glaucocystis (3)*
Ochrophyta	Eustigmatophyceae	Goniochloridales	Goniochloridaceae	*Goniochloris (1), Pseudostaurastrum (1)*
	Xanthophyceae	Vaucheriales	Vaucheriaceae	*Vaucheria (12)*

Prasad, B.N. & T. Fatima (1981c). *Aphanochaete magna* Godward-A new addition to Indian flora. *Geophytology* 11(2): 211–213.

Prasad, B.N. & V.K. Jain (1978). New additions to the algal flora of India-I, two species of *Pithophora. Science Letters, National Academy Sciences* 1(1): 10.

Prasad, B.N., & V. Kumari (1979). On four species of Cladophorales new to Indian flora. *Journal Indian Botanical Society* 58(2): 127–129.

Prasad, B.N. & P.N. Srivastava (1964). Some observations on *Uronema gigas* Visher. *Journal Indian Botanical Sciences* 43(1): 113–120.

Rai, L.C. & H.D. Kumar (1976). Systematic and ecological studies on algae of some habitats polluted with fertillizer factory effluent. *Nova Hedwigia* 22: 805–811.

Randhawa, M.S. (1946). Further observations on *Fritschiella tuberose* Iyengar. *New Phytology* 45(2): 278–279.

Rao, A.R. (1948). *Volvox* in North India. *Current Science* 17: 240.

Rao, C.B. (1937). The Zygnemoides of the United Provinces, India-I. *Journal Indian Botanical Society* 16(5): 269–288.

Ruggiero, M.A., D.P. Gordon, T.M. Orrell, N. Bailly, T. Bourgoin, R.C. Brusca, T.C. Cavalier-Smith, M.D. Guiry & P.M. Kirk (2015). A higher-level classification of all living organisms. *Plos One* 10(4): e0119248. https://doi.org/10.1371/journal.pone.0119248

Sarma, Y.S.R.K. (1962–1963). On collection of algae from Rael Tal of district Varanasi. *Journal Sciences Research* 13(2): 382–392.

Sarma, Y.S.R.K. & R. Shyam (1974). *Lundiella indica* sp. nov. A new member of colonial Volvocales (Chlorophyceae), from India. *British Phycological Journal* 9: 307–311.

Shukla, A.C. (1971). Systematic description of algae from Panki rice fields, India. *Review Algology* 3: 257–270.

Singh, R.N. (1938). The Zygnemoides of the United Provinces, India-II. *Journal Indian Botanical Society* 17(5–6): 369–384.

Singh, R.N. (1939). An investigation into the algal flora of paddy field soils of United Provinces, I. *Indian Journal Agricultural Science* 19(1): 55–77.

Singh, R.N. (1941). On some phases in the life history of terrestrial algae, *Fritschiella tuberose* Iyenger and its autecology. *New Phytology* 40(3): 170–182.

Singh, R.N. (1945). A comparative study of the life cycle of two species of Genus *Stigeoclonium* (*S. farctum and S. amoenum*). *Review Algology* 1: 42.

Suseela, M.R., K. Toppo & M.A. Usmani (2015). Enumeration of fresh water algal flora of Uttar Pradesh, pp. 378–427. In: Mishra, G.K., Nayaka, S., Saini, D.C. (eds.). *Plant diversity of Uttar Pradesh (including Algae and Fungi).* ASR Publications, Ghaziabad.

Tiwari, G.L., D.C. Pandey & R.S. Pandey (1979). *Draparnaldia iyengarii* sp. nov. (Chaetophorales, Chlorophyta), from India. *Phycologia* 18(3): 237–246.

Venkataraman, G.S. (1957). The algal flora of the ponds and puddles inside the Banaras Hindu University Grounds, India. *Journal Bombay Natural History Society* 54(4): 908–919.

Venkataraman, G.S. (1959). Some new and interesting forms of *Oedogonium* from Uttar Pradesh, India. *Journal Bombay Natural History Society* 56(1): 60–65.

Additional bibliography (References not cited in the text, but utilized for compilation of checklist),

Agarwal, S.C. (1990). Studies on the morphology and reproduction of *Stigeoclonium pascheri* (Vischer) Cox & Bold. *Phykos* 29(1–2): 83–87.

Ahmad, M.R. (1972). Algae of Allen forest lake Kanpur, India. *Nova Hedwigia* 23(1): 125–129.

Awasthi, A.K. (2015). Algal flora of Kanpur, Uttar Pradesh, pp. 428–434. In: Mishra, G.K., Nayaka, S., Saini, D.C. (eds.) *Plant diversity of Uttar Pradesh (Including Algae and Fungi)*. ASR Publications, Ghaziabad.

Chadha, A. (1979). Investigation on the algal flora of Allahabad. PhD Thesis. University of Allahabad, Allahabad, 214 pp.

Chadha, A. & D.C. Pandey (1982). Distribution of algae on the walls of buildings. *Phykos* 21: 122–123.

Chadha, A. & D.C. Pandey (1984). Algal flora of Allahabad Part IV, a general account. *Bibliotheca Phycologia* 66: 141–178.

Chaturvedi, B.R. (1983). Karyology of an Indian strain of *Sphaeroplea annulina* (Roth) Ag. *Bibliotheca Phycologia* 66: 101–109.

Chaturvedi, B.R. & R.N. Prasad (1984). Euglenoid flora of Varanasi and its adjoining regions. *The Journal Science Research* 34: 135–140.

Chaturvedi, U.K., D.C. Pandey, I. Habib & H.M. Shukla (1987). Desmids of Bareilly–II. *Phykos* 26: 95–102.

Das, S.K. & S.P. Adhikary (2014). *Freshwater Algae of Eastern India*. Daya Publishers, New Delhi, 423 pp.

Dwivedi, S. (2001). Studies on algal diversity in central and western Uttar Pradesh, India. PhD Thesis. University of Lucknow, Lucknow, 237 pp.

Dwivedi, S., P.K. Misra & M.R. Suseela (2004). Some Desmids from central and western Uttar Pradesh India. *Phytotaxonomy* 4: 64–73.

Dwivedi, S., P.K. Misra, R.D. Tripathi, U.N. Rai, C.P. Dwivedi, V.S. Baghel, M.R. Suseela & M.N. Srivastava (2005). Systematic and ecological studies on Chlorophycean algae of North India and their relationship with water quality. *Journal of Environmental Biology* 26(3): 495–503.

Fatima, T. (1985). Epiphytic algal flora of freshwater ponds of Lucknow-Chaetophorales. *Phykos* 24: 173–174.

Gonzalves, E.A. (1982). *Oedogoniales. Monograph on Algae*. Indian Council of Agricultural Research, New Delhi, 757 pp.

Gupta, A.B. & D.C. Roy (1975). Utilization of algae by some common fishes of two ponds. *Nova Hedwigia* 26 (2–3): 509–515.

Gupta, A.K. (1992). *Morphological and cytological studies of some members of Oedogoniales (Chlorophyceae).* PhD Thesis. Banaras Hindu University, Varanasi, 117 pp.

Gupta, S. (2005). Algae of Basti district of Uttar Pradesh. MSc dissertation. University of Lucknow, Lucknow, 93 pp.

Gupta, S. (2010). Algal biodiversity in Bundelkhand region of Uttar Pradesh, India. PhD Thesis. University of Lucknow, Lucknow, 147 pp.

Habib, I. & U.C. Pandey (1989). On occurrence of *Bulbochaete* sp. from Bareilly India. *Indian Botanical Contractor* 6(3): 103–104.

Habib, I. & U.C. Pandey (1990). The Euglenineae from the Nakatia river, Bareilly UP, India. *Journal of Indian Botanical Society* 69: 387–390.

Habib, I. (1993). Contributions to Desmids of Rohilkhand divison, U.P. India. *Geophytology* 23(1): 177-179.

Habib, I. & U.K. Chaturvedi (2008). Epiphytic algal flora of freshwater bodies of Bundelkhand division of Uttar Pradesh. *Journal Economic Taxonomic Botany* 32(1): 1–3.

Habib, I. (2009). Morphotaxonomic enumeration of Desmids from Hardoi district, Uttar Pradesh, India. *Journal Indian Botanical Society* 88(3–4): 27–31.

Iyengar, M.O.P. & T.V. Desikachary (1981). *Volvocales. Monograph on Algae*. Indian Council of Agricultural Research, New Delhi, 532 pp.

Khan, M. (1985). Algal flora of Sultanpur, Uttar Pradesh, India. *Phykos* 24: 52–57.

Kumar, S. & M.R. Suseela (2004). Fresh water algal variation of river Gomti at three different sites in winter months. *Journal of Economic and Taxonomic Botany* 28(2): 98–402.

Kumar, M., P.K. Khare & R. Singh (2016). Hydrobiological studies of the Yamuna River at Kalpi district, Jalaun, Uttar Pradesh, India. *Hydrobiology Nepal* 18: 41–46. https://doi.org/10.3126/hn.v18i0

Kurra, S. (1989). Studies on karyology, nutrition and developmental morphology of some local Chlorococcalean green algae. PhD Thesis. Banaras Hindu University, Varanasi, 132 pp.

Misra, P.K., A.K. Srivastava, R.K. Mehrotra & S.K. Singh (2002). Genus *Oedogonium* Link from North Eastern Uttar Pradesh. *Geophytology* 30(1–2): 103–109.

Misra, P.K., R.K. Mehrotra, J. Prakash, A.K. Srivastava & S. Kishore (2002). Fresh water planktonic algae from Basti, Uttar Pradesh. *Geophytology* 30(1–2): 61–73.

Misra, P.K., A.K. Srivastava & J. Prakash (2002). Morpho taxonomic survey of Ulotrichales of North Eastern Uttar Pradesh, India. *Journal Indian Botanical Society* 81: 345–350.

Misra, P.K., J. Prakash & A.K. Srivastava (2002). Filamentous green algae from Basti, Uttar Pradesh, India. *Phytotaxonomy* 2: 130–134.

Misra, P.K. & A.K. Srivastava (2003). Some Desmids (Chlorophyceaea) From North Eastern Uttar Pradesh, India. *Journal Indian Botanical Society* 82: 85–92.

Misra, P.K. & A.K. Srivastava (2003). Some Chaetophoralean algae

from North-Eastern Uttar Pradesh, India. *Vegetos* 16: 65–71.

Misra, P.K. & A.K. Srivastava (2004). Some Zygnematalean algae from North-Eastern Uttar Pradesh, India. *Ecoprint* 11(1): 19–25. https://doi.org/10.3126/eco.v11i1.141

Misra, P.K., A.K. Srivastava & J. Prakash (2004). Structural abnormalities in some green algae from North-Eastern part of Uttar Pradesh. *Geophytology* 33(1–2): 17–20.

Misra, P.K., J. Prakash & A.K. Srivastava (2004). Some abnormal planktonic algae from Bakhira lake. *Vegetos* 17: 59–62.

Misra, P.K, J. Prakash, A.K. Srivastava & P.K. Singh (2004). Some fresh water planktonic algae from SantKabir Nagar, Uttar Pradesh. *Phytotaxonomy* 4: 87–94.

Misra, P.K., A.K. Srivastava, J. Prakash & S.K. Rai (2005). Some fresh water filamentous Chlorophycean algae from district Balrampur, Uttar Pradesh, India. *Economic Environment and Conservation* 11(4): 29–431.

Misra, P.K., A.K. Srivastava, J. Prakash, D.K. Asthana & S.K. Rai (2005). Some freshwater algae of Eastern Uttar Pradesh, India. *Our Nature* 3: 77–80. https://doi.org/10.3126/on.v3i1.338

Misra, P.K. & S.K. Tripathi (2009). Some Chlorococclean algae from western Uttar Pradesh, India. *Journal Indian Botanical Society* 88(3–4): 19–23.

Mohan, N., S.K. Singh & G. Mishra (2017). *Algal Flora of Ghatampur Kanpur, Uttar Pradesh.* Lap Lambert Academic Publisher, Deutschland, Germany, 213 pp.

Pal, S. (1975). A checklist of algae from Ghaziabad. *Phykos* 14(1–2): 67–76.

Pandey, B.N. & D.K. Asthana (1975a). Genus *Chaetopeltis* Berthold in India. *Current Science* 44(21): 781.

Pandey, B.N. & D.K. Asthana (1975b). Genus *Spongioplastidium* Visher in India. *New Botanist* 2(3–4): 148–50.

Pandey, B.N. & D.K. Asthana (1978). *Coleochaete pseudosoluta*-New addition to the Indian flora. *Current Science* 47(5): 176.

Pandey, U.C. & D.C. Pandey (1980a). Additions to the algal flora of Allahabad-III, Desmids. *Phykos* 19(1): 71–81.

Pandey, U.C. & D.C. Pandey (1980b). Additions to the algal flora of Allahabad-V, Desmids. *Phykos* 19 (2): 161–170.

Pandey, U.C. & D.C. Pandey (1980c). Desmids of Allahabad. *Journal Indian Botanical Society* 59(3): 246–250.

Pandey, U.C. (1983). *Oedocladium prescotii* Islam. A new record from Rohilkhand division U.P., India. *Biblotheca Phycologia* 66: 111–114.

Pandey, U.C., R.K. Tiwari & D.C. Pandey (1983). An enumeration of Chlorococcales from Allahabad U.P., India. *Bibliotheca Phycologia* 66: 115–126.

Pandey, U.C., R.K. Tiwari & C. Pandey (1983). Addition to the algal flora of Allahabad IX- Chlorophyceae. *Bibliotheca Phycologia* 66: 247–258.

Pandey, U.C., I. Habib, F.C. Gangwar & H.M. Shukla (198 7). A contribution to our knowledge of Desmids from Bareilly. *Phykos* 26: 86–94.

Prasad, B.N. & R.K. Mehrotra (1970). Desmid flora of North Indian paddy fields. *New Botanist* 4(1–4): 49–74.

Prasad, B.N. & R.K. Mehrotra (1977a). Some Desmids new to Indian flora. *Journal Indian Botanical Society* 56: 343–350.

Prasad, B.N. & R.K. Mehrotra (1977b). Desmid flora of North Indian paddy fields. *New Botanist* 4(1–4): 49–74.

Prasad, R.N. (1985). Systematic and cytological studies on Euglenoids flagellates. Ph.D. Thesis. Banaras Hindu University, Varanasi, 171 pp.

Randhawa, M.S. (1936). Occurrence and distribution of the freshwater algae of North India. *Proceedings Indian Academy Science* 4(1): 36–44.

Rishi, V., R. Singh & A.K. Awasthi (2016). A Systematic Account of order Chroococcales from river Ganga at Kanpur U.P., India. *Indian Journal of Fundamental and Applied Life Sciences* 6 (2): 91–100.

Rizvi, A. (2011). Studies on algal indicators of water pollution in river Gomti. PhD Thesis. University of Lucknow, Lucknow, 195 pp.

Sarma, Y.S.R.K. & M. Khan (1991). Freshwater algae, pp 56. In: Khan, M. (eds.) *Indian Phycological Review*. Bishen Singh and Mahendra Pal Sigh, Dehradun.

Saxena, P.N. (1960). Algal flora of usar lands in Uttar Pradesh. *Science and Culture* 25(9): 542–543.

Saxena, M. (1978). Studies on the influence of industrial effluents on some lotic algae. PhD Thesis. University of Lucknow, Lucknow, 180 pp.

Shukla, H.M., R.K. Tiwari, U.C. Pandey & G.L. Tiwari (1987). Addition of two species of the genus *Bulbochaete* Agardh (Oedogoniales, Chlorophyta) to Indian algal flora. *Current Science* 56(9): 429–431.

Shukla, H.M., G.L. Tiwari, U.C. Pandey & I. Habib (1988). Oedogoniales of Uttar Pradesh, India, *Oedogonium* Link. *Proceedings Indian Academy of Sciences* 98(6): 465–470.

Shukla, H.M. & G.L. Tiwari (1989). On some species of the genus *Bulbochaete* Agardh Chlorophyta Oedogoniales from Mauri lake Pratapgarh, Uttar Pradesh, India. *Proceedings Indian Academy Sciences* 59(2): 205–2012.

Shyam, R. (1974). Studies on the cytology and systematics of fresh water algal flagellates. PhD Thesis. Banaras Hindu University, Varanasi, 191 pp.

Singh, R.N. (1938). The Oedogoniales of the United Provinces, India-I. *Proceedings Indian Academy Sciences* 4(2): 97–107.

Singh, V.P. & P.N. Saxena (1969). Preliminary studies on algal succession in raw and stabilized sewage. *Hydrobiologia* 34(3–4): 503–512. https://doi.org/10.1007/BF00045406

Singh, V.P., P.N. Saxena, A. Tewari & M.A. Khan (1970). Studies on the seasonal variation of algal flora of sewage. *Phykos* 9(2): 57–62.

Singh, V.P. (1971). Chlorophyceaea of the Banaras district, India-1. *Proceedings Indian Academy Science* 14(3): 250–255.

Singh, S.B. (1974). Effect of radiations on some green algae with particular reference to their cytology. PhD Thesis. Banaras Hindu University, Varanasi, 79 pp.

Singh, A.K. (1988). Ecophysiological studies on algae of river Ganga in relation to heavy metal pollution. PhD Thesis. Banaras Hindu University, Varanasi, 108 pp.

Singh, V.K. (2009). Morphogenetic and molecular studies in selected Charophyta taxa. PhD Thesis. Banaras Hindu University, Varanasi, 110 pp.

Singh, A.P. & B.R. Chaudhary (2011). Phenological diversity of Chlorophycean algae from river Ganga at Varanasi. *Journal of Algal Biomass Utilization* 2(1): 21–29.

Singh, A.P. (2011). Cytomorphological and allelopathic investigations in Cladophoralean algae. PhD Thesis. Banaras Hindu University, Varanasi, 102 pp.

Singh, A., V. Tiwari & J. Mohan (2014). Chroococcales in river Ganga at Jajmaughat Kanpur. *Tropical Plant Research* 1(1): 28–30.

Srivastava, A.K. (2000). Algal flora of district Barabanki Uttar Pradesh. MPhil dissertation. University of Lucknow, Lucknow, 72 pp.

Srivastava, A.K. (2000). Algal flora of district, Barabanki, Uttar Pradesh. PhD Thesis. University of Lucknow, Lucknow, 181 pp.

Srivastava, A.K. (2002). Studies on freshwater algae of North-Eastern, Uttar Pradesh.PhD Thesis. University of Lucknow, Lucknow, 197 pp.

Srivastava, A.K. & P.K. Misra (2007). Some freshwater red and yellow-green algae from North-Eastern Uttar Pradesh, India. *Ecoprint* 14: 97–100. https://doi.org/10.3126/eco.v14i0.4833

Srivastava, A.K. (2009). Some fresh water filamentous green algae from Faizabad district of Uttar Pradesh, India. *International Journal of Plant Sciences* 5(1): 347–349.

Srivastava, A.K. & P.K. Misra (2009). *Coleochaete* Brebisson and *Bulbochaete* Agardh from North-Eastern Uttar Pradesh, India. *Ecoprint* 16: 59–63. https://doi.org/10.3126/eco.v16i0.3474

Suseela, M.R. & K. Toppo (2010). Algal flora of Katarniyaghat Wildlife Sanctuary, district Bahraich in Uttar Pradesh India. *Indian Journal of Forestry* 33(2): 217–220.

Tiwari, R.K. (1983). *Conochaete comosa* Klebahn (Chlrorophyta) - A new addition to India flora. *Current Science* 52(15): 734–735.

Tiwari, G.L., R.S. Pandey, S.P. Singh & R.K. Tiwari (1984). Observation on the life cycle of *Bulbochaete allahabadensis* sp. nov. (Chlorophyta, Oedogoniaceae). *Hydrobiologia* 114(3): 201–207. https://doi.org/10.1007/BF00031871

Tripathi, A.K. & S.N. Pandey (1985). Algal pollutants of Unnao ponds-

III Euglenineae. *Journal Economic Taxonomic Botany* 7(3): 581–584.

Tripathi, A.K., S.N. Pandey & B.K. Sinha (1987). Algal pollutants of Unnao ponds-IV Chlorococcales. *Journal Economic Taxonomic Botany* 9(1): 239–243.

Tripathi, S.K. (2011). Studies on phyco-diversity of western UP, India. PhD Thesis. University of Lucknow, Lucknow, 191 pp.

Tripathi, S.K., U. Misra & P.K. Misra (2012). Some freshwater Chlorococcalean algae from western Uttar Pradesh. *Journal Applied Bioscience* 38(1): 44–51.

Tripathi, S.K., U. Misra & P.K. Misra (2012). Some Desmids from western Uttar Pradesh, India. *Indian Hydrobiology* 15(1): 1–16.

Tripathi, S.K., U. Misra & P.K. Misra (2013). Occurrence of genus *Scenedesmus* Meyen (Chlorophyceae) in western Uttar Pradesh, India. *Geophytology* 43(2): 139–144.

Tripathi, S.P.M. & J.P. Tiwari (2016). Epiphytic algal flora Chaetophorales of freshwater ponds from North-Eastern U.P., India. *Plant Archives* 16(2): 719–720.

Tripathi, S.P.M. (2016). Diversity of *Draparnaldia* species from rice fields of Garwha, Allahabad, U.P., India. *Environment Conservation Journal* 17(3): 85–86.

Yadava, R.N. & D.C. Pandey (1976). A note on the occurrence of the genus *Microthamnion. Current Science* 45(23): 843–844.

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VIEWPOINT

Wildlife managers ignore previous knowledge at great risk: the case of Rivaldo, the iconic wild Asian Elephant *Elephas maximus* L. of the Sigur Region, Nilgiri Biosphere Reserve, India

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Abstract: Management of wildlife depends mostly on scientific data; ignoring this can lead to unintended consequences. We take the case study of the wild male Asian Elephant Rivaldo of the Sigur Region, who was translocated out of his range. Rivaldo returned to his home range within a few days, which could have been expected if scientific publications had been consulted. We suggest that a simple checklist of relevant publications can help park managers to decide on a proper management procedure. We also used a simple Bayesian framework to visually show how the probability of predicting a management outcome is increased by prior knowledge. The expensive and risky effort to relocate the elephant could have been avoided altogether if prior knowledge had been taken into consideration.

Keywords: Asian Elephant, rehabilitation, translocation.

In wildlife management, as anywhere else, decisions need to be taken for which the outcome is uncertain. "Uncertain" however, should not necessarily be understood as "unpredictable". A typical unpredictable random event is the outcome of tossing an unbiased coin. No knowledge can help predict whether the coin will fall on its head or its tail. A typical uncertain random event is the outcome of tossing a biased coin. By the knowledge acquired that the coin is heavier on one side, it is possible to predict with some amount of confidence that the coin will fall on its head or on its tail. Ignoring knowledge with uncertain events can have disastrous consequences.

Managing wildlife is more complicated than tossing coins but a management plan is based on objectives that are often uncertain. Recently, the Tamil Nadu Forest Department and wildlife experts had to decide whether to translocate an Asian Elephant called Rivaldo. The success of any elephant translocation certainly depends on many variables managers cannot control, including the elephant's preferences.

Rivaldo (Image 1) is a 35–40 year old male elephant from the Sigur Region (Figure 1) which forms the buffer zone of Mudumalai Tiger Reserve in the Western Ghats of India. Rivaldo became habituated to human food, partly because he was fed with fruits and sugarcane while being treated for his injuries. However, it was shown that he could be gradually de-habituated if the feeding were to stop (Puyravaud et al. 2016). His familiarity with people and inherent docility made him approachable and a willing recipient of treats from humans, many of whom utilized this opportunity to make easy money by displaying him to tourists. This encouraged Rivaldo to beg from tourists and villagers. In 2020, he entered the gated community of recent settlers and a narrative

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Image 1. Rivaldo in the Sigur Region on 18 August 2021 after his release in Mudumalai Tiger Reserve. Notice his healthy posture and body even though he had not been fed by humans for more than two weeks.

was built according to which the elephant needed rehabilitation in the Theppakadu elephant camp due to some non-existent disability.

The Mudumalai Tiger Reserve authorities ordered Rivaldo's capture, not inquiring with those who knew the elephant well. They also rejected the possibility of rehabilitation (Davidar et al. 2021) proposed as early as March 2020. The elephant was lured into a kraal (a restraint area) in early May 2021 and kept there for approximately three months. The newly appointed chief wildlife warden, however, reviewed the case in July 2021 and concluded that the capture was not based on solid grounds. He rightly ordered the elephant's release.

As Rivaldo was in the kraal, releasing him had to be done cautiously and several options were available, but translocation was preferred. We don't really know why translocation was chosen but we imagine that the aim of this option was to assess whether the elephant would settle down in another habitat far from where he was being fed. By this measure, a long rehabilitation program could be avoided and Rivaldo's problem forgotten. If this was correct, then we can say for the sake of this paper that the management objective was: "Rivaldo will not come back to his original range in less than a week". This objective is sort of a gamble over an uncertain event, depending a lot upon the individual animal's inclinations.

The likelihood for managers to predict correctly the outcome of a project increases with a fair review

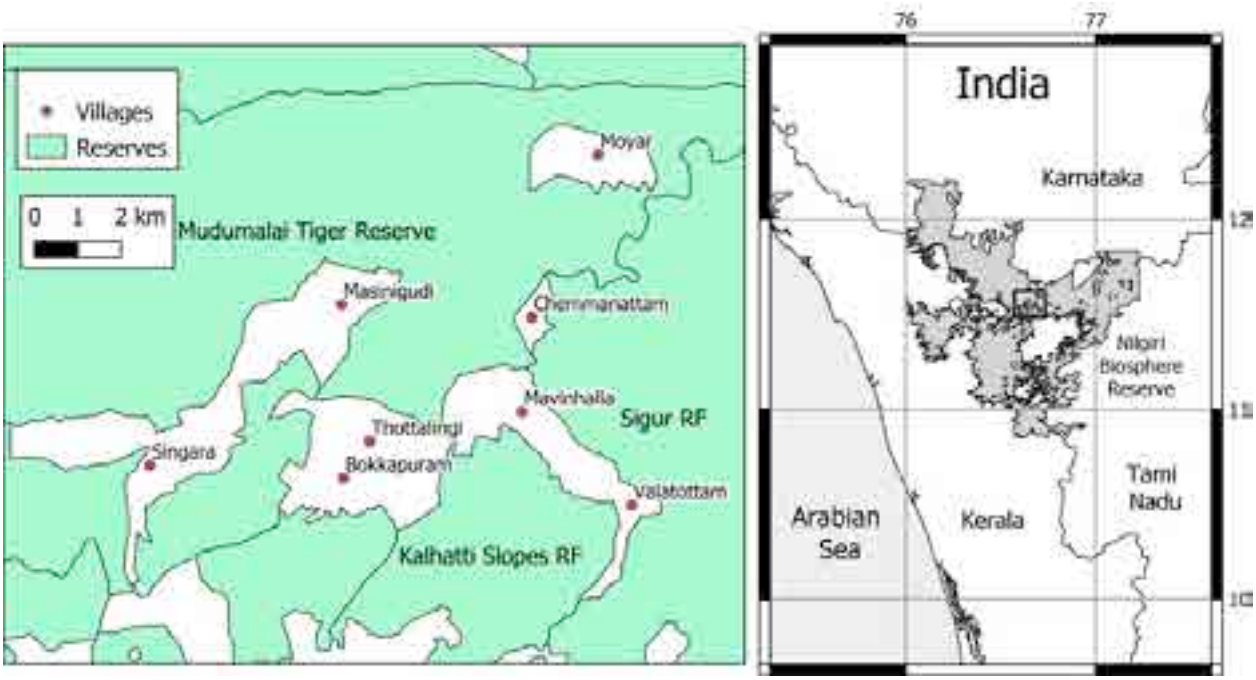

Figure 1. The Sigur Region, Rivaldo's approximate range.

Table 1. Listing published knowledge of elephant behavior increases the probability of predicting operational success.

Accepted hypothesis / observations and references	Translocation likely to succeed?	Translocation likely to fail?
Elephants have ranges (Baskaran et al. 2018a)	0	1
Elephants like human food (Puyravaud et al. 2016)	0	1
Elephants are social (De Silva & Wittemyer 2012)	0	1
Translocation is dangerous (Fernando et al. 2012)	0	1
Translocation is an added cost	0	1
Total	**0**	**5**

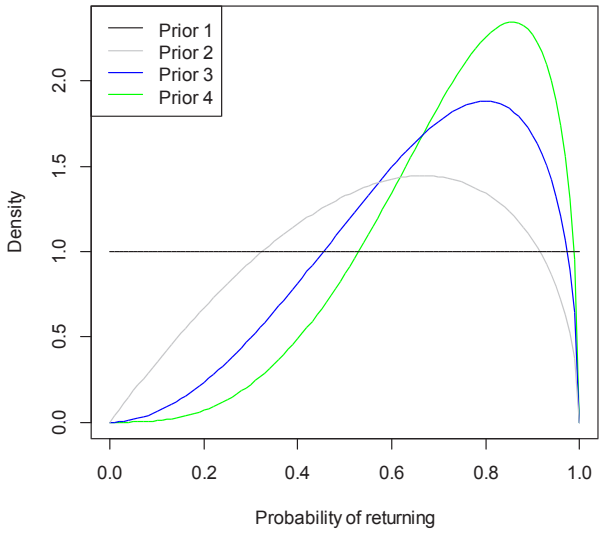

Figure 2. Prior density distribution depicting accumulated knowledge over elephant ranging.

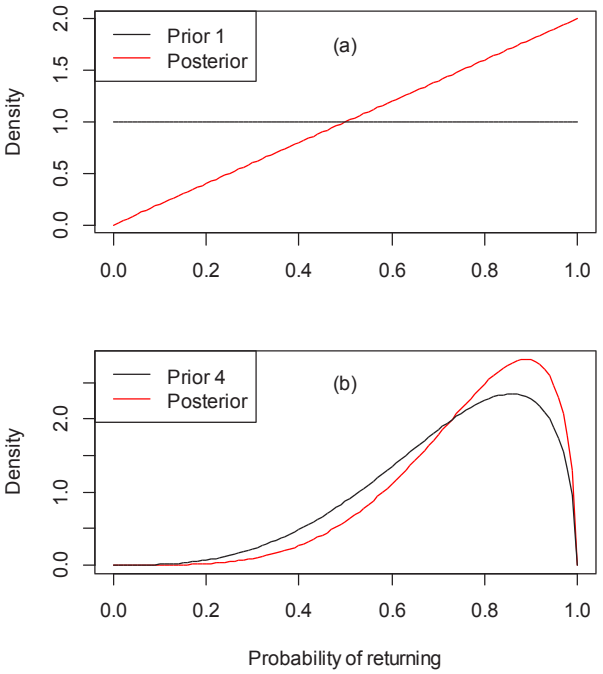

Figure 3. Best Priors and Posteriors when (a) no knowledge of elephant ranging is taken into consideration, and when (b) elephant ranging behavior is taken into consideration.

of published scientific literature. This generally suffices to get a good sense of what may be expected. In this instance, translocation is a difficult choice because it is expensive and increases the risk of mortality of the target animal (Fernando et al. 2012). Moreover, elephants have home ranges (Baskaran et al. 2018a), are highly social (De Silva & Wittemyer 2012), and prefer certain habitats (Baskaran et al. 2018b). Furthermore, mature adult male elephants translocated out of their original protected area tend to return to their home range, often hundreds of kilometers away, whereas young adult elephants tend to wander or settle in their new home (Fernando et al. 2012). With a simple list of publications (Table 1), managers can easily get an idea about the appropriateness of a plan. In this instance, published literature did not weigh in favor of translocation.

In order to maintain objectivity, managers must remember that results published in scientific journals can be open to criticism, but are fairly solid. They represent an excellent basis upon which to argue in favor of or against a given course of action. Reports such as the Right of Passage (Menon et al. 2005) and its sequel which are well-known among elephant specialists did not go through the rigorous peer-reviewed methodological assessment of scientific papers. In consequence, in spite of their wide recognition, such reports cannot be considered on par with peer-reviewed manuscripts. Lastly, expert opinion is probably less reliable than reports and should be accepted only if absolutely nothing published exists on the matter. Managers should also remember that they will have to deal with the consequences of their decisions when their expert advisors have gone back to the comfort of their academic abstractions. Consequently, we cannot stress enough the importance of published scientific evidence.

Taking wagers on management objectives or hypotheses can actually be described with statistics. It is not necessary to use statistics while reviewing scientific literature as we did above. Our purpose here is just to show that accumulation of knowledge increases the chance of taking an appropriate decision. The "chance" distribution can be powerfully depicted

with Bayesian statistics, a branch of statistics that has become mainstream in conservation and ecology. These techniques make statistical abstractions such as accumulation of knowledge tangible and comprehensible with simple graphs. In the following, we attempt to develop an intuition using techniques that are well described in Donovan & Mickey (2019).

Bayesian statistics call "Prior" the statistical knowledge about a phenomenon before an experiment, and "Posterior" the new statistical knowledge transformed by an experiment. If we don't know what an elephant might do after translocation, it is the same as saying that it can come back after one week or not with equal chances. The Prior in this case is a flat line (Prior 1, Figure 2). The chance or probability distribution indicates that anything is possible. But if we take into consideration only one of the papers referring to translocation cited above, for example the fact that elephants are attached to a range, then the Prior is transformed. The Prior 2 (Figure 2) shows that we have a weak "belief" (the strength of evidence) that Rivaldo might come back in a week's time and its curve shows that there is a fair chance that he will not come back. Taking into consideration other published papers, Prior 3 and Prior 4 reinforce our "belief" that the elephant will come back in a week's time: the area under the curve for the Prior 4 shows more than a 50% chance of returning. With increasing knowledge, the shape of the probability distribution tends to provide a clearer and clearer message. The strength of evidence accumulated becomes stronger and stronger.

We know today that Rivaldo came back to his home range in 1–2 days after the attempted translocation. With this outcome our knowledge has increased a little further, which will be described by the "Posterior".

If we started assuming the Prior 1 (Figure 2) was the best, the experiment result (Rivaldo coming back in less than a week) would produce a Posterior that is unexpected. In Figure 3(a) the flat, uninformative Prior provides a tilted Posterior: this indicates that our "beliefs" were seriously inadequate. If we started assuming the Prior 4 (Figure 2) was the best, the same experiment result (Rivaldo coming back in less than a week) confirms the general trend of the Prior. The Posterior (Figure 3(b)) only slightly shifts towards 1, which confirms further that adult male elephants are attached to their range.

To conclude, it is very important that managers do not confuse unpredictable events with uncertain events that both contain an element of randomness. Ignoring published scientific knowledge in wildlife management is like playing against a person who has a biased coin: the price for playing this game can be high, and an elephant translocation effort is indeed costly.

References

Baskaran, N., R. Kanakasabai & A.A. Desai (2018a). Ranging and spacing behaviour of Asian Elephant (*Elephas maximus* Linnaeus) in the tropical forests of Southern India, pp. 295–315. In: Sivaperuman, C. & K. Venkataraman (eds.). *Indian Hotspots. Vertebrate Faunal Diversity, Conservation and Management Volume 1*. Springer, Singapore, XIV+397pp. https://doi.org/10.1007/978-981-10-6605-4

Baskaran, N., R. Kanakasabai & A.A. Desai (2018b). Influence of ranging and hierarchy on the habitat use pattern by Asian Elephant (*Elephas maximus*) in the tropical forests of Southern India, pp. 345–358. In: Sivaperuman, C. & K. Venkataraman (eds.). *Indian Hotspots. Vertebrate Faunal Diversity, Conservation and Management Volume 1*. Springer, Singapore, XIV+397pp. https://doi.org/10.1007/978-981-10-6605-4

Davidar, P., S. de Silva & J.-P. Puyravaud (2021). Rehabilitation of and elephant named "Rivaldo" in the Sigur Region, Nilgiris Biosphere Reserve, India. *Trumpet* 1(3): 20–23.

de Silva, S. & G. Wittemyer (2012). A comparison of social organization in Asian Elephants and African Savannah Elephants. *International Journal of Primatology* 33(5): 1125–1141.

Donovan, T.M. & R.M. Mickey (2019). *Bayesian Statistics for Beginners. A step-by-step approach*. First Edition. Oxford University Press, 419pp.

Fernando, P., P. Leimgruber, T. Prasad & J. Pastorini (2012). Problem-elephant translocation: translocating the problem and the elephant? *PloS one* 7(12): p.e50917.

Menon, V., V. Tiwari, S. Easa & R. Sukumar (2005). *Right of Passage: Elephant Corridors of India*. Wildlife Trust of India, 289pp.

Puyravaud, J.-P., S. Puyravaud & P. Davidar (2016). Can a wild Asian Elephant change its interaction patterns with humans? *Gajah* 44: 30–32.

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SHORT COMMUNICATION

Diversity and distribution of macro lichens from Kalpetta Municipality of Wayanad District, Kerala, India

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Abstract: Macro lichens of Kalpetta Municipality of Wayanad District of Kerala state were studied. The study revealed about 21 macro lichen species. All the species identified are either foliose or fruticose forms belonging to families Coccocarpiaceae, Caliciaceae, Physciaceae, Parmeliaceae, Collemataceae, Lobariaceae, and Ramalinaceae indicating the dominance of these groups in the study area.

Keywords: Caliciaceae, Coccocarpiaceae, Collemataceae, foliose, fruticose, lichen diversity, Lobariaceae, Parmeliaceae, Physciaceae, Ramalinaceae.

India has a rich lichen diversity, represented by 2,513 species, 64 varieties and eight subspecies distributed in various regions (Nayaka 2014). Sinha et al. (2018) added publications after 2010 and recorded 2,714 species, about 14% of the total global lichen flora. Kerala has a rich lichen diversity, especially of micro forms, and exploration of the Western Ghats (Patwardhan 1983) have identified >400 species. Singh & Sinha (2010) listed 75 references related to lichen studies in Kerala, including reports by Kumar (2000), Easa (2003), Sequiera (2003 & 2007), Singh & Sinha (2010), and Biju et al. (2010). Later reports include Nayaka & Upreti (2011), Biju et al. (2012), Bhat et al. (2011), Mesta & Kanivebagilu (2015), Sreekumar et al. (2017), and Zachariah et al. (2018, 2019, 2020). Nevertheless, several interesting habitats such as croplands, wetlands, and coastal areas remain unexplored.

Wayanad is a botanically rich area in Kerala, with an altitude ranging from 700 to 2,100 m. About 886 km^2 of the district is under forest. Kumar & Sequiera (2003) studied lichens from Chembra and Thirunelly hills of Wayanad District, but many gaps remain regarding this region. This study presents the first description of the diversity and distribution of macro lichens of Kalpetta municipality area of Wayanad district, which includes both natural forests and cultivated land.

Materials and Methods

Study area

Wayanad is situated at 11.685^{0}N, 76.132^{0}E (Figure 1). The Wayanad plateau is one of the hotspot regions in the Western Ghats, and is part of the Nilgiri

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Figure 1. Location map of Wayanad district.

Figure 2. Map of Kalpetta Municipality showing collection localities. 1—Maniangode | 2—Puliyarmal | 3—Govt. High School | 4—Nedungode | 5—Emily | 6—Kanyagurukulam | 7—Kainatty | 8—Civil station | 9—Chathothuvayal 10—Municipal Office | 11—Emily Thadam | 12—Ambilery | 13—Gramathu vayal | 14—Pallythazhe | 15—Puthiya Bus stand | 16—Pulpara | 17—Rattakolly | 18—Puthoorvayal Quarry | 19—Puthoorvayal | 20—Madiyoorkuni | 21—Perumthatta | 22—Vellaramkunnu | 23—Adlayed | 24—Onivayal | 25—Turkey | 26—Edaguni | 27—Munderi | 28—Maravayal.

Biosphere Reserve. There are three municipal towns: Kalpetta, Mananthavady, and Sulthan Bathery. Kalpetta municipality comes under Vythiri Taluk and consists of 28 wards (Figure 2). The area is surrounded by coffee and tea plantations, and mountain ranges.

Lichen samples

A total of 112 lichen specimens were collected from 28 wards of Kalpetta Municipality during several field visits (Table 1). Samples were collected in brown acid-free bags of appropriate sizes. Corticolous and saxicolous lichens were collected along with the substratum using sharp chisels. Much care was taken to collect these specimens without any damage to the thallus margins. Fruticose lichens were collected with their holdfasts intact. All specimens were serially numbered in the field according to the date of collection. Characters of lichens which might be lost during drying and preservation—such as the colour of the thallus, reproductive structures, orientation of the specimen, details of associated plants, collection date, locality, and nature of substratum—were noted.

The specimens were dried, and the morphological details were examined under stereo zoom Leica S8 microscope, while anatomical details were examined with a Leica DM 1000 compound microscope with camera and image analysis software. Chemistry was studied by spot tests using 10% aqueous solution of potassium hydroxide, freshly prepared aqueous solution of calcium hypochlorite, 1–5% solution of para phenylenediamine and iodine solution. Thin layer chromatography was performed in solvent system C following Orange et al. (2001). Recent literature, keys and descriptions (Awasthi 1991, 2007; Divakar & Upreti 2005; Wijayawardene et al. 2020) were followed for identification. Nomenclature was confirmed with the database Index Fungorum (http://www.IndexFungorum.org). Lichens were grouped on the basis of collected localities, type of growth forms, type of fungal partner etc. The identified specimens were deposited at the Lichen Herbarium, Department of Botany, Maharaja's College (Autonomous), Ernakulam, Kerala.

Results and Discussion

Analysis of the collected specimens revealed 21 species belonging to seven families from the study area (Table 2). Of the identified samples, 20 were foliose and the remaining one, *Ramalina* sp. was fruticose. The family Physciaceae dominated with 10 species under three genera, followed by Parmeliaceae (5 species under 3 genera), Collemataceae (2 species under 1 genus), Coccocarpiaceae, Caliciaceae, Lobariaceae, and Ramalinaceae with one species and one genus. The genus *Heterodermia* dominated with seven species

Table 1. Details of localities surveyed.

Name of wards	Latitude	Longitude	Altitude
Munderi	11.620521°N	76.070955°E	728.33 m
Emily	11.626677°N	76.080325°E	760.99 m
Turkey	11.606147°N	76.078668°E	733.91 m
Ambilery	11.621339°N	76.07773°E	669.18 m
Vellaramkunnu	11.586156°N	76.06881°E	840.67 m
Onivayal	11.586156°N	76.06881°E	840.67 m
Gramathuvayal	11.618029°N	76.078388°E	712.88 m
Maravayal	11.620512°N	76.071083°E	723.79 m
Adlayed	11.594902°N	76.06158°E	768.18 m
Pallythazhe	11.614368°N	76.080902°E	721.18 m
Maniangode	11.631595°N	76.065617°E	729.76 m
Puthiya Bus Stand	11.607427°N	76.085316°E	766.97 m
Municipal Office	11.621060°N	76.08349°E	767.97 m
Rattakolly	11.602431°N	76.08917°E	764.76 m
Chathothuvayal	11.618887°N	76.086036°E	754.28 m
Nedungode	11.625475°N	76.080638°E	776.5 m
Govt.High School	11.624791°N	76.072009°E	725.85 m
Kainatty	11.636633°N	76.088925°E	741.82 m
Ambilery	11.625269°N	76.012530°E	670.18 m
Puliyarmala	11.638559°N	76.081451°E	669.04 m
Pulpara	11.605586°N	76.089836°E	774.33 m
Kanyagurukulam	11.638568°N	76.081403°E	602.6 m
Puthoorvayal	11.595779°N	76.092082°E	746.43 m
Puthoorvayal Quarry	11.594441°N	76.094251°E	779.86 m
Emily Thadam	11.622284°N	76.079384°E	743.73 m
Gramathuvayal	11.618329°N	76.078613°E	714.88 m
Madiyoorkuni	11.569972°N	76.099636°E	779.69 m
Edaguni	11.697612°N	76.083492°E	745.68 m

followed by *Parmotrema* (3 species), *Physcia* (2 species), and *Leptogium* (2 species). Kumar (2000), recorded about 254 macrolichens from Kerala part of Western Ghats among which he recorded 18 species from Thirunelly and 14 species from Pakshipadalam area of Wayanad.

Corticolous species were dominated in both the natural as well as the cultivated ecosystems. Species such as *Leptogium denticulatum, Myelochroa perisidians*, and *Phaeophyscia ciliata* were found to be saxicolous in nature, while all others were corticolous inhabiting either on the trunks or branches of arboreal elements in the study area. Trunks of trees and small or medium sized rocks inside the ecosystems are the main microhabitats for most of the macrolichens in the study area. Environmental factors influence the lichen community to a great extent and these organisms are very much sensitive to environmental changes and microhabitat has significant influence on lichen distribution (Fryday 2000).

Trees near road side like *Bauhinia purpurea, Mangifera indica, Bixa orellana, Roystonea regia, Casuarina equisetifolia*, and *Cassia fistula* hold very few lichen species such as *Coccocarpia palmicola, Phaeophyscia ciliatea*, and *Pseudocyphellaria aurata*. However, trees which are closer to the natural forests like *Artocarpus hirsutus, Dalbergia latifolia, Phyllanthus emblica, Helicteres isora, Ficus* sp., *Mimusops elengi, Alstonia scholaris*, and *Lagerstroemia microcarpa* exhibit more lichens on their trunks and branches. Species like *Heterodermia comosa, H. galactophylla, H. hypochraea, H. speciosa, Leptogium denticulatum*, and *Myelochroa perisidians* were found distributed here. Environmental factors such as, light, humidiy, rainfall, and stable microclimatic factors govern the distribution of lichen species in such habitats. The result shows strong competitive capability of some lichens and its wide ecological amplitude to survive on the road side trees which has high exposure to vehicular pollution. As per Larsen et al. (2007), transport-related pollution and bark acidity can influence lichen distribution in some areas.

Among cultivated ecosystems, arecanut and coconut plantations had a greater number of lichens than tea and coffee plantations. Macrolichens such as *Dirinaria consimilis, Hypotrachyna infirma, Parmotrema cristiferum, P. praesorediosum, P. tinctorum*, and *Physcia tribacoides* were found distributed in the arecanut plantations. Coconut plantations support species like *Dirinaria consimilis, Parmotrema tinctorum, P. praesorediosum, Physcia dilatate*, and *P. tribacoides*. However, tea plantations in the study area inhabit only three species, *Dirinaria consimilis, Physcia dilatata*, and *P. tribacoides;* and coffee plantations supports only *Physcia dilatata* and *P. tribacoides*. Since, trees are considered as the major supporting system for the successful growth of lichens in tropical vegetations, the bark character, aspects and height of the tree are of greater importance in the distribution of lichens (John 1992). Nayaka et al. (2006) enumerated the occurrence of 23 lichen species on coconut and arecanut orchard of Goa in which crustose lichens were dominated with 17 species, while foliose and fruticose lichens exhibit scarce growth.

With regard to the altitudinal variation, distribution and occurrence of lichens were highest from 840–860 m. The variation of species occurrence along the different

Table 2. Check list of lichens collected from the study area.

	Name	Family	Growth form	Substratum	Localities
1.	*Coccocarpia palmicola* (Spreng.) Arvidss. & D.J. Galloway	Coccocarpiaceae	Foliose	Corticolous	Munderi, Emily, Turkey, Ambilery, Vellaramkunnu Onivayal, Gramathuvayal
2.	*Dirinaria consimilis* (Stirton) D.D. Awasthi	Caliciaceae	Foliose	Corticolous	Maravayal, Adlayed, Pallythazhe
3.	*Heterodermia comosa* (Eschw.) Follmann & Redon	Physciaceae	Foliose	Corticolous	Maniangode, Emily, Puthiya Bus Stand, Municipal Office, Rattakolly, Vellaramkunnu
4.	*Heterodermia galactophylla* (Tuck.) W.L. Culb.	Physciaceae	Foliose	Corticolous	Civil Station, Onivayal, Chathothuvayal, Nedungode Adlayed, Govt.High School
5.	*Heterodermia hypocaesia* (Yasuda ex Rasanen) D.D. Awasthi	Physciaceae	Foliose	Corticolous	Civil Station, Kainatty, Rattakolly Perumthatta, Turkey, Edaguni Onivayal
6.	*Heterodermia hypochraea* (Vain.) Swinsc. & Krog	Physciaceae	Foliose	Corticolous	Civil Station
7.	*Heterodermia japonica* (M.Sato) Swinsc. & Krog	Physciaceae	Foliose	Corticolous	Maravayal, Nedungode, Perumthatta, Govt. High School, Puthoorvayal, Madiyoorkuni Edaguni
8.	*Heterodermia obscurata* (Nyl.) Trevis.	Physciaceae	Foliose	Corticolous	Civil Station, Nedungode, Puthoorvayal,Madiyoorkuni, Emily
9.	*Heterodermia speciosa* (Wulf.) Trevis.	Physciaceae	Foliose	Corticolous	Civil Station,Onivayal,Govt.High School,Edaguni,Maniangode, Adlayed
10.	*Hypotrachyna infirma* (Kurok.) Hale	Parmeliaceae	Foliose	Corticolous	Civil station, Edaguni, Madiyoorkuni,Ambilery Pallythazhe,Kainatty
11.	*Leptogium denticulatum* Nyl.	Collemataceae	Foliose	Saxicolous	Civil Station, Puliyarmala, Ambilery, Pulpara, Rattakolly Vellaramkunnu
12.	*Leptogium* sp.	Collemataceae	Foliose	Saxicolous	Civil Station, Onivayal, Kanyagurukulam,Adlayed, Perumthatta
13.	*Myelochroa perisidians* (Nyl.) Elix & Hale	Parmeliaceae	Foliose	Saxicolous	Munderi, Turkey, Kanyagurukulam, Puthoorvayal Quarry
14.	*Parmotrema cristiferum* (Taylor) Hale	Parmeliaceae	Foliose	Corticolous	Emily, Pulpara,Turkey, Puliyarmala, Perumthatta Puthoorvayal Quarry
15.	*Parmotrema praesorediosum* (Nyl.) Hale	Parmeliaceae	Foliose	Corticolous	Civil Station, Pulpara, Puthoorvayal,Emily, Thadam, Kanyagurukulam
16.	*Parmotrema tinctorum* (Despr. ex Nyl.) Hale	Parmeliaceae	Foliose	Corticolous	Rattakolly,Kainatty,Gramathuvayal,Turkey,Puth iya Bus Stand Municipal Office, Munderi
17.	*Phaeophyscia ciliata* (Hoffm.) Moberg	Physciaceae	Foliose	Saxicolous	Civil Station, Adlayed,Maniangode,Edaguni Perumthatta,Kainatty, Chathothuvayal
18.	*Physcia dilatata* Nyl.	Physciaceae	Foliose	Corticolous	Maravayal, Emily, Puthiya Bus Stand, Maravayal, Puliyarmala
19.	*Physcia tribacoides* Nyl.	Physciaceae	Foliose	Corticolous	Puthoorvayal Quarry, Emily , Thadam, Maravayal
20.	*Pseudocyphellaria aurata* (Ach.) Vain.	Lobariaceae	Foliose	Corticolous	Civil Station, Edaguni, Chathothuvayal,Munderi Gramathuvayal,Municipal Office Maravayal,Puliyarmala
21.	*Ramalina* sp.	Ramalinaceae	Fruticose	Corticolous	Munderi

altitudinal gradients shows that the distribution and occurrence of lichens vary with altitude. Negi & Upreti (2000) observed that species richness of lichens was low at lower altitude gradually rises to a peak at middle altitudes and then fall significantly at higher altitudes while working along the altitudinal gradients in the rock microhabitat of Hemis National Park, in Ladakh. Mishra & Upreti (2015) also observed that diversity of lichens changed with altitude in Govind Wildlife Sanctuary, Uttarakhand. The most probable reason for poor diversity in different localities situated in lower altitudes may be due to environmental conditions, heavy anthropogenic pressure as the inhabitants of the villages largely depend for their fuel and fodder needs on the nearby forest area which resulted into destruction of forests.

References

Awasthi, D.D. (1991). A Key to the Microlichens of India, Nepal and Sri Lanka. *Bibliotheca Lichenologica* 40: 1–337.

Awasthi, D.D. (2007). *Compendium of the Macrolichens from India, Nepal and Sri Lanka*. Bishen Singh Mahendra Pal Singh, Dehradun, India, 580 pp.

Bhat, S., S.N. Dudani., M.D.S. Chandran & T.V. Ramachandra (2011). Lichens of Western Ghats. http://wgbis.ces.iisc.ernet.in/biodiversity/sahyadri_enews/newsletter/issue34/lichens_westernghats/index.htm

Biju, H., R.G. Bagool & S. Nayaka (2010). Additions to the lichen flora of Kerala State I: Parmelioid macro-lichens. *Journal of Economic and Taxonomic Botany* 34(4): 890–897.

Biju, H., R. Bagool, S.Nayaka & T. Palode (2012). Additions to the Lichen Flora of Kerala State II: Graphidaceae. *Journal of Economic and Taxonomic Botany* 36(4): 867–873.

Divakar, P.K. & D.K. Upreti (2005). *Parmelioid Lichens in India (A Revisionary study*). Bishen Singh Mahendra Pal Singh, Dehradun.

Easa, P.S. (2003). Biodiversity documentation of Kerala Part 3: Lichens. Kerala Forest Research Institute, Peechi, Kerala, 61 pp.

Fryday, A.M. (2000). The lichen vegetation associated with areas of late snow lie in the Scottish highlands. *Lichenologist* 33: 121–150.

John, E.A. (1992). Distribution patterns and inter thalline interactions of epiphytic foliose lichens. *Canadian Journal of Botany* 70: 818–823.

Kumar, M & S. Sequiera (2003). Notes on a collection of some lichens from Chembra and Thirunelly hills of Wayanad Districts, Kerala State, India. *Journal of Economic and Taxonomic Botany* 27(Suppl.): 1029–1039.

Kumar, M.S.M. (2000). Lichen (Macrolichen) Flora of Kerala Part of Western Ghats, KFRI Research Report 194, Kerala Forest Research Institute, Peechi, Kerala, 186 pp.

Larsen, R.S., J.N. B. Bell., P.W. James., P.J. Chimonides., F.J. Rumsey, A. Tremper & O.W. Purvis (2007). Lichen and bryophyte distribution on oak in London in relation to air pollution and bark acidity. *Environmental pollution* 146(2): 332–340.

Mesta, A.R. & V.S. Kanivebagilu (2015). Distribution Pattern and Ecology of Usneoid lichens in Western Ghats, Southern India. *Journal on New Biological Reports* 4: 247–254.

Mishra, G.K. & D.K. Upreti (2015). Altitudinal distribution of cetrarioid lichens in Govind Wildlife Sanctuary, Garhwal Himalaya, Uttarakhand, India. Geophytology 45(1): 9–19.

Nayaka, S., D.K. Upreti, S. Phatak & C. Samuel (2006). Preliminary observation on lichen flora of coconut and arecanut orchards of Goa, India. *Phytotaxonomy* 6: 23–25.

Nayaka, S. & D.K. Upreti (2011). Lichens diversity in Western Ghats: Need for quantitative assessment and conservation. Report of the Western Ghats Ecology Expert Panel. Ministry of Environment and Forests, Government of India, https://www.researchgate.net/publication/266143899

Nayaka, S. (2014). Methods and techniques in collection, preservation and identification of lichens, pp. 101–128. In: Rana, T.S., K.N. Nair & D.K. Upreti (eds.). Plant Taxonomy and Biosystematics–Classical and Modern Methods. New India Publishing Agency, New Delhi.

Negi, H.R. & D.K. Upreti 2000. Species diversity and relative abundance of lichens in Rumbak catchment of Hemis National Park in Ladhak. *Current Science* 78: 1105–1112.

Orange, A., P.W. James & F.J. White (2001). Microchemical methods for the identification of Lichens. British Lichen Society, Natural History Museum, London, UK.

Patwardhan, P.G. (1983). *Rare and endemic lichens of Western Ghats, South Western India*, pp. 318–322. In: Jain, S.K. & R.R. Rao (eds.). *An assessment of threatened plants of India.* Botanical Survey of India, Howrah.

Singh, K.P. & G.P. Sinha (2010). Indian lichens: an annotated checklist. Botanical Survey of India. Shiva Offset Press, Dehradun, Uttarakhand.

Sinha, G.P., S. Nayaka & S. Joseph (2018). Additions to the checklist of Indian lichens after 2010. *Cryptogam Biodiversity and Assessment* Special Volume (2018): 197–206. https://doi.org/10.21756/cab.esp16.

Sequiera, S. (2003). Taxonomy and Ecology of lichens of Silent Valley National Park, Southern Western Ghats, India. PhD Thesis, FRI, Dehradun.

Sequiera, S. (2007). Lichens of high ranges and their utilization potential. Technical report, KSCSTE, Thiruvananthapuram, 78 pp.

Sreekumar, V.B., K.H. Hussain & C. Renuka (2017). Virtual herbarium of Kerala Forest Research Institute, Peechi, Kerala, India. Current Science 112: 466–470.

Zachariah, S.A., S. Nayaka, S. Joseph, P. Gupta, S. Thomas & S.K. Varghese (2018). New and noteworthy records of lichens from Pathanamthitta district, Kerala. *Studies in Fungi* 3(1): 349–356. https://doi.org/10.5943/sif/3/1/35

Zachariah, S.A., S. Nayaka, P. Gupta & S.K. Varghese (2019). The lichen genus *Pyxine* (Caliciaceae) in Kerala state with *P. dactyloschmidtii* as new to India. *Hattoria* 10: 109–117.

Zachariah, S.A., S. Nayaka, S. Joseph, P. Gupta & S.K. Varghese (2020). Eleven new records of lichens to the state of Kerala, India. *Journal of Threatened Taxa* 12(10): 16402–16406. https://doi.org/10.11609/jott.5475.12.10.16402-16406

Wijayawardene, N.N., K.D. Hyde, L.K.T. Al-Ani, L. Tedersoo, D. Haelewaters, K.C. Rajeshkumar, R.L. Zhao, A. Aptroot, D. Leontyev, R.K. Saxena, Y.S. Tokarev, D.Q. Dai, P.M. Letcher, S.L. Stephenson, D. Ertz, H.T. Lumbsch, M. Kukwa, I.V. Issi, H. Madrid, A.J.L. Phillips, L. Selbmann, W.P. Pfliegler, E. Horváth, K. Bensch, P.M. Kirk, K. Kolaříková, H.A. Raja, R. Radek, V. Papp, V. Dima, J. Ma, E. Malosso, S. Takamatsu, G. Rambold, P.B. Gannibal, D. Triebel, A.K. Gautam, S. Avasthi, S. Suetrong, E. Timdal, S.C. Fryar, G. Delgado, M. Réblová, M. Doilom, S. Dolatabadi, J. Pawłowska, R. Humber, R. Kodsueb, I. Sánchez-Castro, B.T. Goto, D.K.A. Silva, F.A. de Souza, F.Oehl, G.A. da Silva, I.R. Silva, J. Błaszkowski, K. Jobim, L. Maia, F. Barbosa, P. Fiuza, P. Divakar, B. Shenoy, R.F. Castañeda-Ruiz, S. Somrithipol, A.A. Lateef, S.C. Karunarathna, S. Tibpromma, P.E. Mortimer, D.N. Wanasinghe, R. Phookamsak, J. Xu, Y. Wang, F. Tian, P. Alvarado, D.W. Li, I. Kušan, N. Matočec, A. Mešić, Z. Tkalčec, S. Maharachchikumbura, M. Papizadeh, G. Heredia, F. Wartchow, M. Bakhshi, E. Boehm, N. Youssef, V. Hustad, J. Lawrey, A. Santiago, J. Bezerra, C. Souza-Motta, A. Firmino, Q. Tian, J. Houbraken, S. Hongsanan, K. Tanaka, A. Dissanayake, J. Monteiro, H. Grossart, A. Suija, G. Weerakoon, J. Etayo, A. Tsurykau, V. Vázquez, P. Mungai, U. Damm, Q.R. Li, H. Zhang, S. Boonmee, Y.Z. Lu, A.G. Becerra, B. Kendrick, F.Q. Brearley, J. Motiejūnaitė, B. Sharma, R. Khare, S. Gaikwad, D. Wijesundara, L. Tang, M. He, A. Flakus, P. Rodriguez-Flakus, M. Zhurbenko, E. McKenzie, M. Stadler, D. Bhat, J. Liu, M. Raza, R. Jeewon, E. Nassonova, M. Prieto, R. Jayalal, M. Erdoğdu, A. Yurkov, M. Schnittler, O. Shchepin, Y. Novozhilov, A. Silva-Filho, E. Gentekaki, P. Liu, J. Cavender, Y. Kang, S. Mohammad, L. Zhang, R. Xu, Y. Li, M. Dayarathne, A. Ekanayaka, T. Wen, C. Deng, O. Pereira, S. Navathe, D. Hawksworth, X. Fan, L. Dissanayake, E. Kuhnert, H. Grossart & M. Thines (2020). Outline of Fungi and fungus-like taxa. *Mycosphere* 11(1): 1060–1456. https://doi.org/10.5943/mycosphere/11/1/8

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SHORT COMMUNICATION

Extended distribution of two endemic epiphytes from the Western Ghats to the Deccan Plateau

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Abstract: Extended distribution of two endemic epiphytes, viz., *Hoya wightii* Hook.f. (Apocynaceae) and *Bulbophyllum fimbriatum* Rchb.f. (Orchidaceae) from Western Ghats to Deccan Plateau is reported during field explorations undertaken to document the flora of Kalwan tehsil. The presence of these two species in the Deccan plateau indicates the need of further explorations to document the diversity and endemism of strict endemics of Western Ghats in Deccan plateau.

Keywords: India, Kalwan tehsil, new distribution records, northern Western Ghats, rare plants.

Forests are categorized according to the plant species present in a particular area, which in turn depends upon the environmental conditions prevalent in that area. Similarly, the plant species occurring in a particular area are important in deciding the type of forest present in that area. Forest in Kalwan tehsil has been shown to fall in moist tropical and dry tropical by Lakshminarasimhan & Sharma (1991). From the available literature it is evident that much focus has been given on Markanday hill top and Saptashrungi Fort while remaining area of Kalwan tehsil has been scarcely mentioned in the previous works. Therefore, explorations carried out to study the floristic wealth of less explored areas of Kalwan tehsil from ethno-botanical perspective. During these explorations, two epiphytes, viz., *Hoya wightii* Hook.f. (Apocynaceae) and *Bulbophyllum fimbriatum* Rchb.f. (Orchidaceae) were observed. These species were supposedly endemic to Western Ghats (Pande et al. 2010; Singh et al. 2015) and never been reported from Deccan Plateau. After analysis it is found that, these species have extended their distribution to the Deccan plateau (Figure 1). Their description is provided, the map is given and notes on distribution are also provided.

Material and Methods

Field trips were carried out to explore floristic wealth and record the ethno-botanically important plants of Kalwan tehsil. Plants were photographed, collected, and herbarium specimens were prepared as per Jain & Rao (1971). Plants were identified by using local floras (Sharma et al. 1996; Singh et al. 2001). The map is as per Rodgers & Panwar (1988).

Study area

Kalwan tehsil is located in the northwestern part of Nashik District in Maharashtra state of India, between

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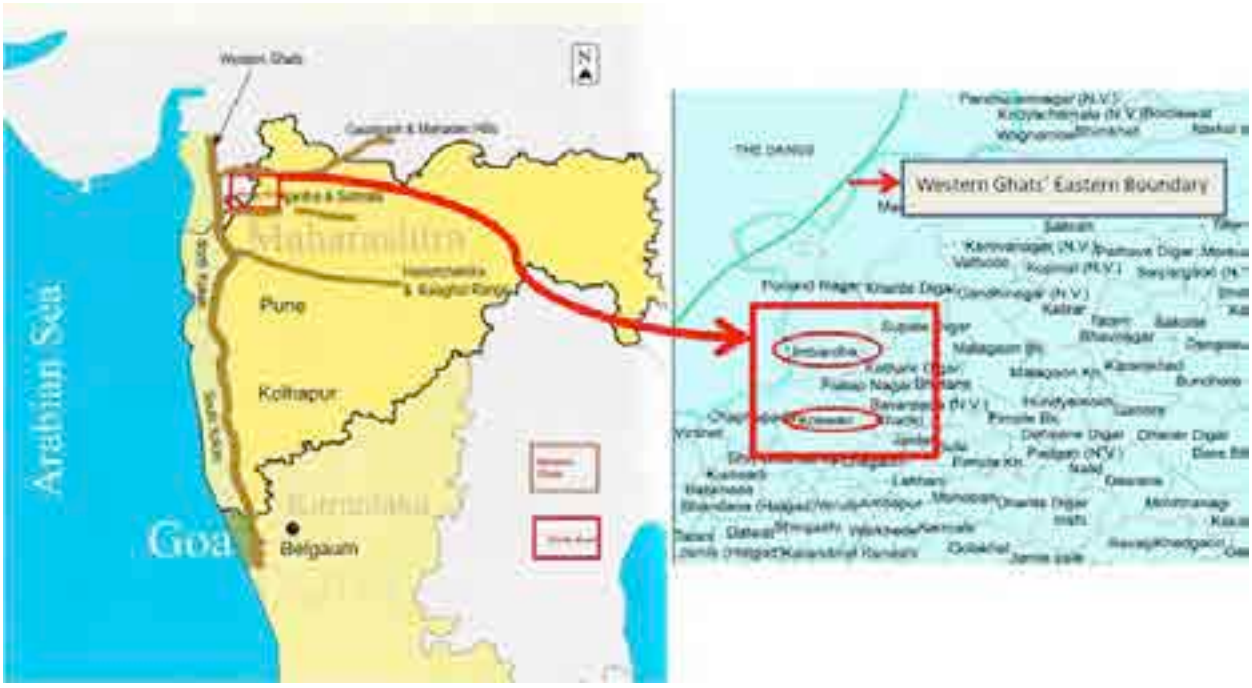

Figure 1. Collection localities of *Hoya wightii* Hook.f. and *Bulbophyllum fimbriatum* Rchb.f. from Deccan Plateau.

20°29'25"N Latitude and 74°01'35"E Longitude. It is bordered by Dang district of Gujarat state towards west, Baglan tehsil Nashik district towards the north, Deola towards east and Chandwad and Dindori tehsils towards the south.

Results

Hoya wightii Hook.f. Fl. Brit. India 4: 59 (1883)

(Image 1A)

Epiphytic pendulous climbers. Stems smooth, cylindrical with adventitious roots at regular intervals. Leaves opposite, petiolate, elliptic lanceolate, acuminate at apex, narrow at base. Flowers in lateral umbellate cymes. Corolla cream coloured, rotate; petals united in the lower halves, slightly pubescent within. Staminal corona purple. Follicles linear to cylindrical.

Phenology: Flowering and Fruiting: May–January.

Notes: Found growing on *Mangifera indica* L. and *Ficus racemosa* L.

Specimens examined: SVD-270620211, 27.vi.2021, India, Maharashtra, Nashik district, Kalwan tehsil, Koswan, coll. S.V. Deore & M.D. Sonawane (Western Circle, BSI, Pune), Image 2.

Distribution: Goa, Karnataka, Kerala, Maharashtra, and Tamil Nadu. The present record is the northern-most distribution of this species from Deccan Plateau.

Image 1. A—*Hoya wightii* Hook.f. | B—*Bulbophyllum fimbriatum* Rchb.f. © Sonali Deore.

Image 2. Herbarium of *Hoya wightii* Hook.f.

Bulbophyllum fimbriatum (Lindl) Rchb.f. Ann. Bot. Syst. (Walpers) 6(2): 260 (1861)
(Image 1B)

Rhizome stout, pseudobulbs sub-globose, about 1.5 to 2 cm long. Leaves altering with flowering, up to 5–12 × 2 cm. Flowers greenish-yellow, lateral sepals much longer than the dorsal ones, lip spathulate, fleshy, re-curved. Capsules green, ob-pyriform, 1 × 0.5 cm.

Phenology: Flowering and Fruiting. February–March.

Specimens examined: SVD-280320211, 28.iii.2021, India, Maharashtra, Nashik district, Kalwan tehsil, Umbardhe, coll. S.V. Deore & M.D. Sonawane (Western Circle, BSI, Pune), Image 3.

Notes: Found growing on *Mangifera indica* L.

Distribution: Kiruthika et al. (2018) reported this species from Gadalur (Tamil Nadu). In Maharashtra it has been reported (Sharma et al. 1996) from Pune Satara and Sindhudurg districts. It has not been reported from Nashik district (Lakshminarasimhan & Sharma 1991; Yadav & Dhanke 2010) previously. It was strictly endemic to Western Ghats (Singh & Singh (2015) and now extended its distribution to Deccan Plateau.

Image 3. Herbarium of *Bulbophyllum fimbriatum* Rchb.f.

References

Jain, S.K. & R.R. Rao (1977). *A Handbook of Field and Herbarium Methods.* Today & Tomorrow's Printers & Publishers, 157 pp.

Kiruthika, K., M. Sulaiman, P.B. Harathi & R. Gopalan (2018). Revelatory notes on *Bulbophyllum fimbriatum* - An Endemic orchid of Western Ghats, India. *Journal of Economic and Taxonomic Botany* 42: 65–69.

Lakshminarasimhan, P. & B.D. Sharma (1991). *Flora of Nasik District*. Botanical Survey of India, 644 pp.

Pande, S., N. Sant, V. Vishwasrao & M.N. Datar (2010). *Wild Orchids of Northern Western Ghats: Including Maharashtra, Goa and Belgaum*. Ela Foundation.

Rodgers, W.A. & H.S. Panwar (1988). Planning a Wildlife Protected Area Network in India. Wildlife Institute of India, Dehradun.

Sharma, B.D., S. Karthikeyan & N.P. Singh (1996). *Flora of Maharashtra Monocotyledons.* Botanical Survey of India, 792 pp.

Singh, J.J. & P. Singh (2015). Threatened orchids of Maharashtra - a preliminary assessment based on IUCN regional guidelines and conservation prioritization. *Journal of Orchid Society of India* 29: 1–14.

Singh, N.P., P. Lakshminarasimhan, S. Karthikeyan & P.V. Prasanna (2001). *Flora of Maharashtra State Dicotyledones,* Vol. 2 Botanical Survey of India, 1080 pp.

Singh, P., K. Karthigeyan, P. Lakshminarasimhan & S.S. Dash (2015). *Endemic vascular plants of India*. Botanical Survey of India.

Yadav, S. & P.V. Dhanke (2010). A Checklist of Plants of Nashik District. Nashik Forest Circle, Nashik, 143 pp.

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SHORT COMMUNICATION

Nomenclatural notes and report of *Boehmeria penduliflora* Wedd. ex D.G. Long from the Terai region of Uttar Pradesh, India

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Abstract: *Boehmeria penduliflora* Wedd. ex D.G.Long (Urticaceae) is rediscovered after 81 years in Barahi range of Pilibhit Tiger Reserve, Pilibhit district, Uttar Pradesh, India. In the present article, detailed description, digital photographs, illustration, nomenclature update and relevant notes are provided to facilitate easy identification.

Keywords: *Boehmeria penduliflora,* Uttar Pradesh, cystoliths, floral cluster.

The family Urticaceae is commonly known as the nettle family, comprising ca. 54 genera and 2,600 species spread throughout the world in tropics, subtropics, and temperate regions (Christenhusz & Byng 2016). This family is represented by 29 genera and 153 species in India (Karthikeyan 2000). The apomictic genus *Boehmeria* (Yahara 1990) is the largest genus in tribe *Boehmerieae.* After revisionary study 47 species were reported from both new world and old world (Wilmot-Dear & Friis 1996, 2013), of which 15–20 species are known from Indian territory, distributed mostly in tropical regions (Gaur 1999). *Boehmeria penduliflora* Wedd ex D.G.Long mostly occurs in eastern India, with maximum concentration in the Naga and Khasi hills of Assam and Meghalaya (Wilmot-Dear et al. 2013).

During field exploration in Pilibhit district of Uttar Pradesh, a few specimens belonging to the genus *Boehmeria* were collected by the last author (VVW). Based on critical microscopic examination and review of literature (Weddell 1854; Lindsat et al. 1874; Hooker 1885; Duthei 1915; Kanjilal 1933, 1940; Wilmot-Dear & Friis 2013) the specimens were identified as *Boehmeria penduliflora* Wedd. ex D.G.Long. From Uttar Pradesh this species was first reported by Kanjilal (1933) in "Forest flora of Pilibhit, Oudh, Gorakhpur, and Bundelkhand", from Kanjilal onwards; there has been no collection of this species in Uttar Pradesh. Present study reports *B. penduliflora* from Uttar Pradesh after 81 years, and provides detailed description, updated nomenclature,

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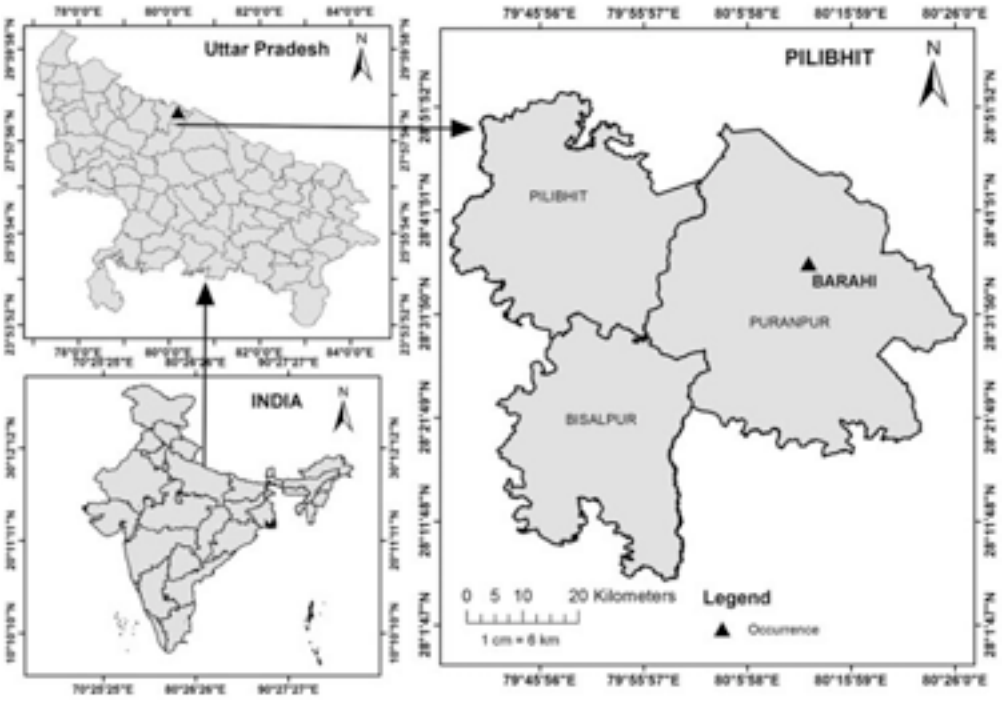

Figure 1. Collection locality of *Boehmeria penduliflora* Wedd. ex D.G.Long in Uttar Pradesh, in India.

phenology, photographs, illustration, and relevant notes to facilitate easy identification.

Material and Methods

Fresh plant materials of *Boehmeria* were collected during field surveys conducted in Barahi forest range of Pilibhit Tiger Reserve, Uttar Pradesh, in 2014 (Figure 1). The habit, habitat features and the geo-coordinates (latitude/longitude/elevation) of each specimen were recorded. Macro and micro-morphological characters were examined critically in freshly collected and herbarium specimens. Plant parts were carefully studied under a stereomicroscope (Leica S8APO). Comparative studies were made by examining the relevant taxonomic literature (Yahara 1981; Friss 1993; Wilmot-Dear & Friis 1996, 2013; Acharya et al. 2002). Specimens housed in ASSAM, BSD, BSHC, CAL, DD, and LWG were studied and digital specimen images were accessed from virtual herbaria of BM, E, G, K, NHNM, and NYBG. The Shenzhen Code (Turland et al. 2018) was followed for nomenclature updates and lectotypification of the plant names.

Taxonomic Treatments

***Boehmeria penduliflora* Wedd. ex D.G.Long**

in Notes Roy. Bot. Gard. Edinb. 40(1): 130. 1982. (Image 1–2; Figure 2–3)

= *Boehmeria macrophylla* D.Don (1825) 60, nom. illeg., non *B. macrophylla* Hornem. (1815).

= *Boehmeria penduliflora* Wedd. (1854) Ann. Sci. Nat., Bot. sér. 4, 1: 199 (1854).

= *Boehmeria densiflora* Hook & Arn. var. *penduliflora* (Wedd. ex D.G.Long) Acharya & Yonek., Acta Phytotax. Geobot. 53(1): 6.

Type: Nepal, Narainhetty, 5.ix.1802. Buchanan-Hamilton s.n. Lectotype BM barcode BM000641028 (digital image !), selected by Long 1982: 130.

= *Boehmeria densiflora* Hook. & Arn. var. *intermedia* Acharya & Yonek., Acta Phytotax. Geobot. 53(1): 8(2002).

Type: Nepal, Gandaki Zone, Gorkha Dist., Dobremez 673; Holotype BM barcode BM00641035 (digital image !)

= *Urtica penduliflora* Wall., Numer. List [Wallich] n. 4595 (1831).

Lectotype (designated here): Nepal. Wallich, Numer. List.: No. 4595a, (G barcode G00354049 [digital image !]; isolectotype: K barcode K000741291 [digital image !])

Perennial, evergreen, small tree or undershrub, ca. 2 m tall. Ultimate stem 1–2 mm diameter, with appressed minute hairs. Leaves simple, opposite, superposed, slightly asymmetric; petiole 0.6–2.4 cm long, cylindrical, pubescent; lamina 9.4–24.6 × 1.6–3.3 cm, lanceolate-ovate, obtuse or shortly attenuate base, acuminate apex, 3-veined at base, serrate-dentate

Image 1 . A—Habit | B—Flowering twig of *Boehmeria penduliflora* Wedd. ex D.G. Long. © Amit Gupta.

margins, adaxially with fine appressed eglandular hairs at young but nearly glabrate during maturation, dark green, leathery, fairly rough with punctuate cystoliths, abaxially having short dense thick hairs along main vein and lateral veins in younger and sparse in older ones, rest with tomentose hairs. Stipules 17 × 2.3 mm, falcate, free lateral, glabrate. Inflorescence borne on leaf axile, each inflorescence bearing axis unbranched or branched at base, having clusters of unisexual flowers; male axis towards the base of branches and comparatively shorter, 5–7 cm, pubescent, 5–10 flowers per cluster. Female axis 10–23 cm long, densely pubescent, each cluster 1.95–2.30 × 1.6–2.8 mm, 0.69–23 mm apart consisting 40-74 flowers. Bract triangular, 2.5–3.4 × 1.19–1.23 mm, pubescent in centre and ciliate along margin; bracteoles inconspicuous. Male flower sessile or subsessile, tetramerous; tepals 4, elliptical, pubescent, fused in bud condition but open at maturity due to physical force applied by stamens; stamen 4 inflexed in bud, filament flattened, anther dithecous, basifixed, longitudinal dehiscent, surrounding the rudimentary carpel. Female flower 1.02–1.76 × 0.21–0.48 mm, sessile or subsessile, hypogynous; tepal attached with ovary, hairy 0.12–0.18 mm long; ovary 0.55–0.53 mm long, obovate, style 0.38–0.75 mm, stigma penicilate. Fruit not seen.

Phenology: August to September

Notes: *Boehemria penduliflora* is distinct having flower clusters sparse, from *B. densiflora* with dense flower clusters. In addition, the upper surface of the leaf bears distinct punctate cystoliths. Young leaves and petiole are more pubescent than the older ones.

Nomenclatural Updates

Boehemria macrophylla D.Don was described by Don (1825) citing the type of Buchanan-Hamilton collection, mentioning type locality Narainhetty, Nepal. Exactly 10 year before, Hornemann in 1815 had described a new species with same name, i.e., *Boehmeria macrophylla* Hornem., and interestingly the two different specimens cited by D.Don and Hornemann individually, were collected by Buchanan Hamilton from same locality. As such D.Don's (1825) assigned name became the later homonym for Hornemann (1815) species and according to ICN later homonyms are illegitimates (Art. 53).

After that Wallich listed *Urtica penduliflora* Wall. (1831) in his numerical list publication, citing the specimen with collection number 4595a. As per www.plantlist.com database, and the current taxonomic status of *U. penduliflora* is considered as an unresolved name. Weddell (1854) gave a manuscript name *Boehmeria penduliflora* Wedd., without any description and was the first to cite *Urtica penduliflora* Wall. as a synonym

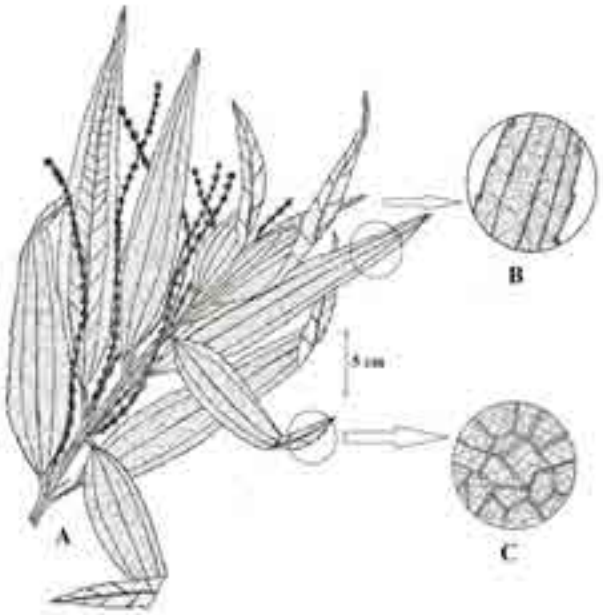

Figure 2. A—Flowering twig | B—Dorsal surface of the leaf | C—Ventral surface of the leaf of *Boehmeria penduliflora* Wedd. ex D.G.Long.

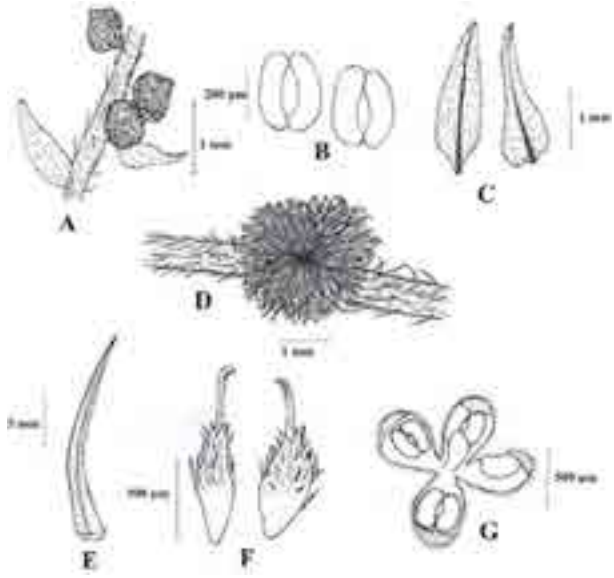

Figure 3. A—Male glomerulus | B—Anther | C—Bract | D—Female glomerulus | E—Stipule | F—Female flower | G—Male flower.

of *B. penduliflora*. But Weddell's name was not validly published (Art. 38.1). Later D.G. Long provided the detailed description and validly published *Boehmeria penduliflora* Wedd. ex D.G.Long (1982).

In the revisionary study of *Boehmeria* Jacq. in southeastern Asia, Acharya followed Wang's view (1995) and recognised *B. densiflora* as an accepted name and treated *B. penduliflora* as a variety of the former (Acharya et al. 2002). Acharya therefore proposed two varieties of *B. densiflora*, viz., *B. densiflora* var. *penduliflora* and *B. densiflora* var. *intermidia* which failed to get recognition and later rendered as synonyms of *B. peduliflora* as it gets the priority over *Boehmeria densiflora.*

The detailed critical study of *Urtica penduliflora,* based on the literature and virtual specimens, we were able to locate Wallich's collection of *Urtica penduliflora* from three different herbaria with same collection number 4595a, housed in K, G, and M herbarium (with barcodes K000741291, G00354049, and M0244322, respectively). As per ICN (Art. 9.6) the specimens deposited in K, G, and M becomes syntypes (Turland et al. 2018) and it is required to select one specimen as a lectotype amongst the three (Art 9.3, Note 2). Here we are designating the specimen housed at Geneva herbarium [G00354049] (Image 4) as lectotype and the one with barcode K000741291 as an isolectotype (Turland et al. 2018).

Habitat: In Barahi range of Pilibhit Tiger Reserve, this species growing with ca. 10–15 individuals along the forest margins, on river bank and road side. The associated species are *Cassia tora*, *Hyptis suaveolens*, also growing under the *Shorea robusta* trees.

Specimen examined: Nepal, Narainhetty, 05.ix.1802, *Buchanan,* # s.n., BM000641028 (BM); Wallich, N., 1821, #4595a, G00354049 (G!), K000741291 (K!), M0244322 (M!); Jagat (Marsyandi), 28.483N,84.366E; 1300 m, 28.xi.1970, Dobremez, J. F., #673, BM006641028 (BM!), KATH01222 (KATH!); India, West Bengal, Jalpaiguri, Chilapata, 10.ix.1981, B. Jafari & Party, 10456 (CAL); Assam, Pynursla, 25.xi.1956, G. Panigrahi, 4595; K & G hills, Mawrynklang, 27.i.1957, G.K. Deka, 5233 (ASSAM); Khasi hill, 4000 ft., 09.x.1913, U. Kanjilal, 2668 (ASSAM); Rial khwan, Khasi Hill, 4500 ft, 29.x.1913, U. Kanjilal, 2463 (ASSAM); K & J hill, Syndai, 500 m., 17.viii.1968, Balakrishnan, 46177 (ASSAM); K & J hill, Mawrynklang, 27.i.1957, G.K. Deka, 5333 (ASSAM); K & J hill, Unsav forest, 26.x.1938, S.R. Sharma 1729 (ASSAM); Meghalaya, Garo hill, Amchigiri, 220 m., 29.xi.1996, Sankar Dash, 105213 (ASSAM); Sensong, 25.ii.2007, 114288 (ASSAM); South Garo hill, Romper, 01.ii.2014, D.K. Roy, 91351 (ASSAM); K & J hill, Barapani, 01.i.1930, P.C. Kanjilal, 8766 (ASSAM); K & J hill, Nongpoh, 26.x.1938, S.R. Sharma, 17928 (ASSAM); Arunachal Pradesh, Tirap, Rusa, 08.ix.1958, G. Panigrahi, 17011 (ASSAM); Titap, Nonpong, 10.iii.1958, G.K. Murthy, 12995 (ASSAM); Kameng, 24.iii.1957, G. Panigrahi, 5937 (ASSAM); Siang, Koppu, 731 m., 08.xi.1958, R.S. Rao, 17454 (ASSAM); Siang, Kappu, 731 m., 08.xi.1958, R.S.

Image 2. Lectotype of *Urtica penduliflora* Wall. (G00354049). © Conservatoire et Jardin botaniques de la Ville de Genève.

Rao, 17459 (ASSAM); Kheti, 22.viii.1958, G. Panigrahi, 14601 (ASSAM); Tirap, Nampong, 12.x.1959, R.S. Rao, 20158 (ASSAM); Tirap, Nompong, 12.x.1959, R.S. Rao, 20005 (ASSAM); Kimin, Subansiri, 230 m., 24.ix.1954, G. Panigrahi, 19345 (ASSAM); Uttar Pradesh, Pilibhit district, Barahi Forest range, 28.602N, 80.182E, 275 m. 11.ix.2014, Vijay V. Wagh, 258047 (LWG).

Distribution: *Boehmeria penduliflora* is widely distributed in southeastern Asia (Acharya et. al. 2002). In India this species is mainly distributed in northeastern region of India like Assam, Meghalaya, Nagaland, Manipur (Wilmot-Dear & Friis 2013) and also in terai region of Uttar Pradesh (Kanjilal 1933). We collected this species from Barahi range of Uttar Pradesh, on the bank of Sharada water canal (28.602N,80.182E, 275 m).

References

Acharya, N., K. Yonekura & M. Suzuki (2002). A new species and a new variety of *Boehmeria* (Urticaceae) from the Himalaya with special reference to the status of *B. penduliflora* Wedd. ex DGLong. *Acta Phytotaxonomica et Geobotanica* 53(1): 1–9.

Christenhusz, M.J. & J.W. Byng (2016). The number of known plants species in the world and its annual increase. *Phytotaxa* 261(3): 20–217.

Don, D. (1825). *Prodromus Florae Nepalensis.* J. Gale, Londini, 256pp.

Duthie, J.F. (1915). *Flora of the upper Gangetic plain, and of the adjacent Siwalik and sub-Himalayan tracts.* Supreintendent of Government Printing, Culcutta, 168pp.

Gaur, R.D. (1999). Flora of the District Garhwal, North West Himalaya. Transmedia.

Grierson A.J.C. & D.G. Long (1982). Notes relating to the Flora of Bhutan 5. *Notes from the Royal Botanic Garden, Edinburgh* 40(1): 115–138.

Hooker, J.D. (1888). Urticaceae, pp. 477–594. In: Hooker, J.D. (Eds.). *The Flora of British India*, Vol. 5. L. Reeve & Co., London.

Hornemann, J.W. (1815). *Hortus Regius Botanicus Hafniensis* 2: 890.

Kanjilal, P.C. (1933). *A Forest Flora of Pilibhit. Oudh, Gorakhpur and Bundelkhand.* Allahabad.

Kanjilal, U.N., P.C. Kanjilal, A. Das, R.N. De & N.L. Bor (1934–1940). *Flora of Assam*. Vols. 1–5. Government of Assam, Shillong.

Karthikeyan, S. (2000). *A statistical analysis of flowering plants of India*, pp. 201–217. Flora of India introductory volume part-II.

Kubitzki, K., J.G. Rohwer & V. Bittrich (1993). *Flowering Plants· Dicotyledons: Magnoliid, Hamamelid and Caryophyllid Families* (Vol. 2). Springer Science & Business Media.

Turland, N.J., J.H. Wiersema, F.R. Barrie, W. Greuter, D.L. Hawksworth, P.S. Herendeen, S. Knapp, W.H. Kusber, D.Z. Li, K. Marhold & T.W. May (2018). International Code of Nomenclature for algae, fungi, and plants (Shenzhen Code) adopted by the Nineteenth International Botanical Congress Shenzhen, China, July 2017. Koeltz Botanical Books. Glashütten; 2018. (Regnum Veg. 159). https://doi.org/10.12705/Code.2018

Uniyal, B.P. (2007). *Flowering plants of Uttarakhand* (A Check List). Bishen Singh Mahendra Pal Singh. Dehradun, 404 pp.

Wallich, N. (1831). Numerical list of dried specimens in the museum of the honl. East India Company, London. https://doi.org/10.5962/bhl.title.1917

Weddell, H.A. (1854). Revue de la famille de Urticacées. *Annales des Sciences Naturelles; Botanique,* Sér. 4(1): 173–212.

Weddell, H.A. (1856). Monographie de la famille des Urticées. Nouv. *Archives du Muséum d'Histoire Naturelle* 9: 1–400.

Weddell, H.A. (1857). Monographie de la famille des Urticées. Nouv. *Archives du Muséum d'Histoire Naturelle* 9: 401–592.

Weddell, H.A. (1869). Urticaceae. In: A. de Candolle (ed.), *Prodromus systematis naturalis regni vegetabilis*. Masson, Paris 6(1): 32–35.

Wilmot-Dear, C.M. & I. Friis (1996). The New World species of *Boehmeria* and *Pouzolzia* (Urticaceae, tribus Boehmerieae): a taxonomic revision. *Opera Botanica* 129, Copenhagen, 103 pp.

Wilmot-Dear, C.M. & I. Friis (2013). The Old World species of *Boehmeria* (Urticaceae, tribus Boehmerieae). A taxonomic revision. *Blumea-Biodiversity, Evolution and Biogeography of Plants* 58(2): 85–216

Yahara, T. (1981). Taxonomic studies of the Urticaceae: 1. The genus *Boehmeria* in Thailand. *Acta phytotaxonomica et Geobotanica* 32(1–4): 1–21.

Yahara, T. (1990). Evolution of agamospermous races in *Boehmeria* and *Eupatorium*. *Plant Species Biology* 5(1):183–96.

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SHORT COMMUNICATION

New distribution record of a true coral species, *Psammocora contigua* (Esper, 1794) from Gulf of Kachchh Marine National Park & Sanctuary, India

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Abstract: Reef-building corals are generally confined to tropical waters across the world oceans. But some coral species are able to tolerate even inhospitable environments and suboptimal extremes, and form lower diversity reefs habitats such as the Gulf of Kachchh, located along the northwestern coast of India. Among the reported hard coral species so far from the Gulf of Kachchh, genus *Psammocora* is represented by only one species, *P. digitata*. The present study confirmed a new distribution record of *Psammocora contigua* from Narara Island. Due to the changing hydro-geographic conditions in the Kachchh region, ramose and branching coral species have been believed to be extinct completely, leaving no sign of live colonies. *P. contigua*, recorded during the present study is the only living species with ramose growth form recorded so far from the Kachchh waters. The present study also holds out hope to record more new coral species records from the region.

Keywords: New coral distribution, Gulf of Kachchh, Narara, *Psammocora*, marginalized reef.

Contributing much in designing, building, and maintaining coral reef habitats in the marine realms, scleractinian corals are often considered as 'ecosystem engineers'. Although these corals are widely distributed throughout the world's seas and deeper ocean environments, reef-building coral species are particularly live in shallow tropical and subtropical seas only. The distribution of corals in the world's oceans generally is confined in two distinct regions; the wider Caribbean (Atlantic Ocean) and the Indo-Pacific (from eastern Africa and the Red Sea to the Central Pacific Ocean) (Veron 1995). As updated by Hoeksema & Cairns (2019), a total of 1,625 coral species have been reported from the seas around the world. Among them, at least 900 extant hermatypic scleractinian species (Wallace 1999; Veron 2000) and at least 707 ahermatypic species (Cairns 1999; Tenjing et al. 2019) are recorded. The diversity of coral species is far greater in the Indo-Pacific than in the Atlantic region; the Atlantic amount to only 1/20th of the number to be found in the Indo-Pacific waters (Veron 1995; Spalding et al. 2001). In most parts of the world, the species richness of coral reefs increases towards the equator, particularly the 'Coral Triangle' region, the 'epicentre' of the richest coral biodiversity (Veron et al. 2015). From this epicenter, the species richness of corals decreases towards latitudes and eastern and western realms. It is astounding to note that not a single coral species is common to both of the Indo-Pacific and the

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Atlantic Ocean regions of the world (Veron et al. 2015). Reef-building corals prefer to grow best in shallow, clear waters that are poor in nutrients, annual water temperature ranges from 23°C to 29°C and a stable salinity range of 27–38 ppt (Achituv & Dubinsky 1990). Because of these strict environmental restrictions, reef-building corals are generally confined to tropical waters. But some coral species are able to tolerate inhospitable environments, sub-optimal extremes and form lower diversity reefs habitats. To a limited extent, corals of those environments can adapt to ambient conditions; consequently, the upper lethal temperature for a species in the tropics will be higher than that of the same species in the subtropics (Camp et al. 2018). Marginalized reefs distribution in the Gulf of Kachchh, along the northwestern coast of India includes sturdy reef assemblages that are adapted to thrive in extreme environmental conditions.

Coral reefs of the Kachchh are scanty and less diverse when compared with other major coral reef regions of India. The meagerness is explained due to the transgression of the sea levels of the Late Pleistocene-Holocene period and the upliftment of tectonic plates of the Gulf (Srivastava 1965). In addition, the prevailing arid climate and the semi-diurnal tidal amplitude fluctuations imply in water quality and heavy sediment depositions on coral reefs hamper their recovery to a healthy state (Michael et al. 2009). Residual coral species living today are quite distinctive in terms of their isolation and their high degree of adaptation to survive in such extreme oceanographic and climatic conditions (Dixit et al. 2010). The water in the Kachchh is murky almost throughout the year and possibilities for exploring sub-tidal reefs is only hardly possible. The distribution of corals in the Gulf is restricted mostly to fore-reefs, edges of reef flats along with the low-tide marks and, inter-tidal pools to reef flats for some extend. So, most studies on coral species diversity and distribution in the Gulf carried out so far were from the low-tide exposed reefs only. A total of 63 hard coral species belonging to 28 genera, under 11 families have been recorded so far from the Gulf of Kachchh (Satyanarayana et al. 2018). Among them, the genus *Psammocora* is represented by only one species, *P. digitata*. *Psammocora* (Dana, 1846) is an Indo-Pacific coral genus, presently comprised of 11 nominal species in the monotypic family Psammocoridae (WoRMS 2020). Species of this genus have highly plastic branching growth forms and exhibit considerable structural complexity in skeletal features (Benzoni et al. 2007). This report confirms the first occurrence of another species of *Psammocora* in the Gulf of Kachchh reefs.

Materials and Methods

Gulf of Kachchh is an East-West oriented, funnel shaped indentation along the Gujarat coast, approximately 125 km long and 75 km wide. The southern shore of the Gulf is fringed by some 42 islands and islets. Seaward side edges and low-tide marks and of these islands are predominantly inhabited by a rich coverage of coral reef. During a regular coral reef health monitoring survey in the Islands of Gulf of Kachchh Marine National Park area, the occurrence of *Psammocora contigua* was recorded on August 2020, a zero low-tide day from an intertidal reef flat of Narara Island (22.455°N 69.671°E) (Figure 1). A recently bleached colony was collected for taxonomic identification. The collected specimen was treated with 10% sodium hypochlorite solution to remove all soft parts, after that washed in freshwater and dried for recording corallites morphology and morphometry. The largest corallites from different parts of branch surface and valleys, which were not visibly undergoing any budding process, were selected for morphometrical analysis. Likewise, average branch variables were measured from different branches of the coral colony with a vernier caliper. The specimen was identified up to species level following published original and synonymized taxonomic descriptions of Stefani et al. (2008) and Venkataraman & Satyanarayana (2012). After taxonomical analysis, the same specimen was deposited as a voucher specimen (MNP/Coel/2020-01) at the Marine Biodiversity Museum, Marine National Park (Gujarat Forests), Jamnagar, India.

Results

Diagnosis

Colony is sub-massive or ramous (Image 1a, 2a) but some younger colonies observed with encrusting growth forms (Image 1c). Live colony was pale brown in colour. Total diameter of the examined colony was 12.82 cm and height measured 6.24 cm. Branches short, stout, tend to be flattened and often anastomosed. Branch tip acute with irregular foliose ends and also form pits at many places (Image 1c). At the base of the colony, branches form valleys. Maximum height of the branch measured up to 2.89 cm and the maximum height of the distal part of the branch measured 1.22 cm. Maximum distance between distal portions of the branches measured up to 2.3 cm. The surface of the colony is smooth.

Corallites are very small, shallow, without any prominent walls and, give a smooth surface appearance to the colony (Image 2b,c). An average number of 26 corallites per cm^2 was measured. The arrangement of septa in each corallite gives a flower-like appearance.

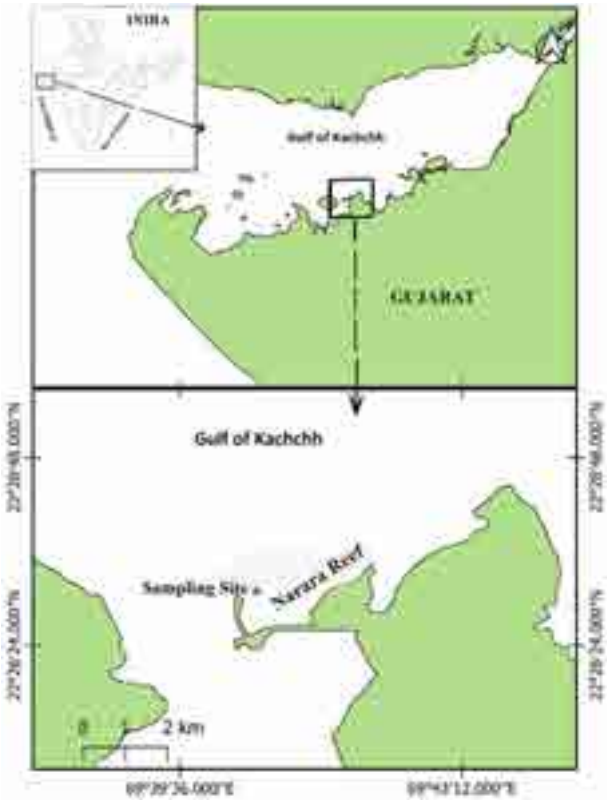

Figure 1. The location from where the coral species recorded in the Gulf of Kachchh MNP area.

Image 1. In situ colonies of *P. contigua*: a—ramous | b—encrusting growth forms | c—branch-tips of the colony. © Marine National Park, Jamnagar.

Corallite walls are indistinct. Calice diameter measured up to 0.789 mm and fossa diameter up to 0.184 mm. Columella was made of a group of pinnules (Image 2d) and measured maximum up to 0.131 mm in diameter. Septal margins with spiny process tend to arrange in whorls along their length. In most of the corallites, eight septa reach the fossa and four of them are petaloid. Maximum length of the petaloid septa reaching the fossa up to 0.302 mm and width up to 0.118 mm. Non-petaloid septa reaching the fossa measured up to 0.105 mm wide. Likewise, enclosed petaloid septa measured up to 0.235 mm wide and 0.392 mm long.

Series of calices often form and can be up to more than 25 calices long even in diameter and following the branch growth direction. Distance between two calices within the same row ranges 0.9–1.2 mm.; the nearest calices of two parallel rows were 2-2.7mm apart from each other. Up to eight rows of enclosed petaloid septa were found between series of corallites. In most of the corallite, one triplet septa (three septa fusing together) and two duplets (two septa fusing together) reaching fossa were observed. Synapticulothecal wall surrounds calices and rows of enclosed septa were seen in many places of the colony surface. Recorded taxonomic characters of the specimen (Table 1) agreed with the description of *Psammocora contigua* (Esper, 1794).

Discussion

Psammocora Dana, 1846, is an Indo-Pacific coral genus, presently comprised of 11 nominal species in the monotypic family Psammocoridae (WoRMS 2020). Geographical distribution of the genus extending to 'high latitudes' in both south and north hemispheres, and from the Red Sea and eastern Africa to eastern Pacific shores (Stefani et al. 2008). The Gulf of Kachchh is also located in a marginalized region and proximate to the Red Sea and Arabian Gulf, as their distribution range. Species of this genus have highly plastic branching growth forms and exhibit considerable structural complexity in skeletal features (Benzoni et al. 2007).

All the taxonomical characters of the examined coral colony, in fact, are agreed with the species *P. obtusangula*. The species *P. obtusangula* was considered a valid species by Glynn & Wellington (1983), Veron (2000), and Reyes-Bonilla (2002). Some studies also claimed it a close synonym of *P. contigua* (Veron & Pichon 1976; Faure 1982; Scheer & Pillai 1983) mentioning phenotypic plasticity as the main factor for their morphological variability. But, Stefani et al. (2008) demonstrated the overlapping morphological and molecular characters of *P. obtusangula* and *P. contigua* and synonymized the earlier with later. Hence the Kachchh specimen examined is identified as the species

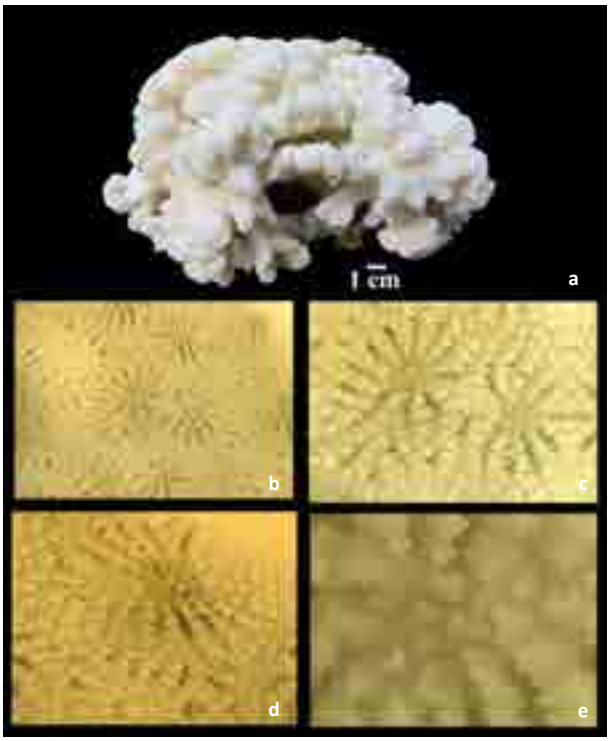

Image 2. a—Examined colony of *P. contigua* | b, c & d—Corallites arrangement and septal characters | e—Collumella. © Marine National Park, Jamnagar

Table 1. Recorded morphometrical characters of the examined specimen, *P. contigua* from Gulf of Kachchh.

	Morphological Characters of Corallites & branches	Morphometry (in mm)
1	Calice diameter	0.750–0.789
2	Fossa diameter	0.157–0.184
3	Columella diameter	0.105–0.131
4	Maximum width of petaloid septa Reaching the fossa	0.118
5	Maximum length of petaloid septa Reaching the fossa	0.302
6	Maximum thickness of non-petaloid septa	0.105
7	Maximum width of enclosed petaloid septa	0.235
8	Maximum length of enclosed petaloid septa	0.392
9	Total branch height	Up to 28.92
10	Height of the distal portion of the branch	12.27
11	Minimum distance between the distal portions of the branch	1.14–2.51
12	Maximum width of the basal part of the branch (m-12)	23.0
13	Minimum width of the basal part of the branch perpendicular to m12	4.97
14	Maximum width of the distal portion of the branch (m-14)	46.40
15	Maximum width of the distal portion of the branch perpendicular to m14	19.20–25.0
16	Minimum width of the distal portion of the branch perpendicular to m14	2.78

P. contigua. Variation in branching morphology is the main character for considering them as two different species. Branches of *P. obtusangula* are small flattened whereas, in *P. contigua*, the branches are flat and larger. But the variation in branching may be due to the habitats they inhabit. A coral transplantation experiment also suggested that *P. obtusangula* is likely to be a shallow, agitated water form of *P. contigua* only (Hoffmeister 1925). Corals of the Gulf of Kachchh are always a puzzle to taxonomists, as the morphology and growth forms vary due to the existing sedimentation, tidal amplitude, and water current. The same might be the reason for variation in the growth form of the present specimen.

Among the recorded coral species so far from the Kachchh waters, *Pocillopora damicornis, Acropora humilis, A. squarrosa, A. microphthalma* are the species having ramose or branching growth forms (Satyanarayana & Ramakrishna 2009). But all these species are presently considered locally extinct with not even a single live colony recorded since the recent past. So, *P. contigua* is the only living species with somewhat ramose growth form recorded so far from the Kachchh waters.

A total of eight species of corals belonging to the genus *Psammocora* have been recorded so far from India

Table 2. List of coral species belonging to the genus *Psammocora* reported so far from Indian waters.

	Species	Location of report	Reference
1	*Psammocora contigua*	Lakshadweep	Pillai 1967
		Gulf of Mannar	Pillai 1986
		Andaman & Nicobar	Venkataraman et al. 2012
2	*P. digitata*	Gulf of Kachchh	Satyanarayana & Ramakrishna,2009; Pillai & Patel 1988
		Lakshadweep	Pillai & Jasmine 1989
3	*P. explanulata*	Andaman & Nicobar	Venkataraman et al. 2012
4	*P. haimiana*	Lakshadweep	Pillai 1971
		Andaman & Nicobar	Venkataraman et al. 2012
5	*P. nierstraszi*	Lakshadweep	Suresh 1991
	P. obtusangula	Andaman & Nicobar	Raghuraman et al.,2012
6	*P. profundacella*	Lakshadweep	Pillai & Jasmine 1989
		Andaman & Nicobar	Venkataraman et al. 2012
7	*P. superficialis*	Andaman & Nicobar	Venkataraman et al. 2012
8	*P. vaughani*	Andaman & Nicobar	Mondal et al. 2015

(Table 2). A maximum of seven species were recorded from Andaman & Nicobar followed by Lakshadweep Islands (five species). *P. contigua* has been previously reported from the Gulf of Mannar (Pillai 1986), Lakshadweep (Pillai 1967), and Andaman & Nicobar Island (Venkataraman et al. 2012). But *P. obtusangula* was only listed out in a checklist of coral species from Andaman & Nicobar Islands by Raghuraman et al. (2012). Among the recorded 64 coral species so far from Gulf of Kachchh, the genus *Psammocora* is represented by only one species, *P. digitata* (Pillai & Patel 1988; Satyanarayana & Ramakrishna 2009). The present study adds one more species of corals to the Gulf of Kachchh corals biodiversity. This species distribution was recorded previously from Australia, Indonesia, Singapore, Malaysia, Taiwan, Papua New Guinea, Viet Nam, Thailand, Philippines, Micronesia, Palau, Marshall Islands, Mayotte, Maldives, Japan, New Caledonia, Réunion, Iran, Guam, Yemen, Bahrain, Vanuatu, French Polynesia, Kenya, Ecuador, Kuwait, Seychelles, Fiji, Christmas Island, American Samoa, Pitcairns, Kiribati, USA, and Madagascar (Veron et al. 2016). Veron et al. (2016) also strongly predicted the distribution of *P. contigua* all along the western coast of India, including the Gulf of Kachchh. The present study confirmed their prediction by recording the species in the Gulf of Kachchh.

This species is also classified under 'IUCN Near Threatened' category (IUCN 2020). In the Gulf of Kachchh, the species distribution was rarely encountered at a low-tide exposed reef edge in the eastern side of Narara Island, and their distribution is recorded nowhere else in the Gulf of Kachchh reefs. Even at the recorded reef site also, a small patch of around 8–10 colonies was only observed. A detailed study needs to be carried out along the Kachchh reefs to record their actual distribution. Attempts with the aid of the latest technologies to explore the sub-tidal reefs may yield a greater number of coral species from the isolated reefs of the Gulf of Kachchh.

References

Achituv, Y. & Z. Dubinsky (1990). Evolution and Zoogeography of Coral Reefs, pp. 1–9. In: Dubinsky, Z. (ed.). *Ecosystems of the World, 25 Coral Reefs*. Elsevier Science Publishing Company, Inc. Amsterdam, The Netherlands, 550pp.

Benzoni, F., F. Stefani, J. Stolarski, M. Pichon & P. Galli (2007). Debating phylogenetic relationships of the scleractinian *Psammocora*: Molecular and morphological evidences. *Contributions to Zoology* 76(1): 35–54. https://doi.org/10.1163/18759866-07601004

Camp, E.F., V. Schoepf, P.J. Mumby, L.A. Hardtke, R. Rodolfo-Metalpa, D.J. Smith & D.J. Suggett (2018). The Future of Coral Reefs Subject to Rapid Climate Change: Lessons from Natural Extreme Environments. *Frontiers in Marine Science* 5(4): 1–21. https://doi.org/10.3389/fmars.2018.00004

Cairns, S.D., B.W. Hoeksema & J. van der Land (1999). Appendix: List of extant stony corals. *Atoll Research Bulletin* 459: 13–46.

Dixit, A.M., P. Kumar, K.D. Pathak & M.I. Patel (2010). *Economic valuation of coral reef ecosystem in Gulf of Kachchh*. Gujarat Ecology Commission, Ghandhinagar, 158 pp.

Faure, G.F. (1982). Recherche sur les Peuplements de Scleractiniaires des récifscoralliens de l'Archipel des Mascareignes (*OcéanIndien Occidental*). PhD Thesis, Universitéd'Aix-Marseille II, 246 pp.

Glynn, P.W. & G.M. Wellington (1983). *Corals and Coral Reefs of the Galapagos Islands*. University of California Press, Berkeley/Los Angeles, 330 pp.

Hoeksema, B.W. & S. Cairns (2019). World List of Scleractinia. http://www.marinespecies.org/scleractinia. Electronic version accessed 20 October 2020.

Hoffmeister, J.E. (1925). Some corals from American Samoa and the Fiji Islands. *Papers from the Department of Marine Biology of the Carnegie Institution of Washington* 22: 1–90.

Michael, L., D.G. Rao, K.S. Krishna & K.H. Vora (2009). Late Quaternary seismic sequence stratigraphy of the Gulf of Kachchh, Northwest of India. *Journal of Coastal Research* 25: 459–468. https://doi.org/10.2112/07-0873.1

Mondal, T., C. Raghunathan & K. Venkataraman (2015). Report of newly recorded eight scleractinian corals from middle and south Andaman Archipelago, India. *Global Journal of Science frontier research C: Biological Science* 15(2): 19-26.

Pillai, C.S.G. (1967). Studies on Corals. PhD Thesis, Department of Aquatic Biology & Fisheries, University of Kerala, XXIV+338 pp.

Pillai C.S.G. (1971). The distribution of shallow water stony corals at Minicoy Atoll in the Indian Ocean with a check-list of species. *Atoll Research Bulletin* 141: 1–12.

Pillai C.S.G. & M.I. Patel (1988). Scleractinian Corals from the Gulf of Kutch, *Journal of Marine Biological Association of India* 30(1&2): 54–74.

Pillai C.S.G. & S. Jasmine (1989). The Coral fauna of Lakshadweep. *Central Marine Fisheries Research Institute Bulletin* 43: 179–195.

Pillai C.S.G. (1986). Recent corals from the southeast of India, pp. 107–201. In: *James P.S.B.R. (ed.). Recent Advances in Marine Biology.* Today and Tomorrow Printers and Publishers, New Delhi, 591 pp.

Raghuraman R., C.R. Sreeraj, C. Raghunathan & K. Venkataraman (2012). Scleractinian coral diversity in Andaman & Nicobar Island in comparison with other Indian reefs, pp. 75–92. In: Uttar Pradesh Biodiversity Board (ed.) *Marine Biodiversity: One Ocean – Many words of life*. Uttar Pradesh State Biodiversity Board, Lucknow, 193 pp.

Reyes-Bonilla, H. (2002). Checklist of valid names and synonyms of stony corals (Anthozoa: Scleractinia) from the eastern Pacific. *Journal of Natural History* 36: 1–13.

Satyanarayana, C. & Ramakrishna (2009). *Handbook on Hard Corals of Gulf of Kachchh*. Published by the Director, Zoological Survey of India, Kolkata, 114 pp.

Satyanarayana, C., T.S.C. Roy, R. Chandran, C. Sivaperuman, C.R. Sreeraj & K. Chandra (2018). *Status of coral resources of India and Strategies for their protection and management*, Published by the Director, Zoological Survey of India, Kolkata, 100 pp.

Scheer, G. & C.S.G. Pillai (1983). Report on the stony corals from the Red Sea. *Zoologica* 45(3): 1–198.

IUCN (2020). The IUCN Red List of Threatened Species. Version 2020-2. https://www.iucnredlist.org. **Electronic version accessed** 22 October 2020.

Srivastava, P.K. (1965). A note on the Quaternary geology of Saurashtra Peninsula. *Quaternary Journal of Geology, Minerology and Metallurgical Society of India* 1: 55–63.

Spalding, M.D., C. Ravilious, E.P. Green (2001). World atlas of coral reefs. The University of California Press, Berkeley, U.S.A., 424pp.

Stefani. F., F. Benzoni & M. Pichon (2008). A multidisciplinary approach to the definition of species boundaries in branching species of the coral genus *Psammocora* (Cnidaria, Scleractinia). *Zoologica Scripta*

37: 71–91. https://doi.org/10.1111/j.1463-6409.2007.00309.x

Suresh V.R. (1991). Studies on the coral reefs of Lakshadweep. PhD Thesis. Cochin University of Science and Technology, Kochi, 123 pp.

Tenjing, S.Y., P. Krishnan, V.D. Samuel & R. Purvaja (2019). *Truncatoflabellum madrasensis*sp. nov. - a new ahermatypic coral species from India and a checklist of species of the genus Truncatoflabellum from the Indian Ocean. *Vie et milieu - Life and Environment* 69(2–3): 89–93.

Venkataraman, K. & C. Satyanarayana (2012). *Coral Identification Manual*. Zoological Survey India, Kolkata, 136 pp.

Venkataraman, K., C. Raghunathan, R. Raghuraman, C. Sivaperuman, C.R. Sreeraj, T. Immanuel & J.S.Y. Kumar (2012). *Scleractinia of Andaman and Nicobar Islands*. Records of Zoological Survey of India, Zoological Survey India, Kolkata, 304 pp.

Veron, J.E.N. (1995). Corals in space and time: the biogeography and evolution of the Scleractinia. Cornell University Press, Ithaca, London, 321 pp.

Veron, J.E.N. (2000). *Corals of the World*. Volumes 1–3. Townsville, Darwin, Perth: Australian Institute of Marine Science, Townsville, Australia, 1382 pp.

Veron J.E.N. & M. Pichon (1976). Scleractinia of Eastern Australia. I Families Thamnasteriidae, Astrocoeniidae, Pocilloporidae. *Australian Institute of Marine Science Monongraph Series* 1: 1–86.

Veron, J.E.N., M. Stafford-Smith, L. DeVantier & E. Turak (2015). Overview of distribution patters of zooxanthellate Scleractinia. *Frontiers in Marine Science* 1(81): 1–19.

Veron, J.E.N., M.G. Stafford-Smith, E. Turak & L.M. DeVantier (2016). Corals of the World. http://www.coralsoftheworld.org/species_factsheets/species_factsheet_distribution/psammocora-contigua/. **Electronic version accessed** 22 October 2020.

Wallace, C.C. (1999). *Staghorn corals of the world: a revision of the coral genus Acropora (Scleractinia; Astrocoeniina; Acroporidae) worldwide, with emphasis on morphology, phylogeny and biogeography*. CSIRO Publishing, Melbourne, Victoria, 422 pp.

WoRMS (2020). World Register of Marine Species. Available from http://www.marinespecies.org at VLIZ. Electronic version accessed 17 October 2020.

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SHORT COMMUNICATION

A new species of flat-headed mayfly *Afronurus meenmutti* (Ephemeroptera: Heptageniidae: Ecdyonurinae) from Kerala, India

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Abstract: A new species of mayfly (Heptageniidae: Ecdyonurinae) *Afronurus meenmutti* sp. nov. is described based on larvae and imagoes from the state of Kerala, southern India. The main characteristics that distinguish the new species from all other species are in having glossae oblong with two stout spines medially; lingua of hypopharynx deeply cleft; absence of postero-lateral spines on terga and gill I slightly lobate in the nymph. Hind wing with the acute costal process; stout spine dispersed on basal and surface of forceps in the adults.

Keywords: Kallar River, mature larva, mayfly, Meenmutti falls, taxonomy, Western Ghats.

The description of the mayfly genus *Afronurus* was illustrated by Lestage (1924) from Africa. Kimmins (1937) proposed the name *Cinygmina* for a single species known from India based on adults only with penes differentiation. Wang & McCafferty (2004) and Kluge (2004) were synonymised the genus *Cinygmina* with *Afronurus (*Braasch & Freitag 2008). Besides, median titillators of penis are reduced: they are either widely separated and diminished (in *assamensis* (C.), *yoshidae* (E.), *levis* (E)), or completely lost. This apomorphy is non-unique, but does not occur in other *Heptagenia*/ f5=g4. Unique apomorphy of egg equator bears several additional anchors of another structure: the additional anchor is many times larger than a usual anchor, and in coiled condition represents a flat spiral for those reasons they were synonymized with *Cinygmina* spp. (Koss & Edmunds 1974; Kopelke 1980; Flowers & Pescador 1984; Kang & Yang 1994). *Afronurus* Lestage is an old world heptageniid genus with 66 species described (Yannai et al. 2017) and includes 48 species from the Oriental region (Kimmins 1937; Braasch & Soldan 1984, 1987; Flowers & Pescador 1984; Braasch 1987, 1990, 2005, 2011; Venkataraman & Sivaramakrishnan 1989; Kang & Yang 1994; Nguyen & Bae 2003; Zhou & Zheng 2003; Braasch & Boonsoong 2010; Braasch & Jacobus 2011; Boonsoong & Braasch 2013). In India, five species of *Afronurus* have been recorded namely *A. assamensis* Kimmins, 1937, *A. curtus* Dubey, 1971, *A. solangensis* Dubey, 1971, *A. keralensis* Braasch & Soldan, 1987, and *A. kumbakkaraiensis* Venkataraman & Sivaramakrishnan, 1987. For three decades, no species has been described in India. In this study, we describe a new species, *Afronurus meenmutti,* based on all life stages, from southern India.

Materials and Methods

The material used in the present investigation was

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preserved in 95% ethanol. The nymphs were collected by kick–net method in the riffle habitats on moderate to fast-flowing streams. Ample numbers of collected mature nymphs were kept in a plastic tray filled with cobbles and pebbles in the natural habitat covered with a mosquito net (1 x 2 m). The modified emergence trap was retained until adult emergence. This emergence trap was monitored each day in the morning and evening until all adults had emerged. Imagoes were carefully removed from the net and preserved in 95% alcohol. The collected specimens were examined using a NIKON 1270i stereo zoom binocular microscope. Drawings were prepared using a camera lucida. Holotype and paratypes were deposited in the Zoological Survey of India (in alcohol), Southern Regional Centre, Chennai, Tamil Nadu, India.

Results

Afronurus meenmutti Balasubramanian & Muthukatturaja sp. nov. (Figure 1–18)

urn:lsid:zoobank.org:act:6F9F7C16-2C22-4B3B-AB0D-9C3DE1232CDA

Type material: Holotype (in ethanol): Reg.No. ZSI–SRC/ I/E 425, 12.v.2018, one mature nymph, India, Kallar River, Kallar, Trivandrum District, Kerala State, India, 08.711^{0}N, 77.128^{0}E, 839m, coll. M. Muthukatturaja & C. Balasubramanian.

Paratypes (same data as holotype): Reg.No. ZSI–SRC/ I/E 426, 5 mature nymphs deposited in Zoological Survey of India (Southern Regional Centre), Chennai, Tamil Nadu.

Mature Nymph: (Figures 1–13) (preserved in 95% ethanol) Dimensions (mm): body length (excluding cerci) 6.5; cerci length 1.84 times longer than body length; median caudal filament 12.0; width of head 2.0; antennae length 1.0. General body coloration brownish-yellow; legs brown.

Head: Dorsum brownish-yellow; scape and pedicel of antennae dark brown, flagellum pale. Mouthparts: emargination of labrum slightly concave (Figure 1); anterior margin with row of stout spines, size of stout spine increases anterolaterally; dorsum with sparse long setae and a clump of hair-like setae directed anteromedially on either side of dorsomedial margin. Right mandible (Figure 2a): incisors trifurcated with numerous serrations; inner incisor with 6–9 hairs laterally; molar with a thick spine at apex, below the molar 7 thin long setae present, clump of bipectinate setae present between molar and prostheca; 1/2 of lateral margin with thin long hairs apically; prostheca with bipectinate processes. Left mandible (Figure 2b): incisors trifurcated with serrations; below the molar three long thin setae present. Maxilla (Figure 3): maxillary palp three-segmented; segment III much smaller than segment I & II; outer margin of segment II with long thin hairs and rows of thin setae apically; 1/3 of inner margin of segment II with short spines; segment I with long hairs at inner and outer margin; galea-lacinia with three acute spines; base of galea with clump of bipectinate setae, ventral base of galea-lacinia with numerous long hairs and 9–15 thin long setae; apex of galea–lacinia with row of comb–like setae. Lingua of hypopharynx (Figure 4) deeply cleft; sublingua slender deeply curved inwardly with long setae at anterior and lateral margin. Labium (Figure 5): two segmented labial palp; basal segment larger than apical segment; outer margin of apical segment with tufts of thin setae, inner margin with clump of short spines; glossae oblong with two stout spines medially (Figure 6); ventral margin with long thin setae; outer margin of glossae with row of long bipectinate setae; posterior and mesal margins of paraglossae with row of thin spines; anterior margin with a row of long setae.

Thorax: Brown, median suture pale, small pale maculae on pro and mesonotum. Legs: femora with scattered prominent brown maculae and median transverse band in fore and hindlegs, midleg macula scattered. Foreleg (Figure 7): length of femora; tibia; tarsi; claw viz., 4.0: 3.7: 1.0: 0.4. femora with row of long monopectinate setae at outer margin, inner margin and dorsal surface with sparse spatulate setae; outer margin of tibia with row of long setae and inner margin with row of few blunt spines, mesal margin with row of few spatulate setae; mesal margin of tarsi with 3 spatulate setae; claw slender, slightly curved with 5 denticles. Midleg (Figure 8): length of femora; tibia; tarsi; claw viz., 4.0: 3.7: 1.0: 0.4. coxae with row of very short spines at dorsomedial margin; posterior margin of trochanter with row of six spatulate setae; femora, tibia, tarsi and claw similar to foreleg. Hindleg (Figure 9): length of femora; tibia; tarsi; claw viz., 4.5: 3.7: 1.2: 0.3. coxa similar to midleg; trochanter similar to midleg except seven spatulate setae at posterior margin; femora similar to midleg except few blunt spines distally; tibia of inner margin with row of spines and with three long blunt spines at apically, distal margin with long blunt spine, mesal margin with row of bipectinate hairs; tarsi with three spatulate setae at apically and with row of very short spines at inner margin; claw hooked with 5 denticles.

Abdomen: Tergum brownish-yellow, sternum yellow;

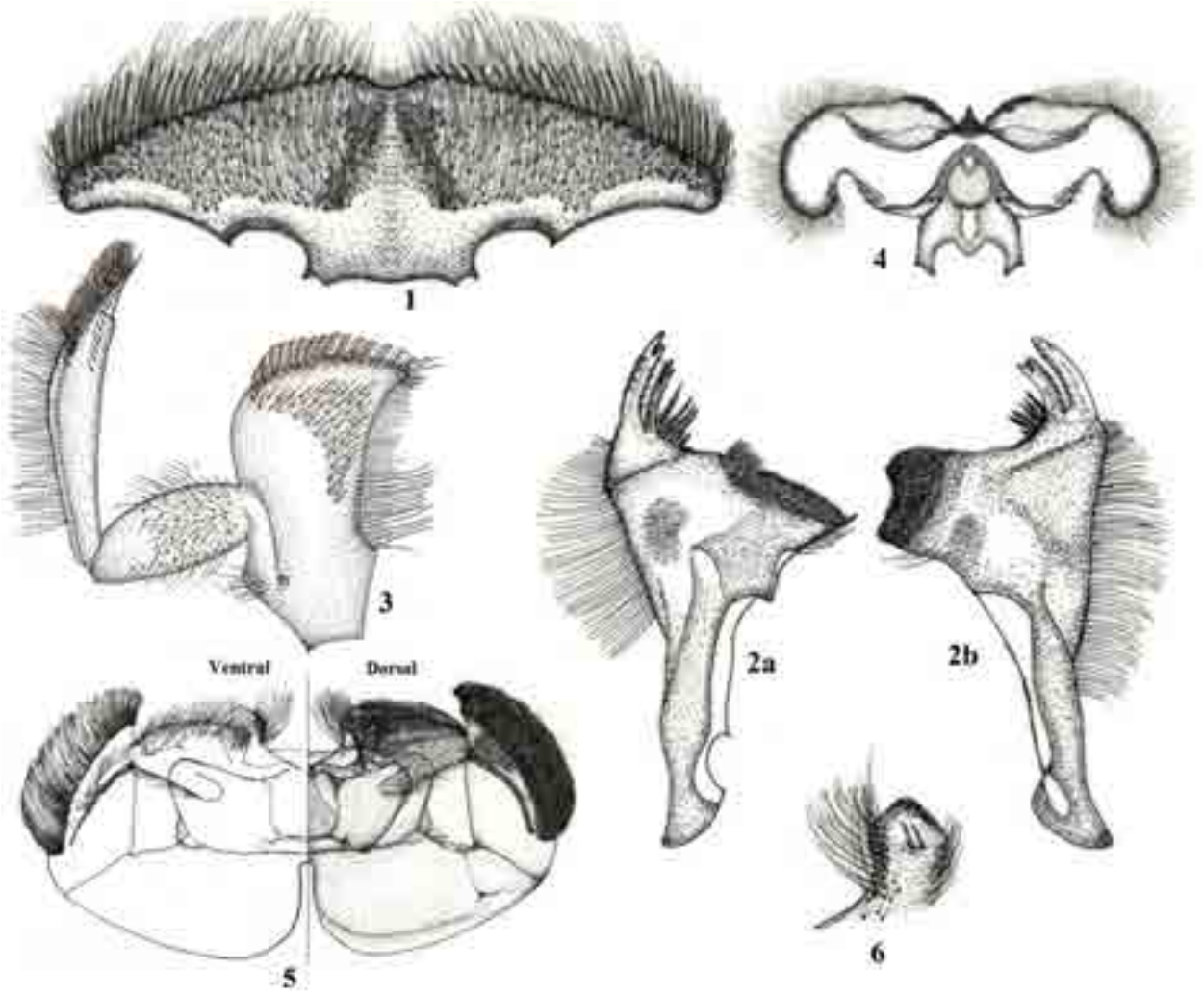

Figure 1–6. Mature larva of *Afronurus meenmutti* sp. nov. (dorsal view): 1—Labrum | 2a—Right mandible | 2b—Left mandible | 3—Maxilla | 4—Hypopharynx | 5—Labium | 6—Glossa enlarged.

posterior margin of terga IV–X with brown band medially; absence of postero-lateral spines in all terga; terga III–VII dark brown with pale yellow maculae, terga VIII–X washed yellow. Gills on abdominal segments (Figure 10–13) I–VI smoky black to translucent, dorsal lamella tracheated, ventral fimbriate; gill I slightly lobate; gill lamellae on abdominal segment 5 with acutely pointed apical elongation; gill VII single lamellate with well developed tracheation. Cerci brown at posterior region of each segment and reminders translucent.

Male imago: (Figures 14–18) (preserved in 95% ethanol) Dimensions (mm): Length: body, 7.5; forewings (Figure 14), 6.5; hindwing (Figure 15), 1.8. Width: forewings, 2.3; hindwing, 0.8; cerci, 17.0.

Head: length 0.5, light yellowish-brown, margin darker. Antennae 0.7, scape and pedicel of antennae yellowish brown, flagellum pale gray. Eyes whitish-black. Basal half of ocelli black, apical half white. Dorsal diameter of eye 0.4; distance between compound eyes 0.1.

Thorax: Yellowish-brown, sutures pale; margins of pronotum brown; venter yellowish-brown. Legs yellowish-brown, all joints of femora, tibiae and tarsi dark brown, ratio of segments in forelegs (Figure 16) femur; tibia; tarsus viz., 2.0/ 2.15/ 3.3, claws pair alike, apically hooked with an opposing hook (Figure 17). Wings longitudinal and cross vein of fore and hind wings pale brown; membranous fore and hind wings hyaline, except cells C and Sc of fore wing pale gray; stigmatic area of forewing with 12 intercalary veins; MA forked near 1/2 of distance from the base of wing to margin; MP forked at 1/4 of distance from the base of wing to margin; anal veins with two fork; first anal area without pair of long intercalary; hind wing transparent, costal

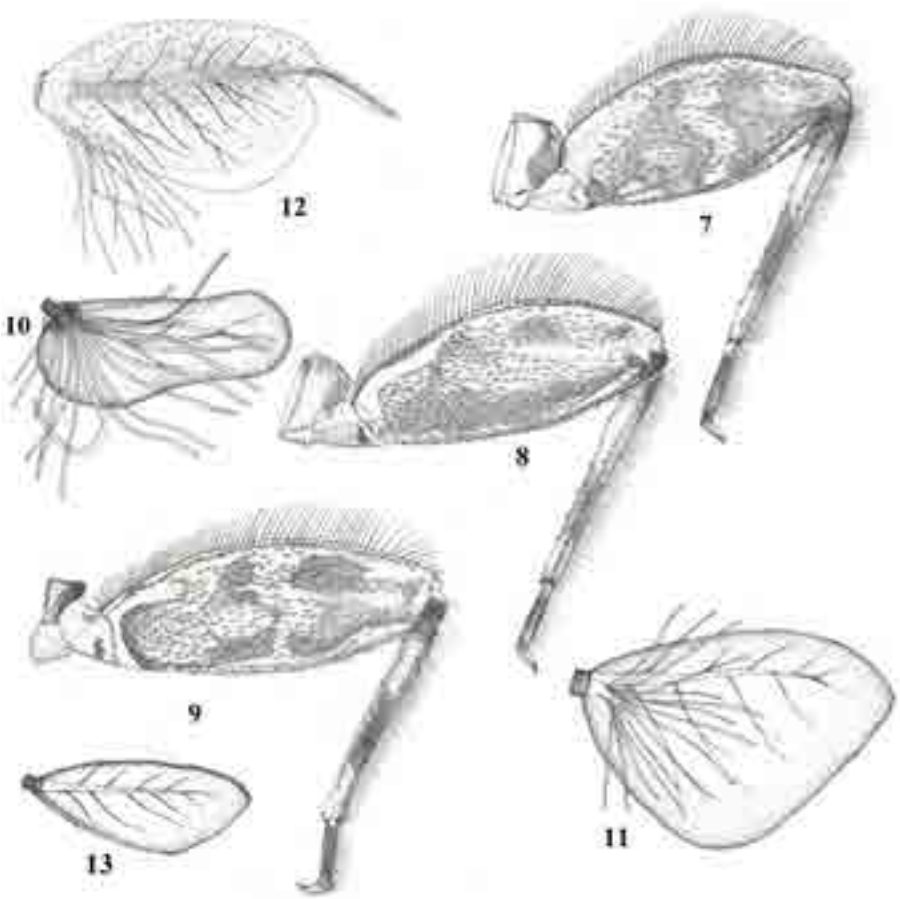

Figure 7–13. Mature larva of *Afronurus meenmutti* sp. nov.: 7—Foreleg | 8—Midleg | 9—Hindleg | 10—Gill I | 11—Gill V | 12—Gill VI | 13—Gill VII.

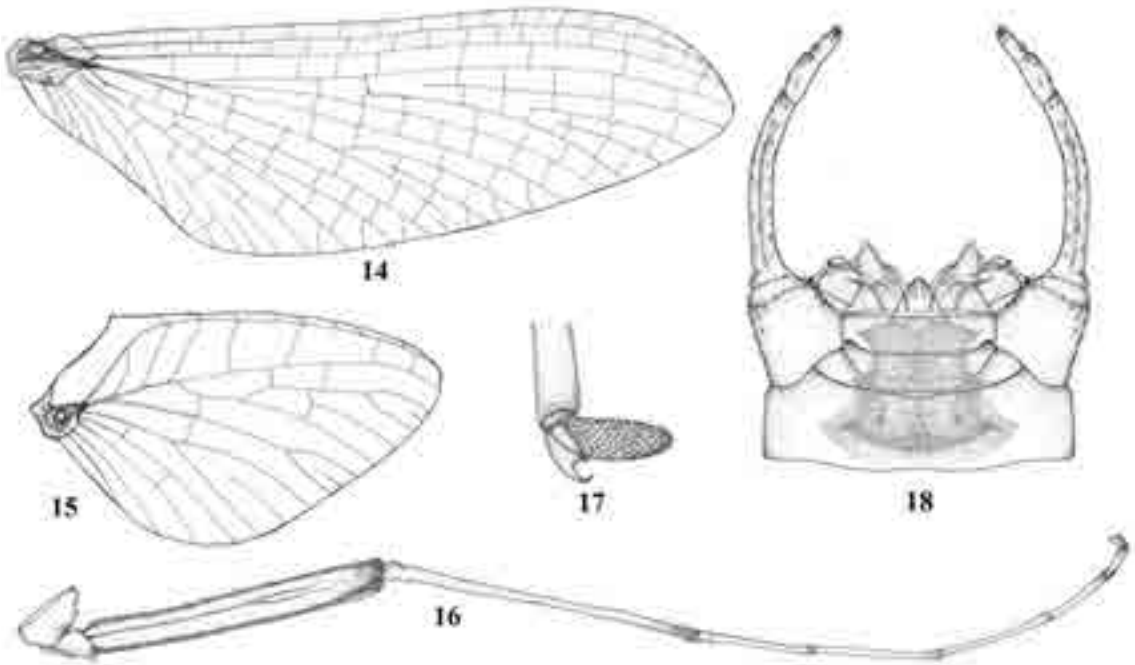

Figure 14–18. Adult of *Afronurus meenmutti* sp. nov.: 14—Forewing | 15—Hindwing | 16—Foreleg | 17—Foreclaw | 18—Genitalia (ventral view).

process acute.

Abdomen: Terga I–X washed with dark brown medially; terga washed yellow laterally except terga VII–X washed with yellowish-brown, lack of marking in postero-lateral edges of abdominal terga, terga I–X dark brown band on posterior margin medially; sterna yellowish-brown. Genitalia (Figure 18) forceps 0.7; penes 0.251; penes pale yellow; basal half of forceps uniformly washed with yellowish-brown, apical half pale brown; stout spine dispersed on inner and outer margin of forceps; outer lobe of penis much broader and slightly elevated; median titillators of penes well developed and prominent; cerci pale brown, annulations at articulations paler.

Female imago: (preserved in 95% ethanol) Dimensions (mm): Length: body, 8.5; forewings, 8.1; hindwing, 2.1. Width: forewings, 2.6; hindwing, 0.9; cerci, 19.0.

Head: Length 1.0 , dark brown, margin darker. Antennae 0.8, scape, pedicel and flagellum of antennae as in male imago. Eyes and ocelli black. Dorsal diameter of eye 0.35; distance between compound eyes 0.8.

Thorax: Brownish-yellow, venter pale yellow; carinae darker; sutures paler. Legs femora of foreleg brownish-yellow remainders as in male imago, middles and hindleg yellow. Wings details as in male imago.

Abdomen:terga I–X yellowish-brown, posterior edges of all terga with dark brown band. Sterna yellow. Cerci pale yellow, annulations at articulation paler.

Etymology

The described new species is named after the place of collection, Meenmutti falls of Kallar River, Thiruvanandhapuram district, Kerala.

Diagnosis

The larvae of *Afronurus meenmutti* sp. nov. can be separated from all other species by the following combination of characters: (i) lingua of hypopharynx deeply cleft; (ii) glossae oblong with two stout spines medially (iii) gill I slightly lobate (Figure 10); (iv) gill lamellae on abdominal segment V with acutely pointed apical elongation; (v) absence of postero-lateral spines on terga; (vi) maculae on midleg scattered (Figure 7–9). The imagoes of *Afronurus meenmutti* sp. nov. can be separated from all other species by the following combination of characters: (i) hind wing with acute costal process; (ii) outer lobe of penis much broader and slightly elevated; (iii) stout spines on forceps.

Discussion

The flat-headed mayfly genus *Afronurus* has been recorded in the Palearctic and Oriental regions. In India, six species have been recorded. Of these, *A. kumbakkaraiensis* and *A. meenmutti* sp. nov. have all life stages described, whereas *A. assamensis, A. curtus,* and *A. solangensis* are known from adults and only the larvae of *A. keralensis* has been described.

The larvae of *A. meenmutti* sp. nov. differs from *A. kumbakkaraiensis* and *A. keralensis* by the following combination of characters: 1) gill I slightly lobate, 2) gill lamellae on abdominal segment V with acute apical elongation, 3) lingua of hypopharynx deeply cleft, 4) posterior-lateral spines absent on terga, 5) glossae oblong with 2 spines medially.

Male imagoes of *A. meenmutti* sp. nov. can be distinguised from *A. kumbakkaraiensis* and *A. assamensis* by the following combination of characters: (i) stout spine dispersed on basal and surface of forceps and (ii) outer lobe of penis much broader and slightly elevated. Female imagoes of *A. meenmutti* sp. nov. can be distinguised from *A. kumbakkaraiensis*, *A. assamensis*, *A. curtus*, and *A. solangensis* by the following combination of characters: (i) stigmatic area of forewing with 12 intercalary; (ii) size of fore and hind wings are smaller.

References

Boonsoong, B. & D. Braasch (2013). Heptageniidae (Insecta, Ephemeroptera) of Thailand. *ZooKeys* 272: 61–93. https://doi.org/10.3897/zookeys.272.3638

Braasch, D. (1987). Neue Heptageniidae von Indien (Ephemeroptera). *Reichenbachia* 24(18): 131–134.

Braasch, D. (1990). Neue Eintagsfliegenaus Thailand, nebsteinigen Bemerkungenzuderengenerischem Status (Insecta, Ephemeroptera: Heptageniidae). *Reichenbachia* 28(2): 7–14.

Braasch, D. (2005). Neue Arten der Gattung *Atopopus* und *Afronurus* aus Sudostasiensowieeinige Bemerkungenzur Gattung *Asionurus*von Malaysia (Insecta: Ephemeroptera: Heptageniidae). *Entomologische Abhandlungen* 62(2): 165–174.

Braasch, D. (2011). New species of the family Heptageniidae (Ephemeroptera) from Borneo and the Philippines. *Deutsche Entomologische Zeitschrift* 58(2): 201–219. https://doi.org/10.1002/mmnd.201100024

Braasch, D. & B. Boonsoong (2010a). A contribution to the Heptageniidae (Insecta: Ephemeroptera) of Thailand and Malaysia. *Zootaxa* 2610: 1–26.

Braasch, D. & B. Boonsoong (2010b). A contribution to the Heptageniidae (Insecta, Ephemeroptera) of Thailand and Malaysia. *Zootaxa* 2610: 1–26.

Braasch, D. & H. Freitag (2008). *Palawaneuria*, a new subgenus of *Compsoneuria* and new species of *Compsoneuria* and *Afronurus* (Ephemeroptera, Heptageniidae) from Palawan, Philippines. *Deutsche Entomologische Zeitschrift* 55: 117–128.

Braasch, D. & L. Jacobus (2011) Two new species of *Afronurus* Lestage, 1924, from Hong Kong, China (Ephemeroptera: Heptageniidae). *Zootaxa* 062: 64–68.

Braasch, D. & T. Soldan (1987) Neue *Cinygmina*-Artenaus Vietnam (Ephemeroptera, Heptageniidae). *Reichenbachia* 24(16): 123–126.

Braasch, D. & T. Soldán (1984). Zweineue Arten der Gattung *Cinygmina* Kimmins, 1937 aus Vietnam (Ephemeroptera, Heptageniidae). *Reichenbachia, Staatliches Museum Tierkunde Dresden* 22(26): 195–200.

Braasch, D. & T. Soldán (1987). Neue *Cinygmina*-Artenaus Vietnam (Ephemeroptera, Heptageniidae). *Reichenbachia, Staatli-ches Museum Tierkunde Dresden* 24(16): 123–126.

Dubey, O.P. (1971). Torrenticole insects of the Himalaya. VI. Description of nine new species of Ephemeridae from the northwest Himalaya. *Oriental Insects* 5: 521–548.

Flowers, R.W. & M. Pescador (1984). A new *Afronurus* (Ephemeroptera: Heptageniidae) from the Philippines. *International Journal of Entomology* 26(4): 362–365.

Kang, S.C. & C.T. Yang (1994). Heptageniidae of Taiwan (Ephemeroptera). *Journal of Taiwan Museum* 47(1): 5–36.

Kimmins, D.E. (1937). Some new Ephemeroptera. *Annals and Magazine of Natural History,* Series 10(19): 430–440.

Kluge, N. (2004). The phylogenetic system of Ephemeroptera. *Kluwer Academic Publishers*, Dordrecht, 442 pp.

Koss, R.W. & G.F. Edmunds Jr. (1974). Ephemeroptera eggs and their contribution to phylogenetic studies of the order. *Zoological Journal of the Linnean Society* 55: 267–349.

Kopelke, J.-P. (1980). Morphologische Studienan den Eiern der Eintagsfliegen (Ephemeroptera) aus der Emergenz des zentralafrikanischen Bergbaches Kalengo. Mitteilungen der Schweizerischen Entomologischen Gesellschaft 53 (2–3): 297–311.

Lestage, J.A. (1924). Les Ephémères de l'Afrique du Sud. Catalogue critique & systematique des espècesconnueset description de trois genres nouveaux et de septespècesnouvelles. *Revue Zoologique Africaine* 12: 316–352.

Nguyen, V.V. & Y.J. Bae (2003). Two new species of *Afronurus* (Ephemeroptera: Heptageniidae) from Vietnam. *Korean Journal of Entomology* 33(4): 257–261. https://doi.org/10.1111/j.1748-5967.2003.tb00079

Venkataraman, K. & K.G. Sivaramakrishnan (1989). A new species of *Cinygmina* (Ephemeroptera: Heptageniidae) from South India and reevaluation of generic traits of *Cinygmina* Kimmins, 1937. *Hexapoda* (InsectaIndica) I (1/2): 117–121.

Wang, T.Q. & W.P. McCaffferty (2004). Heptageniidae (Ephemeroptera) of the world. Part I: Phylogenetic higher classification. *Transactions of the American Entomological Society* 130: 11–45.

Wu, T., C.F. Chen, N. Cong & D.S. You (1986). Three species of nymphs of the genus *Cinygmina*from Yi Xing. *Journal of Nanjing Normal University (Natural Science)* 1: 65–70.

Yanai, Z., M. Sartori, R. Dor & N. Dorchin (2017). Molecular phylogeny and morphological analysis resolve a long-standing controversy over genericconcepts in Ecdyonurinae mayflies (Ephemeroptera: Heptageniidae), *Systematic Entomology* 42: 182–193.

Zhou, C.F. & L.Y. Zheng (2003). The genus *Cinygmina* (Ephemeroptera: Heptageniidae) in China, with description of a new species. *Acta Entomologica Sinica* 46(6): 755–760.

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SHORT COMMUNICATION

Photographic record of Dholes predating on a young Banteng in southwestern Java, Indonesia

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Abstract: A long-term camera-trap study of the Javan Rhinoceros in 2013 in Ujung Kulon National Park (UKNP), Indonesia, allowed us to document the first photographic evidence of Dholes preying on a young Banteng and other species. Our photographs suggested that Dholes get in large packs to predate on Banteng and commonly separate young from adults when attacking the young. Future research should examine the Dhole diet and interspecific relationships between Dhole and Banteng to gain a better understanding of the ecological impacts of endangered predators on endangered prey in UKNP.

Keywords: *Bos javanicus*, camera trap, *Cuon alpinus*, ecological impacts, Indonesia, interspecific relationships, predation.

Historically, Dholes *Cuon alpinus* occurred throughout southern Asia (Bangladesh, Bhutan, India, Nepal, and Pakistan), eastern Asia (China, Korean Peninsula, Russian Far East), and southeastern Asia (Cambodia, Lao PDR, Malaysia, Myanmar, Thailand, Viet Nam, and Indonesia), and as far west as the mountains ranging from eastern Kazakhstan to northern Pakistan (Heptner & Naumov 1967). Recently, most of the Dhole's population has been fragmented and continues to decline (they now occur in <25% of their historical range) and therefore the species is categorized as 'Endangered' by the IUCN Red List (Kamler et al. 2015). In Indonesia, historically, Dholes occurred throughout both Sumatra and Java; however, their current distribution on both islands has contracted considerably during the past 30 years; consequently, the species is protected by Indonesian law (Regulation of the Minister of Environment and Forestry of the Republic of Indonesia No. P.106/MENLHK/SETJEN/KUM.1/12/2018; Indonesian Ministry of Environment and Forestry 2018).

Despite their endangered status and widespread distribution, there is still relatively little known about the ecology of Dholes in Indonesia. For example, there have been only nine studies that determined the daily behavior and feeding habits of Dholes in Indonesia (Pudyatmoko et al. 2007; Nurvianto et al. 2015, 2016; Pudyatmoko 2017, 2018; Rahman et al. 2018, 2019; Rahman & Mardiastuti 2021). Some of these studies have described potential prey for Dholes in two protected areas (Baluran National Park and Ujung Kulon National Park), but evidence of predation behaviour through

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direct observation or camera footage has not been reported. Our study is the first to document predation activity by Dholes on a large-sized ungulate species, the Banteng *Bos javanicus* in Ujung Kulon National Park.

Methods

Study area

Our study area was located in Ujung Kulon National Park (UKNP) in southwestern Java, Indonesia (Figure 1). We conducted long-term camera-trap surveys in the peninsula of UKNP (323 km^2). The park biota is a tropical rainforest that has experienced various natural and anthropogenic disturbances in the past and present. The destructive tsunami in 1883 and landslides in 2018 in the Sunda Strait have caused secondary growth of biota in the Park. The UKNP contains the last known population of Javan Rhinoceros *Rhinoceros sondaicus sondaicus*. The UKNP also contains only one other large-sized ungulate, the Banteng, as well as small- to medium-sized ungulates such as Java Mouse-deer *Tragulus javanicus*, Javan Warty Pig *Sus verrucosus*, Eurasian Wild Pig *Sus scrofa*, Red Muntjac *Muntiacus muntjak*, and Javan Deer *Rusa timorensis*. Large carnivores present in UKNP include the Javan Leopard *Panthera pardus melas* and Dhole (Rahman et al. 2018, 2020).

Field methods

The sampling effort was 39,420 trap days with a grid of 329 1-km^2 trap stations. We placed 108 camera units into 134 trap stations, with 0.3–0.5 km between stations, and ran them from January to December 2013. We used two models of camera traps—Bushnell Trophy Cam 119467 and Bushnell Trophy Cam 119405. At each station, we placed single camera and at approximately

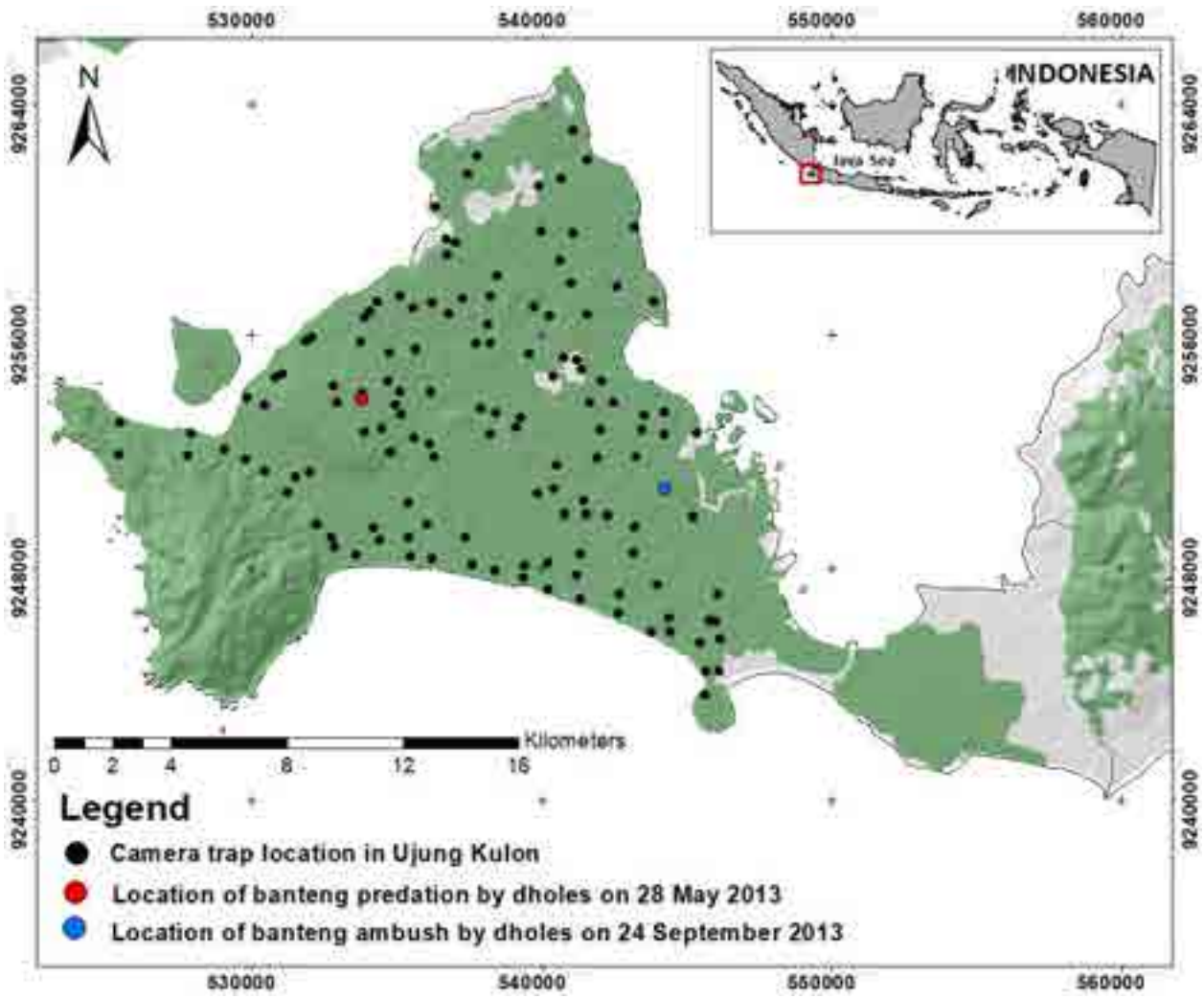

Figure 1. Camera trap locations in Ujung Kulon National Park in southwestern Java with the location of the apparent predation on a young Banteng by Dholes.

170 cm height from ground level with a 10–20 degree angle directed towards the ground (the cameras were set at 1-minute video mode with 1-minute intervals). We checked camera traps every 28–30 days to avoid data loss due to possible camera malfunction and battery and memory card depletion. We moved the camera traps within the same grid when they did not capture any animal (zero presence) after two or three checking. Sequential frames of the same species were counted as an independent photographic event if they were >30 minute apart. We recorded 607 independent photographs of Dholes during a survey period. We used latitude and longitude information converted into digital data in GIS using the ArcMap program to map each photograph location.

Results

On 28 May 2013 at 0743–0757 h, a camera recorded a young Banteng, accompanied by three adult females, attacked and preyed upon by more than 15 adult Dholes (Image 1). On 24 September 2013 at 1700–1712 h, another camera recorded more than six adult Dholes trying to kill a young Banteng (accompanied by 3 adult females) in the same pattern as before (Image 2). The only other video of Dhole-ungulate interactions was of a Java Mouse-deer being chased by five adult Dholes on 18 April at 1216 h, a wild pig attacked by two adult Dholes on 15 October at 1110 h, and one adult male Javan Rhinoceros being followed by three adult Dholes on 31 July at 1643 h (Image 3).

Discussion

These photographs indicate that Dholes are capable of predating on large-sized ungulates such a Banteng, although probably mostly young of this species. A review of Dhole diets showed that their preferred weight range is 130–190 kg, and that the two most preferred species are Sambar and Chital (Hayward et al. 2014). These results are supported by research in India, such as in Nagarahole, which found Dholes usually prefer medium-sized prey (Karanth & Sunquist 2000), such as Chital Deer *Axis axis* and Sambar Deer *Rusa unicolor* (Karanth & Sunquist 1995). In India, Dholes were occationaly found to consume Gaur *Bos gaurus*, a large-sized ungulate (Johnsingh 1983; Karanth & Sunquist 1995; Hayward et al. 2014), indicating large-sized ungulates are not common prey of Dholes in India. In Bhutan and Laos, Dholes were found to prey mostly on both medium and small-sized ungulates (Wang & Macdonald 2009; Thinley et al. 2011; Kamler

Image 1. Photographs of predation on a young Banteng by a pack of Dholes on 28 May 2013: 1—a Dhole bites the neck of a young Banteng | 2–4—an adult female Banteng tries to protect the young Banteng | 5—several members of the Dhole pack try to separate the young Banteng from an adult female Banteng | 6–7—Dholes kill a young Banteng on the far side of picture | 8—adult female Bantengs come back to try and save the young Banteng | 9—the process of predation by Dholes is complete which is marked by several pack members resting.

Image 2. Photographs of predation on a young Banteng by a pack of Dholes on 24 September 2013: 1—young Banteng accompanied by three adult females | 2—one individual Dhole starts attacking the Banteng | 3–5—an adult female Banteng tries to protect the young Banteng | 6–8—three Dholes are moving forward and attacking Banteng on the far side of picture | 9—another individual Dhole running moving forward on the same side.

et al. 2012). In Cambodia, although Dholes preferred Muntjac, a small-sized ungulate, they also regularly consumed Banteng (18% of diet), indicating Dholes are capable of sometimes preying on large-sized ungulates (Kamler et al. 2020). Similary, in Baluran National Park, East Java, Dholes were found to consume mostly large-sized ungulates including Banteng and Water Buffalo *Bubalus bubalis* (Nurvianto et al. 2016). Thus, Dholes in Indonesia and other areas of southeastern Asia might be more likely to prey on large-sized ungulates compared to Dholes in India, where medium-sized ungulates are more common.

Dholes may hunt alone, in pairs or large packs (Cohen 1977; Venkataraman et al. 1995), and we recorded similar group sizes in UKNP. Previous studies have shown that larger pack sizes of Dholes take larger prey (Hayward et al. 2014; Kamler et al. 2020), and our photographs supported this conclusion because a pack of at least 15 Dholes were involved in the predation event on the young Banteng. Previous researchers have reported that Dholes attack young of Banteng, Gaur, and Water Buffalo by chasing the herds and separating calves from their mothers (Krishnan 1972; Prater 1980). In our case, the Dhole pack attacked the calf while it was still next to its presumed mother, although during the attack the Dholes appeared to try and separate the young from its mother. A throat injury tyipcally is not part of a Dhole hunting technique (Johnsingh 1983), although in our case a Dhole first grabbed the young Banteng by the throat in an attempt to bring it to the ground. The estimated time of the predation event (from contact to killing) was approximately 14 minutes.

Although three Dholes were photographed following an adult male Javan Rhinoceros, this probably was not a predation attempt. Firstly, adult male Javan Rhinoceros' weigh approximately 1,000–2,000 kg, which is far outside of accessible prey range for Dholes (30–235 kg; Hayward et al. 2014). Secondly, only three Dholes were following the Rhinoceros, suggesting the pack size was not large enough to successfully attack such a large-sized prey. It is unclear why the three Dholes appeared to be following the male Rhinoceros, but perhaps they were escorting the Rhinoceros away from their young pups or den site. Our frame shows results in line that Dhole activity in denning increases at dawn and dusk.

In summary, we provide the first photographic evidence of a predation on Banteng by Dholes. Although previous studies found that Dholes regularly consumed Banteng in Cambodia (Kamler et al. 2020) and East Java (Nurvianto et al. 2016), their predatory behavior

Image 3. 1–3—a Java Mouse-deer being chased by five adult Dholes | 4–6—Wild Pig attacked by two adult Dholes | 7–9—an adult male Javan Rhinoceros followed by three Dholes.

towards Banteng had never been photographed. These photographs suggests that Dholes get in large packs to predate on Banteng and separate young from adults when attacking the young. We do not know the Dhole diet in UKNP, nor do we know the impact of Dhole predation on the local Banteng population. Since both are threatened species, to protect potentially impacted resources, understanding the dynamics of destructive species can lead to more efficient and effective strategies (e.g., Knowlton et al. 1999). Just because a predator is identified as harming an endangered species, managing predators does not guarantee to help the conservation of an endangered prey to be more effective, efficient or cost-effective. A thorough understanding of when and why predation occurs and the conditions that make endangered prey most susceptible to predation is necessary for predator management by UKNP managers. The mitigation program in the future can be carried out by the manager by optimizing the management of predators during the state of greatest vulnerability of endangered prey and maximizing the conservation benefit-cost ratio in species management.

References

Cohen, J.A. (1977). A review of the biology of the Dhole or Asiatic Wild Dog (*Cuon alpinus* Pallas). *Animal Regulation Studies* 1: 141–158.

Hayward, M.W., S. Lyngdoh & B. Habib (2014). Diet and prey preference of Dholes (*Cuon alpinus*): dietary competition within Asia's apex predator guild. *Journal of Zoology* 294: 255–266. https://doi.org/10.1111/jzo.12171

Heptner, V.G. & N.P. Naumov (1967). *Mammals of the Soviet Union*. Vysshaya Shkola Publishers, Moscow.

Johnsingh, A.J.T. (1983). Large mammalian prey-predators in Bandipur. *Journal of the Bombay Natural History Society* 80: 1–57.

Kamler, J.F., A. Johnson, C. Vongkhamheng & A. Bousa (2012). The diet, prey selection, and activity of Dholes (*Cuon alpinus*) in northern Laos. *Journal of Mammalogy* 93(3): 627–633. https://doi.org/10.1644/11-MAMM-A-241.1.

Kamler, J.F., N. Songsasen, K. Jenks, A. Srivathsa, L. Sheng & K. Kunkel (2015). *Cuon alpinus*. The IUCN Red List of Threatened Species 2015: e.T5953A72477893. https://doi.org/10.2305/IUCN.UK.2015-4.RLTS.T5953A72477893.en

Kamler, J.F., K. Thatdokkham, S. Rostro-García, A. Bousa, A. Caragiulo, R. Crouthers, V. In, C. Pay, C. Pin, S. Prum, C. Vongkhamheng, A. Johnson & D.W. Macdonald (2020). Diet and prey selection of Dholes in evergreen and deciduous forests of Southeast Asia. *Journal of Wildlife Management* 84: 1396–1405. https://doi.org/10.1002/jwmg.21931

Karanth, K.U. & M.E. Sunquist (1995). Prey selection by tiger, leopard and Dhole in tropical forests. *Journal of Animal Ecology* 64: 439–450. https://doi.org/10.2307/5647

Karanth, K.U. & M.E. Sunquist (2000). Behavioral correlates of predation by Tiger (*Panthera tigris*) Leopard (*Panthera pardus*) and Dhole (*Cuon alpinus*) in Nagarahole, India. *Journal of Zoology* 250(2): 255–265. https://doi.org/10.1111/j.1469-7998.2000.tb01076.x

Knowlton, F.F., E.M. Gese & M.M. Jaeger (1999). Coyote depredation control: An interface between biology and management. *Journal of Range Management* 52(5): 398–412. https://doi.org/10.2307/4003765

Krishnan, M. (1972). An ecological survey of the larger mammals of peninsular India. *Journal of the Bombay Natural History Society* 69: 42–47.

Ministry of Environment and Forestry (2018). Peraturan Menteri Lingkungan Hidup dan Kehutanan Republik Indonesia No. P.106/ MENLHK/SETJEN/KUM.1/12/2018 tentang perubahan kedua atas peraturan Menteri Lingkungan Hidup dan Kehutanan No. P.20/ MENLHK/SETJEN/KUM.1/6/2018 tentang jenis tumbuhan dan satwa yang dilindungi. Sekretariat Kabinet RI, Jakarta, Indonesia.

Nurvianto, S., M.A. Imron & S. Herzog (2015). The influence of anthropogenic activities and availability of prey on the distribution of Dholes in a dry deciduous forest of East Java, Indonesia. *Asian Journal of Conservation Biology* 4(1): 26–36.

Nurvianto, S., R. Eprilurahman, M.A. Imron & S. Herzog (2016). Feeding habits of pack living Dhole (*Cuon alpinus*) in a dry deciduos forest of East Java, Indonesia. *Taprobanica* 8(1): 10–20. https://doi.org/10.47605/tapro.v8i1.210

Prater, S.H. (1980). *The Book of Indian Animals*. Bombay Natural History Society, Revised ed. 316 pp.

Pudyatmoko, S., Djuwantoko & Y. Sabarno (2007). Evidence of Banteng (*Bos javanicus*) decline in Baluran National Park, Indonesia. *Journal of Biological Sciences* 7(6): 854–859. https://doi.org/10.3923/jbs.2007.854.859

Pudyatmoko, S. (2017). Free-ranging livestock influence species richness, occupancy, and daily behaviour of wild mammalian species in Baluran National Park, Indonesia. *Mammalian Biology* 86: 33–41. https://doi.org/10.1016/j.mambio.2017.04.001

Pudyatmoko, S. (2018). Spatiotemporal inter-predator and predator-prey interactions of mammalian species in a tropical savanna and deciduous forest in Indonesia. *Mammal Research* 64: 191–202. https://doi.org/10.1007/s13364-0180391-z

Rahman, D.A., P. Rianti, M. Muhiban, A. Muhtarom, U.M. Rahmat, Y. Santosa & S. Aulagnier (2018). Density and spatial partitioning of endangered sympatric Javan Leopard (Felidae) and Dholes (Canidae) in a tropical forest landscape. *Folia Zoologica* 67(3–4): 207–219. https://doi.org/10.25225/fozo.v67.i3-4.a8.2018

Rahman, D.A., R. Herliansyah, P. Rianti, U.M. Rahmat, A.Y. Firdaus & M. Syamsudin (2019). Ecology and conservation of the endangered Banteng (*Bos javanicus*) in Indonesian tropical lowland forest. *Hayati Journal of Biosciences* 26: 68–80. https://doi.org/10.4308/hjb.26.2.68

Rahman, D.A. (2020). Ecological niche and potential distribution of the endangered *Bos javanicus* in south-western Java, indonesia. *Therya* 11(1): 57–68. https://doi.org/10.12933/therya-20-840

Rahman, D.A. & A. Mardiastuti (2021). Factors influencing the activity patterns of two deer species and their response to predators in two protected areas in Indonesia. *Therya* 12(1): 149–161. https://doi.org/10.12933/therya-21-1087

Thinley, P., J.F. Kamler, S.W. Wang, K. Lham, U. Stenkewiz & D.W. Macdonald (2011). Seasonal diet of Dholes (*Cuon alpinus*) in northwestern Bhutan. *Mammalian Biology* 76: 518–520. https://doi.org/10.1016/j.mambio.2011.02.003

Venkataraman, A.B., R. Arumugam & R. Sukumar (1995). The foraging ecology of Dholes (Cuon alpinus) in Mudumalai sanctuary, southern India. *Journal of Zoology* 237(4): 543–561. https://doi.org/10.1111/j.1469-7998.1995.tb05014.x

Wang, S.W. & D.W. Macdonald (2009). Feeding habits and niche partitioning in a predator guildcomposed of tigers, leopards and Dholes in a temperate ecosystem in central Bhutan. *Journal of Zoology* 277(4): 275–283. https://doi.org/10.1111/j.1469-7998.2008.00537.x

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Latrine site and its use pattern by Large Indian Civet *Viverra zibetha* Linnaeus, 1758: record from camera trap

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Abstract: Latrine sites are the places used for urination and defecation, which mostly act as a signaling agent for multiple purposes like territorial marking, confrontation with extruders or potential predators, delivering different inter and intra-communication messages. To understand latrine site visit pattern, a single camera trap was deployed for 91 trap nights at the latrine site of Large Indian Civet during the months of December 2016 and February & March 2017. Latrine site was found under the tree with abundant crown cover and bushes. At least two individuals were found to be using a single latrine site in an irregular manner between 1800 h and 0600 h with higher activity between 1800 h and 2300 h. Our results indicated an irregular latrine site visit pattern, hence similar studies with a robust research design in larger areas are required to understand specific latrine use patterns.

Keywords: Activity pattern, behavior, camera trap, clock chart, seasonal, scent marking, territorial marking, territory, urination.

The repeated use of specific latrine sites has been described for several mammals, including omnivores, ungulates, and primates (Dröscher & Kappeler 2014). Such sites vary in location (arboreal, terrestrial, or subterranean), in volume of faeces, spatial distribution, and behaviours associated with defecation and seem to vary in the functions they serve (Irwin et al. 2004). Understanding the use of latrine sites is one of the most effective and fundamental tools that provides future directions and insights into the ecological and behavioural relationships among conspecifics. Time stamped camera trap data have been very useful for understanding the presence, ecology and behaviour of the species (Ridout & Linkie 2009; Rowcliffe et al. 2014).

The Large Indian Civet *Viverra zibetha* is a widespread species and has been recorded up to 2,420 m in Nepal (Appel et al. 2013), and up to 3,080 m in India (Khatiwara & Srivastava 2014). Its presence was documented in the riverine and Sal *Shorea robusta* forests, near human settlements (Ghimirey & Acharya 2014), grasslands and in thick bushes (Jnawali et al. 2011) as well as in the primary, secondary, degraded forest, scrubland and plantations areas (Duckworth 1997; Azlan 2003; Jennings & Veron 2011; Choudhury 2013; Chutipong et al. 2014). Due to its wide distribution across a variety of habitats, it is listed as Least Concern (LC) in IUCN Red List (Timmins et al. 2016). It is a ground dwelling (Lekagul & McNeely 1977; Duckworth 1997) solitary, nocturnal animal; with occasional records at daytime (Than et al.

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2008; Gray et al. 2014). In this note, we documented its latrine site and its use pattern in the premises of the Institute of Forestry, Pokhara, using camera trap records.

Study area

The Institute of Forestry (IOF), Pokhara campus is situated in Pokhara, Kaski district, Gandaki province of Nepal. We identified the latrine site of the Large Indian Civet during mammalian profile survey within Banpale forest, a legal asset of IOF, which mainly includes the natural *Schima-Castanopsis* forest; having species of *Dalbergia*, *Albezia*, *Michelia*, and *Alnus*. The Seti river is a perennial that flows within a close vicinity of the forest. The recorded latrine site was very close to the Marshyangdi hostel. Agricultural crops, vegetables, and banana gardens were found around the study site.

Material and methods

A single piece of Bushnell camera trap was deployed without any lure for 91 days from 1–30 December 2016 and 01 February to 30 March 2017. The camera trap, having active motion inbuilt function with non-motion sensor, was deployed at the base of a *D. sissoo* tree at a height of 25–30cm above the ground in such a way that the entire latrine site was visible. It was set to both photo and video mode option so as to record two photos per second followed by a video of 10 seconds from 1800–0600 h for each trap night.

Data analysis

Both photo and video from the camera trap were imported, collated, and cleaned for further analysis. Only those photos and videos with the evidence of the record of a Large Indian Civet in the latrine site were considered for the interpretation. The obtained data were analyzed in R software using the package ggplot2, dplyr, lubridate (R core team 2019) to create the clock chart.

Results

The geographic location of the latrine site was at an elevation of 808 m. Monitoring of the latrine site for three months yielded a total of 215 videos and 1,017 camera trap images during the effort of 91 camera trap nights.

The latrine site was under the bush coverage of a *D. sissoo* tree, with 80% canopy intertwined with bushes and climbers, making the site enclosed with openings at two ends. The defecating site was excavated 5-cm deep at the center of the pit (a cavity or hole in the ground usually made by digging). The individuals deposited the feces along with spraying of urine in the latrine site, and rubbing their anus in soil right after defecation. Two

Image 1. Map of the study area (camera trap recorded locations of Large Indian Civet in the Banpale forest and latrine site at backside of Marsyangdi hostel at Institute of Forestry, Pokhara Campus, Nepal).

Large Indian Civets were seen together in the recorded video of March 2017 in the latrine site, however, their sexes could not be distinguished.

Large Indian Civets visited the latrine site from 1800–0500 h (Figure 1). It was active for most of the night time with the highest record during the hour between (2100–2200 h) followed by (1800–1900 h), with the lowest at the start of the day (0500–0600 h). It visited the site for eight days in December, seven days in February and six days in March. After the first eight days of frequent visits, the animal was not observed for the next 22 days in December.

Of the total video duration (1,423 seconds), the presence of the Large Indian Civet was recorded for 1,046 seconds, the major activity during this was sniffing (782 seconds, 78%) and defecating & urinating (224 seconds, 22%). It initially sniffed the site, afterwards urinated and defecated.

Discussion

The recorded latrine site was outside the forest area and in close proximity to the settlement area. A tree surrounded by tall bushes with a small outlet in both sides was used by the Large Indian Civet as latrine site.

Irregular visits to the monitored latrine site suggest that the animals have maintained other latrine sites too. A species maintaining more than one latrine site can be attributed to territory marking such as in otters (Torgerson 2014) and could be an interesting aspect of study. It could be a special vigilance behavior of the small carnivores to avoid any risk or conflict around the habitat.

The Malay Civets *Viverra tangalunga* were predominantly active from 1800 h to 0700 h (Colon 2006), and reported frequent walking and sniffing as a physiological olfactory sense use of carnivores to check the potential predator and conspecifics before the use of the latrine site for defecation and urination. This could be attributed as a special form of scent marking serving as a commonly invoked chemical communication function (Irwin et al. 2004; Wronski et al. 2013; Dröscher & Kappeler 2014; King et al. 2017) for avoidance of parasite transmission (Gilbert 1997), avoidance of detection by predators (Boonstra et al. 1996), and territoriality (Gorman & Trowbridge 1989). The nocturnal and crepuscular activity would help in increasing the encounters with prey (Colon 2006), a similar behavior was observed in our current study.

Image 2. Camera trapped photographs taken from the video recorded during the latrine site monitoring of Large Indian Civet: 1—the latrine trench of the species marked by yellow circle | 2—species urinating on its latrine site | 3—species defecating on its latrine site.

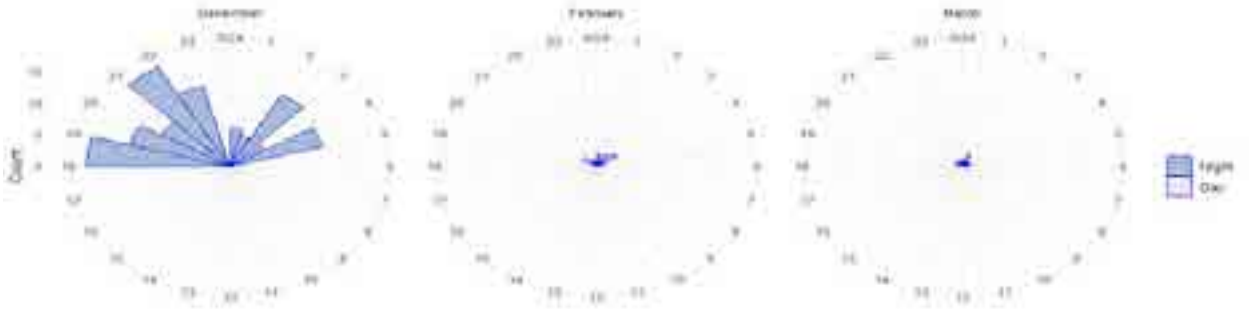

Figure 1. Frequency of camera-trap photographs and videographs of Large Indian Civet during survey period (1800–0500 h has been treated as night while the rest is day).

References

Appel, A., G. Werhahn, R. Acharya, Y. Ghimirey & B. Adhikary (2013). Small carnivores in the Annapsurna Conservation Area, Nepal. *Vertebrate Zoology* 63: 111–121.

Azlan, J. (2003). The diversity and conservation of mustelids, viverrids, and herpestids in a disturbed forest in Peninsular Malaysia. *Small Carnivore Conservation* 29: 8–9.

Boonstra, R., C.J. Krebs & A. Kenney (1996). Why lemmings have indoor plumbing in summer. Canadian. *Journal of Zoology* 74: 1947–1949.

Choudhury, A. (2013). *The Mammals of North East India*. Gibbon Books and the Rhino Foundation for Nature in NE India, Guwahati, Assam, India.

Chutipong, W., N. Tantipisanuh, D. Ngoprasert, A.J. Lynam, R. Steinmetz, K.E. Jenks, J.L. Grassman, M. Tewes, S. Kitamura, M.C. Baker, W. McShea, N. Bhumpakphan, R. Sukmasuang, G.A. Gale, F.K. Harich, A.C. Treydte, P. Cutter, P.B. Cutter, S. Suwanrat, K. Siripattaranukul, Hala-Bala Wildlife Research Station, Wildlife Research Division & J.W. Duckworth (2014). Current distribution and conservation status of small carnivores in Thailand: a baseline review. *Small Carnivore Conservation* 51: 96–136.

Colon, C. (2006). Ranging behaviour and activity of the Malay civet (Viverra tangalunga) in a logged and an unlogged forest in Danum Valley, East Malaysia. *Journal of Zoology* 257: 473– 485. https://doi.org/10.1017/S0952836902001073

Gray, T.N.E., C. Pin, C. Phan, R. Crouthers, J.F. Kamler & S. Prum (2014). Camera-trap records of small carnivores from eastern Cambodia, 1999–2013. *Small Carnivore Conservation* 50: 20–24

Dröscher, I. & P. Kappeler (2014). Maintenance of familiarity and social bonding via communal latrine use in a solitary primate (*Lepilemur leucopus*). *Behavioral Ecology and Sociobiology* 68: 2043–2058. https://doi.org/10.1007/s00265-014-1810-z

Duckworth, J.W. (1997). Small carnivores in Laos: a status review with notes on ecology, behaviour and conservation. *Small Carnivore Conservation* 16: 1–21.

Ghimirey, Y. & R. Acharya (2014). Notes on the distribution of Large Indian Civet in Nepal. *Small Carnivore Conservation* 50: 25–29.

Gorman, M.L. & B.J. Trowbridge (1989). The role of odor in the social lives of carnivores, pp. 57–88. In: Gittleman, J.L. (ed.). *Carnivore Behavior, Ecology, and Evolution*. Cornell University Press, Ithaca, New York.

Gilbert, K.A. (1997). Red howling monkey use of specific defecation sites as a parasite avoidance strategy. *Animal Behavior* 54: 451–455.

Irwin, M., K. Samonds, J.L. Raharison & P. Wright (2004). Lemur latrines: Observations of latrine behavior in wild primates and possible ecological significance. *Journal of Mammalogy* 85: 420–427. https://doi.org/10.1644/1545-1542(2004)085<0420:LLOOLB>2.0.CO;2

Jnawali, S.R., H.S. Baral, S. Lee, K.P. Acharya, G.P. Upadhyay, M. Pandey, R. Shrestha, D. Joshi, B.R. Laminchhane, J. Griffiths, A.P. Khatiwada, N. Subedi & R. Amin (compilers) (2011). The Status of Nepal Mammals: The National Red List Series, Department of National Parks and Wildlife Conservation Kathmandu, Nepal.

Jennings, A.P. & G. Veron (2011). Predicted distributions and ecological niches of 8 civet and mongoose species in Southeast Asia. *Journal of Mammalogy* 92: 316–327.

Khatiwara, S. & T. Srivastava (2014). Red Panda *Ailurus fulgens* and other small carnivores in Kyongnosla Alpine Sanctuary, East Sikkim, India. *Small Carnivore Conservation* 50: 35–38.

King, T., R. Salom, L. Shipley, H. Quigley & D. Thornton (2017). Ocelot latrines: communication centers for Neotropical mammals. *Journal of Mammalogy* 98: 106–113. https://doi.org/10.1093/jmammal/gyw174

Lekagul, B. & J.A. McNeely (1977). *Mammals of Thailand*. Association for the Conservation of Wildlife, Bangkok, Thailand, 758pp.

R Core Team (2019). R: A language and environment for statistical computing. R Foundation for Statistical Computing, Vienna, Austria.URL https://www.R-project.org/

Rowcliffe, J., M.R. Kays, B. Kranstauber, C. Carbone & P.A. Jansen (2014). Quantifying levels of animal activity using camera trap data. *Methods Ecology Evolution* 5: 1170–1179.

Ridout, M.S. & M. Linkie (2009). Estimating overlap of daily activity patterns from camera trap data. *Journal of Agricultural, Biological, and Environmental Statistics* 14: 322–337.

Torgerson, T. (2014). Latrine site selection and seasonal habitat use of a coastal river otter population. A Thesis Presented to The Faculty of Humboldt State University In Partial Fulfillment of the Requirements for the Degree Master of Science in Natural Resources: Wildlife, xi+91pp. https://doi.org/10.13140/RG.2.2.35183.43685

Than, Z., H. Saw, Po. Tha, M. Myint, A.J. Lynam, T.L. Kyaw & J.W. Duckworth (2008). Status and distribution of small carnivores in Myanmar. *Small Carnivore Conservation* 38: 2–28.

Timmins, R..J., J.W. Duckworth, W. Chutipong, Y. Ghimirey, D.H.A. Willcox, H. Rahman, B. Long & A. Choudhury (2016). *Viverra zibetha*. The IUCN Red List of Threatened Species 2016: e.T41709A45220429. Accessed 19 May 2020. https://doi.org/10.2305/IUCN.UK.20161.RLTS.T41709A45220429.en

Wronski, T., A. Apio, M. Plath & M. Ziege (2013). Sex difference in the communicatory significance of localized defecation sites in Arabian Gazelles (*Gazella arabica*). *Journal of Ethology* 31: 129–140.

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NOTE

Two additions to the flora of Kerala, India

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Agasthyamalai, a compact block of hill range on the southern most end of the Western Ghats falls within the Thiruvananthapuram district of Kerala state. It lies between 8.500–8.733N latitude and 77.083– 77.300E longitude and spreads over a geographical area of c. 200 km^2. It descends steeply westwardly from the highest peak of Agasthyarkoodam with an altitude of 1,868 m in the east, to 300–400 m high hilly forest areas of Thiruvananthapuram district in the west, Tirunelveli district in the east, Kanyakumari district in south. The Agasthyamalai harbours more than 1,100 species of flowering plants which includes c. 320 species (28%) are found to be endemic to India. Of these, 46 species are reported and restricted to Agasthyamalai regions of Kerala state (Mohanan & Sivadasan 2002).

In a recent botanical exploration in Agasthyamalai, Thiruvananthapuram district, Kerala, the authors collected two specimens belongs to the genera *Acilepis* D.Don and *Psychotria* L., respectively. After critical study with relevant literatures and protologue (Chelladurai & Gopalan 2001; Murugan & Gopalan 2007), these were identified as *Acilepis pothigaiana* (Chellad. & Gopalan) Kottaim. and *Psychotria henryana* Murugan & Gopalan which are found in the eastern slopes of Agasthiamalai, Tamil Nadu state. On perusal of literature (Mohanan & Henry 1994; Mohanan & Sivadasan 2002; Sasidharan 2004, 2013; Nayar et al. 2006, 2014) revealed that these two species have so far not been reported from Kerala state, and hence they constitute new distribution records for state. Its short description along with nomenclature notes, distribution, image, phenology is provided for the further collection and identification in the field.

Asteraceae

***Acilepis pothigaiana* (Chellad. & Gopalan) Kottaim. (Image 1)**

Telopea 18: 376. 2015. *Vernonia pothigaiana* Chellad. & Gopalan in J. Econ. Taxon. Bot. 25: 271. 2001; Singh et al. End. Vasc. Pl. India: 115. 2015.

Type: India, Tamil Nadu, Tirunelveli District: Pothigaimalai peak (Agasthiamalai), ±1868 m, 06.ii.1989, R. Gopalan 88741 (Holo: CAL image!; Iso: MH!).

Large herbs to shrubs, up to 1.2 m high; branchlets grooved or 6–10 ribbed, young parts woolly white powdery tomentose. Leaves simple, spirally alternate, elliptic-lanceolate or lanceolate, 3–10 × 1.5–3 cm, glabrous above, woolly white tomentum beneath, attenuate at base, margins distantly glandular serrate and revolute, acute-acuminate with mucronate at apex; lateral nerves 8–10 pairs; petioles up to 2 cm long, flat

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Image 1. ***Acilepis pothigaiana*** **(Chellad. & Gopalan) Kottaim.: A—branching of inflorescences | B & C—achenes with style and stigma | D—phyllaries | E—floret | F—split open corolla | G—corolla with stamens | H & I—achenes with pappus. © P. Murugan.**

above, rounded below. Inflorescence terminal or axillary, lax, panicled cymes up to 12 cm long; peduncles up to 6 cm long, ribbed; capitula, 1–1.5 long; Phyllaris 20–25 in 4–5 seriate; outermost 1-seriate 1–4, up to 1 mm long, triangular, margins ciliate, apex at mucronate; second seriate 5–11, up to 2.5 mm long, ovate, ciliate along margins; third seriate 12–16, up to 3 mm long, oblong or oblong to ovate, ciliate at margins; fourth seriate 17–19, up to 4 mm long, oblong-ovate, obtuse and apiculate at apex, 3-ribbed; fifth seriate 20–21, up to 4.5 mm long, concave, obtuse and apiculate at apex, tri-nerved; innermost seriate 22–25, 4–5 mm long, oblanceolate or spathulate, hyaline, obtuse and apiculate at apex, tri-nerved; pedicels 2–8 mm long, ribbed. Disc florets bisexual, homogamous. Corolla 8–10 mm long, infundibuliformis; lobes 5, 4–5 mm long, oblong-laceolate or linear-lanceolate, hyaline, margins at entire with thick layer, apex at acute. Stamens 5, syngenesious; filaments alternate to the corolla lobes, 0.5–1 mm long; anthers 2–3 mm long, oblong-linear, tailed at base, acute at apex. Ovary oblong-obovate, ca 2 mm long, 8–10 ribbed; style 6–8 mm long, filiform; stigma 2–3 mm long, arms, feathery or hairy. Achene oblong-obovate, 2–3 mm long, 8–10 ribbed, brown; pappus up to 7 mm long, plumose trichomes, biseriate, barbellate. Ray florets 0

Image 2. Herbarium sheet of *Acilepis pothigaiana*.

Flowering & Fruiting: January–April

Distribution: India (Tamil Nadu & Kerala), endemic.

Specimens examined: 145004 (MH, Image 2), 25.iii.2021, Agasthyarkoodam, slope of first rope base, Thiruvananthapuram District, Kerala, India, 8.61808333 N 77.24702778 E, ± 1,750 m, coll. P. Murugan

Biotic association: *Acilepis pothigaiana* was found growing along with other species such as *Impatiens agastyamalayensis* (Bhaskar) A.Joe, Bhaskar & M.Sabu, *Impatiens henslowiana* Arn., *Symplocos wynadense* (Kuntze) Noot., *Senecio ludens* C.B.Clarke, *Hedyotis travancorica* Bedd., *Nostolachma crassifolia* (Gamble) Deb & Lahiri, and *Tarenna flava* Alston

Note: Chelladurai & Gopalan (2001) described this species based on their collections (1977 & 1989) from the Pothigaimalai, Tirunelveli hills, Tamil Nadu. Later Kottaimuthu (2015) transferred *Vernonia pothigaiana* Chellad. & Gopalan into the genus *Acilepis* D.Don. The present collection turns to be the relocation of the plant after type and a new addition to the flora of Kerala.

Rubiaceae

***Psychotria henryana* Murugan & Gopalan**

(Image 3)

Nordic J. Bot. 24: 415. 2007; Singh et al. End. Vasc. Pl. India: 237. 2015.

Type: India, Tamil Nadu, Kanyakumari District: Muthukuzhi, ±1400 m, 19.i.1978, A.N. Henry 52454 (Holo: CAL image!; Iso: MH!).

Evergreen, large shrubs, up to 3 m high; branchlets terete, smooth, young parts stem green with white dotted. Leaves simple, opposite-decussate, oblanceolate, 8–20 × 4–8 cm, membranous, cuneate at base, margins at entire, acute to acuminate at apex; lateral nerves 8–15 pairs, reticulated; petioles up to 4 cm long, terete to towards apex flat, scare; stipules up to 3 cm long, oblong-lanceolate, flat with longitudinal channels, caudate and twisted towards apex when young and become obtuse at apex, folded longitudinally and caducous when mature. Inflorescence terminal, loosely corymbose cymes, up to 6 cm long; branches opposite; peduncles 0.5–1 cm long, stout, terete; pedicels up to 4 mm long, terete; bracts caducous. Flowers 5–10 mm across, green, pentamerous, actinomorphic. Calyx tube obconical, 2–3 mm in diam.; lobes 5, obscurely toothed. Corolla valvate, 8–10 mm in diam., shortly tubed, densely white-villous at throat; lobes 5, oblong, 4–6 mm long, obtuse to acute at apex. Stamens 5, slightly exerted; filaments 0.5–1.5 mm long, filiform; anthers c. 2 mm long, oblong, dorsifixed, dithecous. Ovary inferior, subglobose, 2-locular; ovule

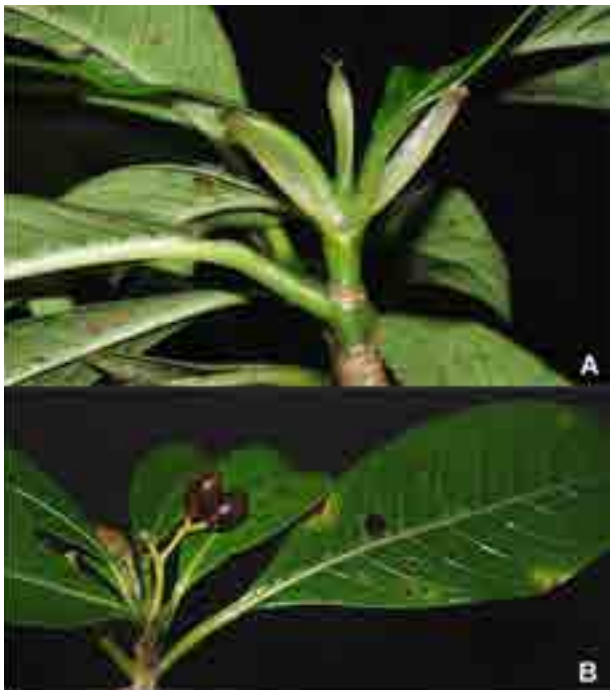

Image 3. *Psychotria henryana* Murugan & Gopalan: A—stipules | B—fruiting twig. © P. Murugan.

1 in each locule, placentation basal; style subulate, 4–6 mm long, towards to apex thickened; stigma bi-lobed, tongue shaped. Fruits ellipsoid-oblong, 1–1.5 cm long, dark brown or dark purple and yellow dotted.

Flowering and Fruiting: December–March

Specimens examined: 145011 (MH, Image 4), 25.iii.2021, Pongala Para, slope of way to Agasthyarkoodam peak, Thiruvananthapuram district, Kerala, India, 8.62119444 N 77.24852778 E, 1650–1750 m, coll. P. Murugan.

Distribution: India (Kerala and Tamil Nadu States), endemic.

Biotic association: *Psychotria henryana* was found growing along with other species such as *Canthiumera neilgherrensis* (Wight) K.M.Wong, *Casearia thwaitesii* Briq., *Hedyotis travancorica* Bedd., *Nostolachma crassifolia* (Gamble) Deb & Lahiri, *Phlogacanthus grandis* Bedd, *Pittosporum neelgherrense* Wight & Arn. and *Symplocos wynadense* (Kuntze) Noot.

Note: *Psychotria henryana* closely resembles *Psychotria anamalayana* Bedd., but can be distinguished from it by its stipules 2, flat with longitudinal channels, when young towards apex twisted and when mature obtuse (vs stipules 2–3, rarely bilobed, densely villous at base); leaves opposite-decussate, cuneate at base (vs leaves whorled, attenuate at base); inflorescence terminal, opposite, terete (vs inflorescence terminal or axillary, whorled, trigonous); flowers green (vs flowers white); calyx funnel, minutely teethed (vs calyx obconic, 5-toothed); disc discoid (vs subglobose); stigma shaped tongue (vs stigma ovate) and fruits when mature without calyx crowned with persistent (vs fruits when mature with calyx crowned with persistent).

Image 4. Herbarium sheet of *Psychotria henryana.*

References

Chelladurai, V. & R. Gopalan (2001). A new *Vernonia* Schreb. (Asteraceae) from Southern India. *Journal Economic & Taxonomy Botany* 25: 271–273.

Murugan, C. & R. Gopalan (2007). *Psychotria henryana* (Rubiaceae), a new species from the Southern Western Ghats, India. *Nordic Journal Botany* 24: 415–418.

Kottaimuthu, R. (2015). Three new combinations in *Acilepis* D.Don (Asteraceae) from India. *Telopea* 18: 375–377.

Mohanan, N. & A.N. Henry (1994). *Flora of Thiruvananthapuram District, Kerala*. Botanical Survey of India, Kolkata, 621 pp.

Mohanan, N. & M. Sivadasan (2002). *Flora of Agasthyamala*. Bishen Singh Mahendra Pal Singh, Dehra Dun, 889 pp.

Nayar, T.S., R.A. Beegam & M. Sibi (2014). *Flowering Plants of the Western Ghats India*. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala, 933 pp.

Nayar, T.S., R.A. Beegam, N. Mohanan & G. Rajkumar (2006). *Flowering Plants of Kerala-A Handbook*. Tropical Botanic Garden and Research Institute, Thiruvananthapuram, Kerala, 1059 pp.

Sasidharan, N. (2004). *Biodiversity Documentation for Kerala. Part 6. Flowering Plants*. Kerala Forest Research Institute, Peechi, Kerala, 702 pp.

Sasidharan, N. (2013). Flowering plants of Kerala: CD–ROM ver 2.0. Peechi: Kerala Forest Research Institute.

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NOTE

Pentatropis R.Br. ex Wight & Arn. (Apocynaceae), a new generic record for Kerala, India

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The Genus *Pentatropis* R.Br. ex Wight & Arn. (Apocynaceae) comprises six species, with a distribution ranging from Africa & Madagascar through Arabia, India, Pakistan, Sri Lanka, to Australia (Jagtap & Singh 1999). In India it is represented by two species, viz., *P. capensis* and *P. nivalis*. The generic name *Pentatropis* is derived from Greek words *penta* meaning 'five' and *tropis* meaning 'a keel', referring to the shape of the corona (Jagtap & Singh 1999). The genus is characterized by slender twining herbs or undershrubs, semi succulent leaves, small purplish flowers with rotate corolla and corona of five erect laterally compressed processes with an upcurved spur at base (Gamble & Fischer 1936). *Pentatropis capensis* is highly medicinal and the whole plant is used as antifungal, antiseptic, coolant and useful in skin diseases (Pandey et al. 2005).

During the floristic survey of Palakkad Gap, Western Ghats, Kerala, the authors came across a population of *Pentatropis* near Kozhinjampara, Palakkad, Kerala, which lies on the eastern front of the Palakkad Gap. Specimens were collected in flowering and the identity of specimen was confirmed as *Pentatropis capensis* (L.f.) Bullock using pertinent literature and consultation of specimens available at global biodiversity information facility (https://www.gbif.org/) and Kew science (https://specimens.kew.org/). The taxon was previously known in India from Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Maharashtra, and Gujarat (Matthew 1983; Pandey et al. 2005; Rao et al. 2016) but not reported from the state of Kerala (Vajravelu 1990; Sasidharan 2013). It is reported here as a new record for the state of Kerala. The description is given with notes and keys for easy identification.

Key to the *Pentatropis* in India

Flowers 3–4 per umbel, buds subglobose, corolla-lobes 3.5–6 mm long, deltoid, not tailed; corona-lobes acute at base, which curves outwards .... *P. capensis*

Flowers 5–7 per umbel, buds acuminate, corolla-lobes 8–13 mm long, with linear tail; corona-lobes rounded at base ..... *P. nivalis*

Pentatropis capensis (L.f.) Bullock, Kew Bull. 10(2): 284. 1955; Matthew, Fl. Tamil. Carn. 1: 955. 1983; Sharma et al., Fl. Karnataka 168. 1984; Singh, Fl. East. Karnataka 1: 414. 1988. *Cynanchum capense* L.f., Suppl. Pl. 168. 1781. *Pentatropis microphylla* (Roth.) Wight &

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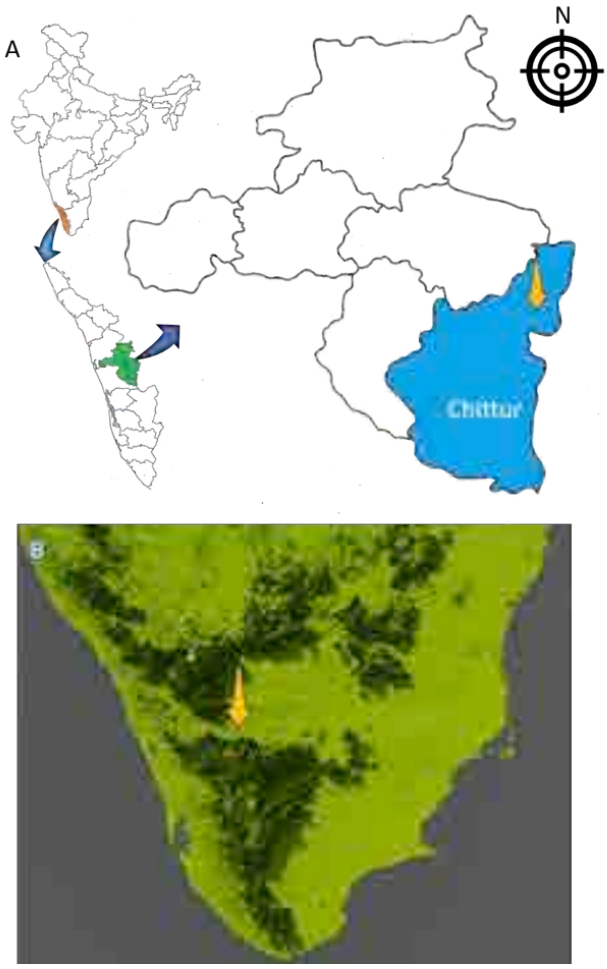

Image 1. a—Line map of the district showing the location of sighting *Pentatropis capensis* in the Chittur Taluk (Blue Shaded area). b—topographical map of south India showing the location of sighting *Pentatropis capensis* at the mouth of Palakkad Gap (Arrow).

Image 2. *Pentatropis capensis*: a—Habit | b—Calyx | c—Flower LS | d—Pollinia | e—Ovary CS. © V. Suresh.

Arn. in Wight, Contrib. 52. 1834; Hook.f., Fl. Brit. India 4: 20. 1883; Gamble, Fl. Pres. Madras 2: 587. 1957 (Repr. Ed.); Prain, Bengal plants 2: 512. 1963 (Repr. Ed.); Cooke, Fl. Pres. Bombay 2: 218. 1967 (Repr. Ed.). *Asclepias microphylla* Heyne ex Roth, Nov. Pl. Spec. 177. 1821. *Colostephanus capensis* (L.f.) Harv., Gen. S. Afr. Pl. 417. 1838. *Vincetoxicum capense* (L.f.) Kuntze, Revis. Gen. Pl. 2: 424. 1891. *Cynanchum acuminatum* Thunb., Observ. Cynanch. 5. 1821. *Cynoctonum capense* (L.f.) E. Mey., Comm. Pl. Afr. Austr. (Meyer) 216.

Herbaceous twiners. Stem slender, glabrous, greenish-purple. Leaves simple, opposite, ovate, 1–3.5 × 0.5–2.5 cm, base rounded or cordate, margin entire, apex obtuse mucronate, glabrous, semi-succulent, petiole 4–7 mm long. Flowers in axillary umbels, 3–4 flowers per umbel, greenish-purple colour, buds subglobose; pedicel filiform, 1.7 cm long. Calyx 5-partite, lobe elliptic-lanceolate, 1.5 mm long, hyaline at margin, acute at apex, glabrous. Corolla rotate, lobes deltoid, 3.5–6 mm long, recurved at margin, apex acute, hairy, purple. Corona single, 5 erect laterally compressed processes with an upcurved spur at base. Pollinia pendulous, obovate, ca. 0.2 mm long, pollen- masses waxy, opaque without pellucid margin, glabrous, brown (Image 2; Figure 1). Follicles 3-angled, 6.5 cm long, lanceolate, beaked at apex, persistent with calyx. Seeds many, ovoid, 5 mm long, whitish at margin, end silky hairy, 2 cm long.

Specimen examined: Suresh GVCP-SV339 (Image 2) 14 October 2019, Kozhinjampara, Chittur, Palakkad district, Kerala state, India, 10.738°N, 76.820°E, 172m (Image 1, GVCH! Government Victoria College Herbarium - acronym submitted, not yet accepted).

Additional specimens examined: *Pentatropis capensis* (L.f.) Bullock:- BM001014189, January 1774, India, 22.883°N, 79.6162°E, Koenig s.n. (Isotype BM!); MO100951520, 14 September 1956, Yanam, Andhra Pradesh, 16.733°N, 82.213°E, Wagh 3863 (MO!); S10-25878, October 1981, Madras, near the Qutar minaret, Tamil Nadu, Fagerlind 9516 (S!).

Phenology: Flowering and fruiting: September to January.

Ecology: *Pentatropis capensis* is found growing on

Figure 1. Illustration of *Pentatropis capensis* and its floral parts: A—Habit | B—Flower | C—Pedicel with Calyx and Gynoecium | D—Pollinia.

road sides in association with *Abutilon indicum* (L.) Sweet, *Calotropis procera* (Aiton) Dryand. and *Cardiospermum halicacabum* L. The species is well adapted to the arid climate of the Deccan and northwestern India.

Distribution: Bangladesh, India, Pakistan, Sri Lanka, and Vietnam (POWO 2021); India (Karnataka, Tamil Nadu, Andhra Pradesh, Odisha, Gujarat (Pandey et al. 2005; Rao et al. 2016), and Kerala (Chittur, Kozhinjampara, reported here).

This species is widely distributed in arid to semiarid belts of central and peninsular India. It is a therophyte (therophytes are annual but this species is perennial) according to life form classification by Raunkiaer and it thrives in arid climate by bearing unfavourable dry seasons in dormant form (Raunkiaer 1934; Kambhar & Kotresha 2012).

In this report, a therophytic perennial species of *Pentatropis* genus (*P. capensis*) belonging to the family Apocynaceae was reported as a new record for the state of Kerala from the eastern part of the Palakkad Gap.

References

Gamble, J.S. & C.E.C. Fischer (1936). *Flora of the Presidency of Madras.* Adlard & Son Ltd, London, 834–835pp.

Jagtap, A.P. & N.P. Singh (1999). *Fascicles of Flora of India:* Fascicle 24, pp. 38–39. Botanical Survey of India, Kolkata,

Kambhar, S.V. & K. Kotresha (2012). Life-forms and biological spectrum of a dry deciduous forest in Gadag District, Karnataka, India". *Research and Review Journal of Botany* 1(1): 1–28.

Matthew, K.M. (1983). *The Flora of Tamil Nadu Carnatic*. The Rapinat Herbarium, St. Joseph's College, Tiruchirapalli 3(1): 925, 928, 955 pp.

Pandey, C.N., B.R. Raval, S. Mali & H. Salvi (2005). Medicinal plants of Gujarat- Species Description and Medicinal Uses: Chapter-XIV. Gujarat Ecological Education and Research Foundation, Gandhinagar, Gujarat, 233 pp.

POWO (2021). "Plants of the World Online. Facilitated by the Royal Botanic Gardens, Kew. Published on the Internet; http://www.plantsoftheworldonline.org/ Retrieved 30 October 2021."

Rao, K.S., R.A. Singh, D. Kumar, R.K. Swamy & N. Page (2016). Digital Flora of Eastern Ghats. http://flora-peninsula-indica.ces.iisc.ac.in/EasternGhats/herbsheet.php?id=487&cat=4

Raunkiaer, C. (1934). *Life forms of plants and statistical plant geography.* Calderon Press, Oxford. (English translation of collected papers by C. Raunkiaer 1903).

Sasidharan, N. (2013). Flowering plants of Kerala CD-ROM (Version 2). Kerala Forest Research Institute, Peechi, Kerala.

Vajravelu, E. (1990). *Flora of Palghat District including Silent Valley National Park, Kerala*. Botanical Survey of India, Calcutta.

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NOTE

New record of Kashmir Birch Mouse *Sicista concolor leathemi* (Thomas, 1893) (Rodentia: Sminthidae) in the Indian Himalaya

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Birch mice are grouped under the monotypic genus *Sicista* Gray, 1827 with 14 recognized species currently distributed over the Palearctic realm (Holden et al. 2017). The genus was earlier variably placed under the families Dipodidae of subfamily Sicistinae (Ellerman 1961; Ellerman & Morrison-Scott 1966; Holden & Musser 2005) and Zapodidae (Corbet & Hill 1992) but at present it is accommodated under the family Sminthidae of superfamily Dipodoidea (Holden et al. 2017). The Chinese Birch Mouse *Sicista concolor* Buchner, 1892 is a montane species with three fragmented populations reported so far, the nominate subspecies *S. c. concolor* Buchner, 1892 reported from northcentral China, *S. c. leathemi* (Thomas, 1893) including *Sicista concolor flavus* (True, 1894) from India (Jammu & Kashmir, Ladakh), western China (southwestern Xinjiang), & northern Pakistan (Kaghan valley), and *S. c. weigoldi* Jacobi, 1923 from southcentral China (Holden et al. 2017).

The Kashmir Birch Mouse is found in the alpine and sub-alpine scrub zones in the Himalaya and grassy slopes of moist montane forests at elevations of 2,140–4,000 m. It undergoes prolonged hibernation in winter and digs its own underground burrows. It is nocturnal, fossorial, in habit, and feeds on berries, wild fruits, seeds, fungi, and insects. Little is known about its breeding; it is reported to produce a single litter of 3–6 young annually (Roberts 1997).

It has a longer obscurely bicolored tail that averages over 160% of the head-&-body length, with short hairs throughout the length. The dorsum varies from rufous-brown and greyish-brown to yellowish-brown with conspicuous black guard hairs on back; there is no dark mid-dorsal stripe on the back. The fur of the body is thick and soft; greyish-white (white with gray base) venter without clear demarcation from the dorsum. Ears are short, rounded, thickly clothed with short chocolate brown hairs. Hind feet are long and narrow, about 22–28% of head and body length, lighter than the back, silvery white on upper surface, without plantar pads. Due to overlapping characters, the subspecies *flavus* was synonymized under *S. c. leathami* (Holden et al. 2017).

During one faunistic survey in the grasslands of Lahaul Valley of Himachal Pradesh between 16–29 August 2021, we had an opportunity to closely observe and photograph (Image 1, 2) a live small-sized mouse

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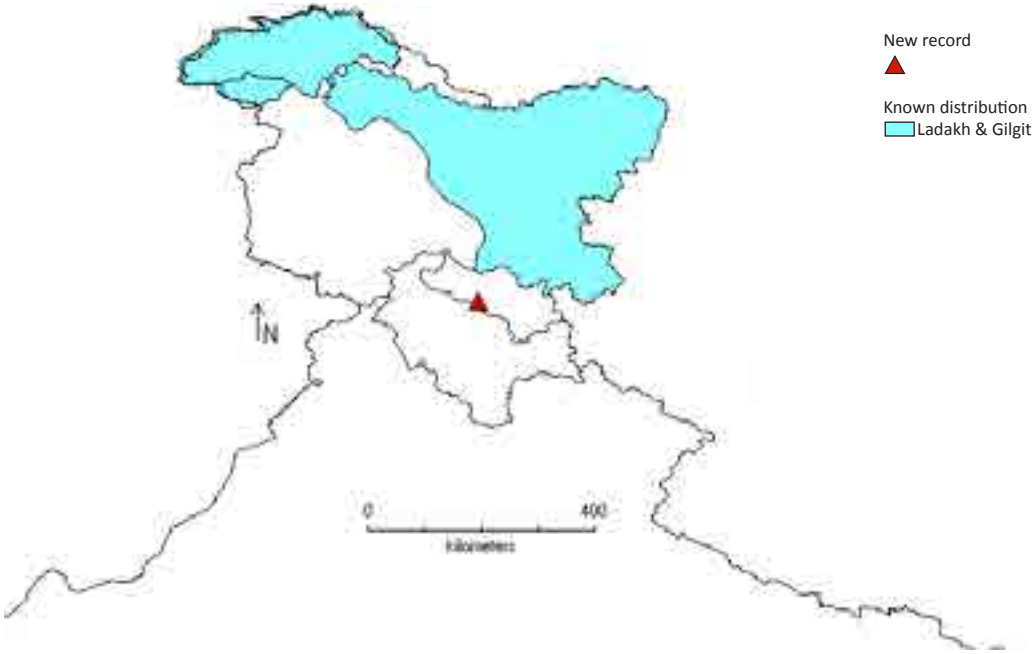

Figure 1. Showing distribution of Kashmir Birch Mouse *Sicista concolor leathemi* (Thomas, 1893).

with distinctly longer and faintly bicolored tail in an area between Gramphu and Chhatru in Lahaul valley (32.373N & 77.291E; 3,220m) on 27 August 2021. The landscape was typical trans-Himalayan terrain with very dry stony and sandy habitat interspersed with grassy clumps. The mouse was observed foraging around grassy growths at about 1330 h with temperature and humidity at 22.8°C and 23%, respectively. Being a reportedly nocturnal species, its apparent day time foraging is intriguing. The animal was quite docile and could be comfortably handled and released thereafter. On the basis of the key morphological characters mentioned in the literature (Ellerman 1961; Roberts 1997; Holden et al. 2017) the animal in the photographs (Image 1, 2) was identified as the Kashmir Birch Mouse *Sicista concolor leathemi*.

A few scattered literatures are available on the records of rodent fauna from Himachal Pradesh (Lindsay 1926; Chakraborty et al. 2005; Sharma et al. 2008; Sharma & Saikia 2009, 2013), however, none of them mention the occurrence of the Kashmir Birch Mouse in Himachal Pradesh. Therefore, on the basis of photographic evidence, we hereby report this rodent species for the first time from Himachal Pradesh. The present locality is also recorded the southernmost point in its distribution range.

The type locality of *S. c. leathemi* is Krishnye valley, Wardwan (=Warwan), in Kishtwar district of the union territory of Jammu & Kashmir and of *S. c. flavus* is central Kashmir (c. 3,305 m). The *leathami* population is also reported from other localities of Kashmir like Chilas, Nanga Parbat, Astore (Gilgit-Baltistan), Rupal (Kupwara), Malangan, Kagnarg mountains, and Ladakh (Ellerman 1961; Chakraborty 1983; Molur et al. 2005) (Figure 1).

Ellerman & Morrison-Scott (1966) and Ellerman (1961) listed both *leathemi* and *flavus* as subspecies of *Sicista concolor*. However, Corbet & Hill (1992), Holden (1993), Holden & Musser (2005) synonymized both the taxa with the *S. concolor*. Further, Holden et al. (2017) treated *flavus* as junior synonym of *S. c. leathemi.* As per the IUCN Red List of Threatened Species, the global status of the species is 'Least Concern' due to its wide distribution and the lack of known threats (Molur 2016). However, for India *S. c. leathemi* is categorized as Near Threatened by Molur et al. (2005), which requires revalidation.

References

Chakraborty, S. (1983). Contribution to the knowledge of the mammalian fauna of Jammu and Kashmir, India. *Records of the Zoological Survey of India, Occasional Paper* No. 38: 1–129.

Chakraborty, S., H.S. Mehta & S. Pratihar (2005). Mammals, pp. 339–359. In: *Fauna of Western Himalaya (Part-2)-Himachal Pradesh*. Zoological Survey of India, Kolkata.

Corbet, G.B. & J.E. Hill (1992). *The Mammals of the Indomalayan Region*: *A Systematic Review.* Natural History Museum Publications and Oxford University Press, Oxford, U.K., 488pp.

Ellerman, J.R. (1961). *The Fauna of India including Pakistan, Burma and Ceylon. Mammalia. Vol. 3 (Rodentia),* Part I & II. Govt. of India, Delhi, 884pp.

Ellerman, J.R. & T.C.S. Morrison-Scott (1966). *Checklist of Palaearctic*

Image 1–2 . Kashmir Birch Mouse *Sicista concolor leathemi* (Thomas, 1893) sighted in the grasslands of Lahaul Valley of Himachal Pradesh. © Avtar Kaur Sidhu.

and Indian Mammals 1758–1946, 2nd Ed. British Museum (Natural History), London, 810pp.

Holden, M.E. (1993). Family Dipodidae, pp. 487–500. In: Wilson, D.E. & D.M. Reeder (eds.). *Mammal Species of the World: A Taxonomic and Geographic Reference.* Smithsonian Institution Press, Washington DC, USA.

Holden, M.E., T. Cserkesz & G.M. Musser (2017). Family Sminthidae (Birch Mice), pp. 22–48. In: Wilson, D.E., T.E. Lacher Jr. & R.A. Mittermeier (eds.). *Handbook of the Mammals of the World.* Vol. 7. Rodents II. Lynx Edicions, Barcelona.

Holden, M.E. & G.G. Musser (2005). Family Dipodidae, pp. 871–893. In: Wilson, D.E. & D.M. Reeder (eds.). *Mammal Species of the World: A Taxonomic and Geographic Reference*. Smithsonian Institution Press, Washington DC, USA.

Lindsay, H.M. (1926). Bombay Natural History Society's Mammal Survey of India, Burma and Ceylon. Report No. 44. Kangra and Chamba. *Journal of the Bombay Natural History Society* 31: 597–606.

Molur, S. (2016). *Sicista concolor* (errata version published in 2017). The IUCN Red List of Threatened Species 2016: e.T20188A115157138. Downloaded on 08 October 2021. https://doi.org/10.2305/IUCN.UK.2016-3.RLTS.T20188A22204686.en

Molur, S., C. Srinivasulu, B. Srinivasulu, S. Walker, P.O. Nameer & L. Ravikumar (2005). Status of South Asian Non-Volant Small Mammals: Conservation Assessment and Management Plan (C.A.M.P.) Workshop Report. Zoo Outreach Organization, CBSG South Asia, Coimbatore, India, 618 pp.

Roberts, T.J. (1997). *The Mammals of Pakistan*. Oxford University Press, Oxford, 525 pp.

Sharma, D.K. & U. Saikia (2009). Mammalia, pp. 103–118. In: *Faunal Diversity of Simbalbara Wildlife Sanctuary, Conservation Area Series,* 41. Zoological Survey of India, Kolkata.

Sharma, I. & U. Saikia (2013). Mammalia, pp. 107–120. In: *Faunal Diversity of Pangi Valley, Chamba District, (Himachal Pradesh), Himalayan Ecosystem Series,* 3. *Zoological Survey of India,* Kolkata.

Sharma, D.K., P.C. Tak & U. Saikia (2008). Mammalia, pp. 137–147. In: *Fauna of Pin Valley National Park, Conservation Area Series,* 34. Zoological Survey of India, Kolkata.

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NOTE

Breeding record of Black-headed Ibis *Threskiornis melanocephalus* (Aves: Threskiornithidae) at Mavoor wetland, Kozhikode District, Kerala, India

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Black-headed Ibis *Threskiornis melanocephalus* is a nomadic and medium-sized wading bird that belongs to the family Threskiornithidae (Hancock et al. 2001). It is also known as Oriental White Ibis and comes under IUCN 'Near Threatened' category (Birdlife International 2021) and is experiencing moderately rapid decline across its distribution range (BirdLife International 2021). It is distributed across India, Pakistan, Sri Lanka, Nepal, China, Bangladesh, Myanmar, Thailand, Vietnam, Cambodia, and is a rare visitor to Japan, Indonesia, and Philippines (Hancock et al 2001; Ali & Ripley 2007; BirdLife International 2012). In the Indian subcontinent, it is widespread resident, however unrecorded in eastern and northwestern Indian subcontinent (Grimmet et al. 2011). Though the bird is often a common species across Kerala but little information is available about its nesting site ecology so far.

As part of my PhD program, I have been surveying and monitoring the Mavoor wetland since January 2020 and collecting ecological data on wetland associated avian fauna. Mavoor wetland (11.260N, 75.939E) is situated on the north-west side of Mavoor town, 21 km east of Kozhikode city (Aarif & Basheer 2012). Mavoor wetlands have three types of aquatic habitats: agricultural land, shallow water body (< 0.3 m depth) and deep-water body (> 0.3 m depth). Shallow waterbody (vegetated with sedges and cattails) dominate in the Mavoor wetlands, followed by deep water body with *Nymphaea, Salvinia, Elodea* species (Renila et al. 2020). A total of 57 species of waterbirds were documented from Mavoor wetlands (Aarif & Basheer 2012) including resident and migrant species. Further, they reported the status of Black-headed Ibis as a common, non-breeding and locally migrant species. A recent study (Bobika et al. 2021) showed that a total of 40 species of waterbirds were encountered during their study, which clearly shows the declining trends of avian species from this fragile ecosystem.

During initial visits, I found Black-headed Ibises foraging on shallow water columns, in groups or solitarily. Juveniles and adults in breeding plumage were also observed foraging at Mavoor Wetland. But, only the first week of September 2021, found them roosting in the heronry. There were 10 nests, two with two chicks each and 3–4 nests were under construction. Many pairs were engaged in mating. In addition to Ibises, nests of Purple Herons and 'Near Threatened' Oriental Darters were also encountered. The nests built in those parts which were inaccessible to me, are not included in the report and hence the actual number of nests in the area

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Table 1. Breeding species of waterbirds in Mavoor heronry during July–September

Species	Total number of nests	Active/Inactive	Number of nests with incubating birds	Number of chicks	Number of juveniles
Black-headed Ibis	10	10	3	8	5
Oriental Darter	5	5	2	0	23
Purple Heron	2	1	0	0	15

Image 1. Black-headed Ibis foraging in shallow water habitat at Mavoor wetland.

Image 2. Nesting site of Black-headed Ibis seen associated with Purple Heron and Oriental Darter at Mavoor wetland.

Image 3. Black-headed Ibis with chicks. Two nests seen closer with two chicks in each nest at Mavoor wetland.

may well have been higher than the number reported here. Earlier breeding records of Black-headed Ibis were reported from Panamaram Heronry at Wayanad District (Balakrishnan & Thomas 2004), Kumarakom at Kottayam District (Narayanan et al. 2006), and Manthakad at Palakkad District (Roshnath et al. 2017). Breeding success of Ibis in captivity at Trivandrum Zoo were also reported (Bindya et al. 2019). This is probably the first breeding record of Black-headed Ibis for the Kozhikode district and fourth breeding location for this bird in Kerala.

Black-headed Ibis breeds in or during rainy seasons. In southern India, November–March is the general breeding season for Black-headed Ibises (Ali & Ripley 1983; Ali 1996); however, at Kumarakom heronry, they were found nesting in July–September (Narayanan et al. 2006). Nesting of Ibises at Mavoor wetland were also found in July–September. This coincides with the south-west monsoon in Kerala. Though, Mavoor wetland extends over an area of 37.23148 ha (Aarif & Basheer 2012), a suitable nesting site especially in an anthropogenic stress free zone is rare.

An additional breeding site at Mavoor wetland for Black-headed Ibis is a positive sign towards its declining population trends. Regular monitoring of the population of Ibises especially from the newly recorded breeding sites in Kerala may enhance the breeding population of this species and help in recovering the regional populations.

References

Aarif, K.M. & M. Basheer (2012). The Water Birds of Mavoor Wetland, Kerala, South India. *World Journal of Zoology* 7(2): 98–101. https://doi.org/10.5829/idosi.wjz.2012.7.2.6216

Ali, S. & S.D. Ripley (1968). *Hand Book of the Birds of India and Pakistan, Vol. 1*. Oxford University Press, London.

Balakrishnan, M. & S.K. Thomas (2004). Conserving the breeding habitat of the Near Threatened Oriental White Ibis (*Threskiornis melanocephalus*). *Current Science* 87(9): 1190–1192.

Bindya, A., R. Roshnath & J. Alexander (2019). Notes on breeding and management of Black-hedaded Ibis *Threskiornis melanocephalus* (Aves: Pelecaniformes: Threskiornithidae) at Thiruvananthapuram Zoo, Kerala, India. Bird-o-soar #31, In: *Zoo's Print* 34(8): 27–31.

BirdLife International (2021). Species factsheet: *Threskiornis melanocephalus*. http://www.birdlife.org.

Bobika, V.K., M.D.E. Khemis, R. Renila, K. Manjusha & K.M. Aarif (2021). Does substrate quality influence diversity and habitat use of waterbirds: a case study from wetlands of south India. *Ekologia Bratislava - Journal of the Institute of Landscape Ecology, Slovak Academy of Sciences* 40(1): 70–71.

Grimmet, R., C. Inskipp & T. Inskipp (2011). *Birds of the Indian Subcontinent*. Oxford University Press & Christopher Helm., London, 528 pp.

Hancock, J.A., J.A. Kushlan & M.P. Kahl (2001). *Storks, Ibises and Spoonbills of the World*. Academic Press, Harcourt Brace Jovanovich.

Narayanan, S.P., B. Sreekumar & L. Vijayan (2006). Breeding of the Oriental White Ibis Threskiornis melanocephalus at Kumarakom heronry (Kerala, India). *Indian Birds* 2(6): 150–151.

Renila, R., V.K. Bobika, A. Nefla, K. Manjusha & K.M. Aarif (2020). Hunting behaviour and feeding success of three sympatric Kingfisher species in two adjacent wetlands in southwestern India. *Proceedings of Zoological Society* 71(3): 392–399. https://doi.org/10.1007/s12595-020-00344-4

Roshnath, R., C. Sashikumar, C.K. Vishnudas, J. Palot, S. Raju, H. Mannar, B. Sreekumar, H. Mavelikara, A.K. Sivakumar & S. Meppayur (2017). Heronries of Kerala, 2015: a summary of the Heronry Census. *Malabar Trogon* 15(3): 35–40.

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RESPONSE

Crop and property damage caused by Purple-faced Langurs *Trachypithecus vetulus* (Mammalia: Primates: Cercopithecidae)

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Sri Lanka is an excellent area to study the relationships between Humans *Homo sapiens* and commensal primates: the island is home to slender lorises, macaques and langurs and, for the last 40,000 years or so, humans (Nekaris & de Silva Wijeyeratne 2007; Nijman & Nekaris 2013). The extensive presence of home gardens, mimicking the forest structure by adopting different layers, allows primates to come into close contact with humans, and the predominant religions adopted by Sri Lankans may facilitate a peaceful co-existence (cf. Rudran 2008; Rudran et al. 2021). Repeated crop-raiding and conflict over space, however, may cause people to become increasingly intolerant to primates.

Wijethilaka et al. (2021) lamented the small number of reports on conflicts between Humans and Western Purple-faced Langur *Trachypithecus vetulus nestor*. In their introduction and discussion Wijethilaka et al. (2021) refer to a large number of studies that report on Human-primate conflict and crop-raiding involving a wide range of primate species, including Chimpanzees *Pan troglodytes*, Olive Baboons *Papio anubis*, Red-tailed Monkeys *Cercopithecus ascanius*, Vervet Monkeys *Chlorocebus pygerythrus*, Rhesus Macaques *Macaca mulatta*, Hanuman Langurs *Semnopithecus entellus,* and Bonnet Macaques *Macaca radiata*. What they overlooked were those studies that had been conducted on Western Purple-faced Langurs. To rectify this and to provide the reader of the *Journal of Threatened Taxa* with a more complete (chronological) overview I here give brief summaries of the outcomes of these studies and how they concur or contrast with that reported by Wijethilaka et al. (2021).

Wijethilaka et al. (2021) evaluated the intensity of Human-langur conflict through the identification of the crop and property damages caused by these langurs. Their assessment was based on interviews with 80 households in villages bordering Danawkanda Forest in western Sri Lanka collected over a six-month period in 2014-2015. They also quantified the loss (financial and otherwise) reportedly incurred to these households. Over 90% of the interviewees indicated that the damage had been done to commercially important plants (primarily Banana *Musa paradisiaca*, Papaya *Carica papaya*, Rambutan *Nephelium lappaceum* and Mango *Mangifera indica*). Three-quarter reported damage of roof tiles and over 40% reported having had frightful encounters with the langurs. Wijethilaka et al. (2021) found a strong negative correlation between the amount of money spent on firecrackers (a proxy for the intensity of crop raiding and used by 99% of the interviewees)

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Table 1. Non-exhaustive overview of research conducted on Purple-faced Langurs (sometimes in addition to other primates or vertebrates). Researcher(s) only list one of the main persons involved, but it is acknowledged that the team often comprised more people. Dates in Italics indicate periodic monitoring or intermittent studies with gaps of up to two years. Ethnoprimatology includes studies on crop-raiding and human-wildlife conflict. Methods for ethnoprimatological studies: A—direct observation of langurs and people | B—interviews and questionnaires | C—workshops.

Period	Researcher(s)	Location	Topics studied	Methods	Example reference
ii 1968–iv 1970	R. Rudran	Horton Plains, Polonnaruwa	Ecology, behaviour		Rudran 1973
iii 1969–ii 1970	C.M. Hladik	Polonnaruwa	Ecology		Hladik 1977
ii 1985–ii 1987	J.D.S. Dela	Piliyanadala, Panadura	Ecology, behaviour		Dela 2007
iii 1987–xii 2006	J.D.S. Dela	Piliyanadala, Panadura	Ecology, behaviour, ethnoprimatology	A, B	Dela 2011
1998–2018	W.P.J. Dittus	Polonnaruwa	Ethnoprimatology	A, B, C	Dittus et al. 2019
vi 2000–xii 2001	P. Jayasekara	Sinharaja	Behaviour		Jayasekara et al. 2007
v 2001–vii 2010	K.A.I. Nekaris	Island-wide	Ethnoprimatology	A, B, C	Nekaris et al. 2013
? 2004–ii 2007	C.A.D. Nahallage	Island-wide	Ethnoprimatology	A, B	Nahallage et al. 2008
vi 2004-vii 2008	R.S. Moore	Talangama, Masmullah	Ecology, behaviour, ethnoprimatology	A, B	Douglas et al. 2008
vi–vii 2007	R. Rudran	West	Ethnoprimatology	A, B	Rudran 2008
vii 2008–xi 2009	R.P. Vandercone	Kaludiyapokuna	Ecology, behaviour		Vandercone et al. 2012
vi 2009–xii 2010	R. Rudran	Waga	Ecology, behaviour		Rudran et al. 2008
vii 2014–i 2015	S. Wijethilaka	Danawkanda	Ethnoprimatology	B	Wijethilaka et al. 2021
i 2015–ix 2016	C.A.D. Nahallage	Mihintale	Ecology, behaviour, ethnoprimatology	B	Kumara et al. 2019
ii 2015–iii 2019	R. Rudran	Island-wide	Ethnoprimatology	B, C	Cabral et al. 2018
iv–xi 2016	W.A.D.S.N. Weerakkody	Delkanda, Homagama	Ecology		Weerakkody et al. 2018
v–vii 2018	C.A.D. Nahallage	Mihintale	Ethnoprimatology	B	Westwood 2018

and the distance between Danawkanda Forest and the interviewees' residence or fields. The research I refer to that also reports on crop and property damage caused by Western Purple-faced Langurs was based on interviews, similar to Wijethilaka et al. (2021), workshops, direct observations, and often a combination of these methods (Table 1).

In their 'Primates of Sri Lanka', Nekaris & de Silva Wijeyeratne (2007), based on extended periods of fieldwork in western Sri Lanka, noted specifically for the Western Purple-faced Langur that because the animals eventually come into contact with people, conflict is inevitable. This conflict mainly involved crop raiding (primarily of fruit trees) and using rooftops as 'runways' and thereby damaging the tiles. Interviews with local people showed that conflict was greatest in areas with the largest populations (of langurs), and in particular with those people who came into daily contact with the langurs. They noted that conflict can be so severe that landowners may shoot the langurs (Nekaris & de Silva Wijeyeratne 2007).

Parker et al. (2008) conducted 735 interviews throughout the range of the Western Purple-faced Langur. At the village level, estimates of local langur population size (by means of counting langurs directly as well as interviews) did not correlate with positive or negative perceptions towards langurs but the proportion of interviewees that held negative views towards the langurs was correlated with the time the langurs spent in their gardens and farmland (more time equates to more negative feelings). A quarter of all interviewees considered the langurs a nuisance, primarily because, just as in Wijethilaka et al.'s study, of the langurs raiding on Jackfruit *Arctocarpus heterophylus*, Rambutan, Banana and Mango. Destruction of roof tiles was reported as a problem. Several deterrents were used by the interviewees to drive langurs from their land, including throwing stones, shouting or setting dogs on them, and using firecrackers. Nijman & Nekaris (2008) noted that the Western Purple-faced Langur appeared to be largely dependent on fruit grown in traditional home gardens, making the langurs almost wholly dependent on the tolerance of local people. With increasing urbanization, perceptions by local people of the langurs had changed for the worse. Negative attitudes towards the langurs increased with the amount of time langurs spend in

close proximity to people. Besides the loss of habitat, attacks on langurs by landowners' and stray Dogs *Canis familiaris* add another source of mortality, and the need for arboreal continuity has put them into lethal contact with electric power lines in this urban domain.

Eschmann et al. (2008) and Moore et al. (2010), over a seven-month period, studied five groups of Western Purple-faced Langur and Humans in a suburban area in Talangama, where the langur's homeranges completely overlapped with Human living space. Twelve of the thirteen trees most used for feeding by the langurs were also used by Humans, with Jack Fruit, Mangos and Rambutans topping the list. They noted that when langurs crossed rooftops of occupied houses, the owners often chased them away or complained about damage the langurs caused. The most common methods to chase the langurs out of feeding trees or off rooftops were using firecrackers followed by throwing stones. Eschmann et al. (2008) reported that to the meagre canopy continuity in Talangama exposed much of the langurs' homeranges to direct sunlight. While this in turn led to the langurs to start calling earlier in the morning compared to groups living in forests, overall Eschmann et al. (2008) found the langurs to be remarkably desensitised to the effects of most Human activities.

Nijman & Nekaris (2010) analysed data from 48 interviewees from villages with and without forest in its vicinity and found that the intensity of conflict, and especially reports of the killing of langurs, was higher in villages where the forest was no longer present. The amount of forest and trees buffers against the need to feed on Human-grown foods or the use of man-made structures as arboreal pathways.

Of all the studies reported here, the one by Dela (2011) is most closely aligned to that of Wijethilaka et al. (2021) in terms of methodology, results, and conclusions. In 1987, she conducted a questionnaire survey with 112 participants in Panadura and Piliyandalawhere where she also studied the langurs (Dela 2007). Roof and crop damage were the most frequently cited damage (64% and 23% of interviewees, respectively) and conflict was most prominent when the langurs fed on Mango, Banana and Bread Fruit *A. incisus*. Two-thirds of the interviewees resorted to making loud noises (firecrackers, shouting) and one third to throwing stones or using slingshots or catapults to deter crop raiding. When corrected for inflation to June 2021, the distribution of household income in Dela's (2011) study was similar to that of Wijethilaka et al. (2021), with ~80% of people earning less than US$160–180 month^{-1}. While the desire to destroy langurs was higher in households with an income of over US$160 month^{-1} compared to those that earned less (i.e., 12.5% vs 6.2%) the difference was not statistically significant (Dela 2011). Dela's (2011) is one of the most comprehensive study on how the perceptions and real day-to-day experiences of people have an effect of on both the langur's habitat and the langurs themselves and her findings and conclusions, despite being partially based on a survey conducted over three decades ago, ring true to this day.

Nijman and Nekaris (2013) advocated the adoption an ethnographic perspective as this would allow for mitigation policies to be defined with regard to a local cultural context in which traditions and religious parameters often exist for the preservation or to the detriment of wildlife. Based on 182 days of observations of langurs (and Toque Macaques *M. sinica*) and an interview survey of 1,036 people they assessed levels of conflict between Humans and primates both in an agricultural and urban context. With respect to the Western Purple-faced Langur they found generally high levels of tolerance in both settings, but high levels of crop-raiding along the forest edge and frequent use of roofs as part of arboreal pathways caused discontent. They concluded that a heavy reliance on fruit by otherwise folivorous langurs may compromise their dietary needs and parasite loads of commensal primates were suspected to be unhealthily high.

Weerakkody et al. (2018) found that in urban and semi-urban landscapes the homerange size of Western Purple-faced Langurs is both determined by the resource base (e.g., the number of fruiting trees) and impassable boundaries (rice fields, houses); these anthropogenetic factors hinder the movement of the arboreal langurs across the landscape, and may explain the proximate causes of Human-langur conflict.

Rudran et al. (2020b) addressed in detail and with great consideration how to deal the issue of engaging local communities in the conservation of Western Purple-faced Langurs at a time when the people are facing difficulties caused by the conflicts with the langurs. While they did not present new data on crop or property damage caused by the langurs, the solutions they offer are relevant to the challenges highlighted by Wijethilaka et al. (2021). Finally, for completeness I will discuss Rudran et al. (2021) who reported on a mitigating Human-primate conflict study by means of interviewing people from 11 districts in Sri Lanka. This paper appeared after the publication of Wijethilaka et al. (2021) but data collection for this study had commenced only one year after Wijethilaka et al. (2021) had finished collecting theirs (viz., it ran from January

2016 to June 2018). While Rudran et al. (2021)'s study covered all three diurnal primate species, some of their data can be attributed to Western Purple-faced Langurs as it specifies data for Colombo District. Of the 147 people interviewed in Colombo, 70% were Buddhist and 8% Hindu. In contrast to reports by Wijethilaka et al. (2021) levels of tolerance towards Western Purple-faced Langurs was high (ranked 4.3 on a scale from 1 to 6) something that Rudran et al. (2021) attributed to the majority of interviewees practising Buddhism which preaches compassion to all living beings. The reported monthly cost, corrected for inflation to June 2021, of damage due to Western Purple-faced Langur and Toque Macaques in Colombo ranged from less than US$2.79 (19% of respondents), US$2.80-5.59 (36%), US$5.60-27.96 (28) to more than US$27.97 (16%). This is within the same range as the monthly average of US$10.05-18.10 reported by Wijethilaka et al. (2021).

The overview presented here demonstrate that a great deal is known conflict between Humans and Western Purple-faced Langurs. This is not surprising as arguably the Purple-faced Langur is among the most thoroughly studied colobine monkeys globally (Table 1). It is also clear that over time there has been a shift in research focus from purely ecology and behaviour of the langurs in the 1970s to 1990s to a mixture of ecology and behaviour, and ethnoprimatology during the last two decades (Table 1). There is a great level of concordance between the data from Danawkanda and that from Panadura, Piliyandala and Talangama, and indeed other sites. What remains unanswered are the possible underlying factors for the apparent differences. For instance, Wijethilaka et al. (2021) make no mention of langurs being electrocuted or killed by dogs, while this did come up prominently in the studies of Parker et al. (2008), Nijman & Nekaris (2008), Moore et al. (2010), Dela (2011) and indeed Rudran (2008), and Nahallage et al. (2008). It is possible that there are no dogs in Danawkanda (or no dog large enough to do harm to Purple-faced Langurs), and perhaps there are still enough natural arboreal pathways for the langurs to use so they can avoid powerlines (it is even possible that there are no powerlines), but a proper comparison by Wijethilaka et al. (2021) of their data with that collected by others could have made that clear. Shooting at Purple-faced Langurs with air-rifles or pellet guns is also commonly mentioned –Wijethilaka et al. (2021) pooled this with the use of catapults and reported that 18% of household in Danawkanda used this method– but there seems to be significant variations in its frequency. In 2011 the Ministry of Coconut Development and State Plantations as well as local Directors of Planning, endorsed the idea of issuing air rifles to farmers and planters to ward off primates and Common Giant Squirrel *Ratufa macroura* from damaging their crops (Rodrigo 2011; Sugathapala & Wijeweera 2011; Dittus et al. 2019), but at present it is unclear what the uptake of this has been and the effects it has on Purple-faced Langurs.

In conclusion, despite the langur's small area of occupancy (2,000 km^2) and its small population size (Rudran et al. 2020b) I find that over the last decades a number of studies have been published on the interactions between Humans and Western Purple-faced Langurs (Table 1), the perceptions that people have towards the langurs, especially in (semi-)urbanised areas, and how to best mitigate any negative effects of having langurs and people living in close proximity. For primate conservation to work in Sri Lanka sharing space with monkeys and ensuring levels of Human tolerance towards primates remain high is paramount (in addition to having enough areas set aside specifically for primates and other wildlife: Dittus et al. 2021). The findings by Wijethilaka et al. (2021) in terms of the proportion of people that report crop damage or damage to roofs is high in comparison with earlier studies, which may reflect a decrease in tolerance towards the langurs, differences in methodology or it may reflect random geographical differences.

References

Cabral, S.J., T. Prasad, T.P. Deeyagoda, S.N. Weerakkody, A. Nadarajah & R. Rudran (2018). Investigating Sri Lanka's human-monkey conflict and developing a strategy to mitigate the problem. *Journal of Threatened Taxa* 10: 11391–11398. https://doi.org/10.11609/jott.3657.10.3.11391-11398

Dela, J.D. (2011). Impact of monkey-human relationships and habitat change on *Semnopithecus vetulus nestor* in human modified habitats. *Journal of the National Science Foundation of Sri Lanka* 39: 365–382. https://doi.org/10.4038/jnsfsr.v39i4.4144

Dela, J.D.S. (2012). Seasonal food use strategies of *Semnopithecus vetulus nestor*, at Panadura and Piliyandala, Sri Lanka. *International Journal of Primatology* 28: 607–626. https://doi.org/10.1007/s10764-011-9538-3

Dittus, W.P., S. Gunathilake & M. Felder (2019). Assessing public perceptions and solutions to human-monkey conflict from 50 years in Sri Lanka. *Folia Primatologica* 90: 89–108. https://doi.org/10.1159/000496025

Dittus, W.P., S. Gunathilake & M. Felder (2021). Sharing space with monkeys and human tolerance are critical supplements to primate conservation, but not substitutes for protected nature reserves: a long-term view from Sri Lanka. *Folia Primatologica* 92: (in press).

Douglas, P.H., R.S. Moore, S. Wimalasuriya, A. Gunawardene & K.A.I. Nekaris (2008). Microhabitat variables influencing abundance and distribution of diurnal primates (*Trachypithecus vetulus vetulus* and *Macaca sinica aurifrons*) in a fragmented rainforest network in southern Sri Lanka. *Folia Primatologica* 79: 324–325. https://doi.org/10.1159/000137690

Eschmann, C., R. Moore & K.A.I. Nekaris (2008). Calling patterns

of western purple-faced langurs (Mammalia: Primates: Cercopithecidea: *Trachypithecus vetulus nestor*) in a degraded human landscape in Sri Lanka. *Contributions to Zoology* 77: 57–65. https://doi.org/10.1163/18759866-07702001

Hladik, C.M. (1977). A comparative study of two sympatric species of leaf monkeys: *Presbytis entellus* and *Presbytis senex*, pp. 323–353. In: Clutton-Brock, T.H. (Ed.). *Primate Ecology: Studies of Feeding and Ranging Behaviour in Lemurs, Monkeys, and Apes.* Academic Press, London.

Jayasekara, P., U.R. Weerasinghe, S. Wijesundara & S. Takatsuki (2007). Identifying diurnal and nocturnal frugivores in the terrestrial and arboreal layers of a tropical rain forest in Sri Lanka. *Ecotropica* 13: 7–15.

Moore, R.S., K.A.I. Nekaris & C. Eschmann (2010). Habitat use by Western Purple-faced Langurs *Trachypithecus vetulus nestor* (Colobinae) in a fragmented suburban landscape. *Endangered Species Research* 12: 227–234. https://doi.org/10.3354/esr00307

Nahallage, C.A., M.A. Huffman, N. Kuruppu & T. Weerasingha (2008). Diurnal primates in Sri Lanka and people's perception of them. *Primate Conservation* 23: 81–87. https://doi.org/10.1896/052.023.0109

Nekaris, K.A.I. & G. de Silva Wijeyeratne (2007). *The Primates of Sri Lanka*. Sri Lanka Tourism Promotion Bureau and JetWing Holidays, Colombo, 152 pp.

Nekaris, K.A.I. & V. Nijman (2008). Attention to Sri Lankan monkey paints a bleak picture yet gives glimmer of hope. *Oryx* 42: 487–488. https://doi.org/10.1017/S0030605308423141

Nekaris, K.A.I., A. Boulton & V. Nijman (2013). An ethnoprimatological approach to assessing levels of tolerance between human and commensal non-human primates in Sri Lanka. *Journal of Anthropological Sciences* 91: 219–231. https://doi.org/10.4436/jass.91008

Nijman, V. & K.A.I. Nekaris (2010). Effects of deforestation on attitudes and levels of tolerance towards commensal primates (Cercopithecidae) in Sri Lanka. *International Journal of Pest Management* 56: 153–158. https://doi.org/10.1080/09670870903248850

Nijman, V. & K.A.I. Nekaris (2013). Assessing conflict between humans and commensal non-human primates in Sri Lanka following an ethnoprimatological approach. *Folia Primatologica* 84: 307–308. https://doi.org/10.1159/000354129

Parker, L., V. Nijman & K.A.I. Nekaris (2008). When there is no forest left: fragmentation, local extinction, and small population sizes in the Sri Lankan western purple-faced langur. *Endangered Species Research* 5: 29–36. https://doi.org/10.3354/esr00107

Rodrigo, M. (2011). Air rifles to take aim at protecting agriculture. *Sunday Times*, 22 May 2011.

Rudran, R. (1973). Adult male replacement in one-male troops of purple-faced langurs (*Presbytis senex senex*) and its effect on population structure. *Folia Primatologica* 19: 166–192. https://doi.org/10.1159/000155537

Rudran, R. (2008). A survey of Sri Lanka's Endangered and endemic Western Purple-faced Langur (*Trachypithecus vetulus nestor*). *Primate Conservation* 22: 139–144. https://doi.org/10.1896/052.022.0115

Rudran, R., H.S.K. Dayananda, D.D. Jayamanne & D.G.R. Sirimanne (2013). Food habits and habitat use patterns of Sri Lanka's Western Purple-faced Langur. *Primate Conservation* 27: 99–108. https://doi.org/10.1896/052.027.0111

Rudran, R., S.C. de Mel, H.G. Salindra, K. Dayananda, R.M.R.R. Ratnayake, S. Weerakkody & R.K. de Mel (2020a). An ethnoprimatological approach to conserving Sri Lanka's Critically Endangered western purple-faced langur. *Primate Conservation* 34: 227–233.

Rudran, R., W. Dittus, S.N. Gamage & K.A.I. Nekaris (2020b). *Semnopithecus vetulus* ssp. *nestor*. The IUCN Red List of Threatened Species 2020: e.T39844A17988280. Downloaded on 5 May 2021. https://doi.org/10.2305/IUCN.UK.2020-2.RLTS.T39844A17988280.en

Rudran, R., S.J. Cabral de Mel, A. Sumanapala, R.K. de Mel & K.K.T.I. Mahindarathna (2021). An ethnoprimatological approach to mitigating Sri Lanka's human-monkey conflicts. *Primate Conservation* 35: 1–10.

Sugathapala, D.G. & S. Wijeweera (2011). Pros and cons of using air rifles in crop protection. Daily Mirror (Sri Lanka), 21 December 2011.

Vandercone, R.P., C. Dinadh, G. Wijethunga, K. Ranawana & T.D. Rasmussen (2012). Dietary diversity and food selection in Hanuman langurs (*Semnopithecus entellus*) and purple-faced langurs (*Trachypithecus vetulus*) in the Kaludiyapokuna Forest Reserve in the dry zone of Sri Lanka. *International Journal of Primatology* 33: 1382–1405. https://doi.org/10.1007/s10764-012-9629-9

Weerakkody, W.A.D.S.N., D.K. Weerakoon & M.R. Wijesinghe (2018). Group characteristics and home range size of the Western Purple-faced Langur (*Semnopithecus vetulus nestor*) in a human-modified landscape. *WildLanka Journal of the Department of Wildlife Conservation of Sri Lanka* 6: 37–47.

Westwood, W. (2018). Praying with Primates: The Impact of Buddhism on the Perceptions of Human-primate Interactions in Mihintale, Sri Lanka. MSc Thesis, Oxford Brookes University, Oxford, 57 pp.

Wijethilaka, S., L.S. Weerasekara, S. Bandara & K.B. Ranawana (2021). Assessment of crop and property damage caused by *Semnopithecus vetulus nestor* (Bennett, 1833) (Mammalia: Primates: Cercopithecidae) in Gampaha District, Sri Lanka. *Journal of Threatened Taxa* 13: 18141–18147. https://doi.org/10.11609/jott.6582.13.5.18141-18147

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REPLY

If habitat heterogeneity is effective for conservation of butterflies in urban landscapes of Delhi, India? Unethical publication based on data manipulation: Response of original authors

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Das & Singh (2021) published a paper representing serious flaws, forgery, and data manipulation in the paper published in the same journal in 2021 by Paul & Sultana, which may have led to an inadvertent understanding developed by Das & Singh (2021). Therefore, through this communication, below-mentioned facts and circumstances are shared which should resolve the queries raised by Das & Singh (2021).

The title of the original paper is "**Is** habitat heterogeneity effective for conservation of butterflies in urban landscapes of Delhi, India?" and not "**If** habitat heterogeneity is effective for conservation of butterflies in urban landscapes of Delhi, India?" which totally changes the concept of the paper.

1. Thesis is objective based writing as per the guidelines of the University whereas paper writing is solely an exclusive style of concept presentation by the author. The data presented in the paper were not included in the thesis as they don't comply with the objectives of the thesis. Such raw reanalysed data were published in the paper (Paul & Sultana 2021). This paper was updated with new idea and improved by the considered comments and suggestions of reviewers. Authors agree that in the thesis (Paul 2019) the word microhabitat was used which are in fact small specialised 'habitats' only within a larger habitat. It is clearly mentioned in the study area and methodology section that three random transects were laid at each six different sites and habitats were sampled on those transects only. The data were collected on different habitats on different transects at these sites. Those habitats were pooled together irrespective of sites because the objective was to check the effect of habitat heterogeneity on butterfly species and accordingly diversity indices were calculated after normalising data only. The unequal sample size can be standardised for the analyses. The data were collected on different scales, so it was transformed to normalise and thus reduced the heteroscedasticity. These lines of action are prerequisite before analyses, so they were not mentioned in the paper. The mentioned paper (Paul & Sultana 2020) comprised totally different objective and not dealt with habitats therefore should not be seen as repetition.

2. The data were collected and was available with first author and it was utilised to calculate diversity indices. Diversity indices were calculated habitat wise for 'Pollard walk' method. That's why the diversity indices were '0' for the 'Artificial light' as only one species was found, and it was sampled by other type of study which is clearly mentioned in the paper. Transects were laid at different sites not in different habitats (mentioned in methodology). Nine habitats were identified on these transects at different sites. So as mentioned in Table 3, bird droppings were present at all sites. *Melanitis leda* was sighted in dense forested habitat throughout the day.

3. Artificial light is considered a microhabitat/ habitat by many researchers (Usman 1956; Donahue 1962; Shull 1964; Shull & Nadkerny 1967; Sharma &

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Chaturvedi 1999; Nair 2001; Sharma & Chaturvedi 2005; Chowdhury & Soren 2011). The diagram was accordingly presented in the paper which was somehow not considered in the thesis and therefore should not be considered as tampered. It may be noted that many other views of reviewers are also incorporated in the paper in general to further bring new ideas. Figure 2 shows data in a graphical mode with species name only whereas Table 2 represents numerical data which is not reflected in Figure 2 and therefore should not be seen as duplication. Generalist and specialist butterflies name have not been included in the paper as the scope of the paper is always limited in any journal. It is not written anywhere in the paper that species found in flowerbeds and grass are specialist so should not be seen as misinterpretation of data. The actual percent overlapping among various habitats are clearly mentioned in Table 2. The independent sharing was calculated for overlapping of different habitats in terms of species shared and it was not calculated for the species. The percentage sharing of habitats (Table 2) between artificial light and Hedges/crops/bushes was 2.5%. Coincidentally, *Melanitis leda* was the only butterfly species found in the artificial light during the study, Similar kind of sharing was shown by other habitats too like between trees and Hedges/crops/bushes for *Colotis fausta*.

4. The raw data were reanalysed to discuss the effectiveness of habitat heterogeneity for conservation of butterfly species in urban landscape. Das & Singh (2021) were right that in the thesis the preference of habitat was discussed in terms of number of sightings but in the paper the authors have discussed the diversity of butterfly species, i.e., number of species which was considered as new idea. The flowerbeds were absent in the randomly transect laid in Northern Ridge and discussion was based on results only. Das & Singh (2021) may be right in saying that flowerbeds must be present in Northern Ridge.

COVID 19 statement should not be considered as mere speculation but may be seen as increasing the scope of study in urban centres for butterflies as have been published for other faunal species (Rutz et al. 2020; Gilby et al. 2021) during lockdown.

5. The first author sincerely apologizes to her supervisor and co-supervisor for not bringing the manuscript to their knowledge before publication. She had some hearing mistake while having verbal discussion with her Ph.D. supervisor to publish the research papers without their names in the authorship. However, the first author thoroughly acknowledged everyone (including both of her supervisors) who so ever helped her during her Ph.D. work in her thesis. It happened unintentionally and first author sincerely apologizes for her mistake. The co-author of the original paper provided all technical contribution to the paper for publication and therefore became co-author as per the desire of the first author.

In the light of the above facts and circumstances these issues should be closed with learning for the co-author to think before extending any support and help to students to avoid such unnecessary controversies.

References

Chowdhury, S. & R. Soren (2011). Light attracted butterflies: a review from the Indian sub-region with an inventory from West Bengal, India. *Journal of Threatened Taxa* 3(6): 1868–1871.

Das, S.K. & R. Singh (2021). If habitat heterogeneity is effective for conservation of butterflies in urban landscapes of Delhi, India? Unethical publication based on data manipulation. *Journal of Threatened Taxa* 13(13): 20140–20142. https://doi.org/10.11609/jott.7673.13.13.20140-20142

Donahue, J.P. (1962). Observations and records of butterflies attracted to light in India. *Journal of the Lepidopterists' Society* 16(12): 131–135.

Gilby, L.B., C.J. Henderson, A.D. Olds, J.A. Ballantyne, E.L. Bingham, B.B. Elliot, T.R. Jones, O. Kimber, J.D. Mosman & T.A. Schlacher (2021). Potentially negative ecological consequences of animal redistribution on beaches during COVID-19 lockdown. *Biological Conservation* 253: 108926. https://doi.org/10.1016/j.biocon.2020.108926

Nair, V.P. (2001). Butterflies attracted to light at Aralam Wildlife Sanctuary, Kerala. *Zoos' Print Journal* 16(12): 670.

Paul, M. & A. Sultana (2020). Studies on butterfly (Insecta: Lepidoptera) diversity across different urban landscapes of Delhi, India. *Current Science* 118(5): 819–827.

Paul, M. (2019). Studies on Biotic Interactions of Lepidoptera in Urban Landscapes of National Capital Territory, Delhi. PhD Thesis. Submitted to Guru Gobind Singh Indraprastha University.

Rutz, C., M.C. Loretto, A.E. Bates, S.C. Davidson, C.M. Duarte, W. Jetz, M.Johnson, A. Kato, R. Kays, T. Mueller, R.B. Primack, Y. Ropert-Coudert, M.A. Tucker, M. Wikelski & F. Cagnacci (2020). COVID-19 lockdown allows researchers to quantify the effects of human activity on wildlife. *Nature Ecology and Evolution* 4: 1156–1159. https://doi.org/10.1038/s41559-020-1237-z

Sharma, R.M. & N. Chaturvedi (1999). Black Rajah *Charaxes fabius* attracted to light at Tadoba National Park. *Journal of the Bombay Natural History Society* 96(1): 168–169.

Sharma, R.M. & N. Chaturvedi (2005). Additions to the light attracted butterflies. *Journal of the Bombay Natural History Society* 102(1): 129.

Shull, E.M. & N.T. Nadkerny (1967). Insects attracted to mercury vapour lamp in the Surat Dangs, Gujarat State. *Journal of the Bombay Natural History Society* 64(2): 256–266.

Shull, E.M. (1964). Butterflies attracted to light in Gujarat State, India. *Journal of the Lepidopterists' Society* 18(30): 159–163.

Usman, S. (1956). Some insects attracted to light- Part III. *Journal of the Bombay Natural History Society* 53(3): 482–484.

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BOOK REVIEW

Freshwater fishes of the Arabian Peninsula

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The Arabian Peninsula covering an area of >3 million km^2, though considered to be mostly dry and arid, has several interesting freshwater systems such as the *wadis* (a valley or stream bed that is dry except during the rains). However, compared to other parts of the world, very little ichthyological research has been undertaken in this region, and the freshwater system here, are known to harbour comparatively few freshwater fish species than the rest of Asia. Since the publication of the IUCN report on 'Status and distribution of freshwater fishes of the Arabian Peninsula' in 2015, in which the conservation status of 21 species occurring in the Arabian Peninsula was documented, there has been a significant improvement in the knowledge on taxonomy and distribution of fishes of this region – necessitating a need for an updated compilation. This is what the 272-page book on *Freshwater Fishes of the Arabian Peninsula* offers – the most authoritative account of Arabian ichthyofauna, published till this day. As William Darwall, Head of the IUCN's Freshwater Biodiversity Program aptly writes in his foreword, this book is a tremendous recognition of the hard work and effort of the authors who make sure that it is not only a book for today, but also a valuable contribution for informing the future conservation of Arabia's native fish species.

The Arabian Killfish, *Aphanius stoliczkanus* adorns the cover of *Freshwater Fishes of the Arabian Peninsula*, a book that undoubtedly fits the anatomy and definition of a 'field guide' to perfection, not only in its contents, but also in its compactness (one can very easily carry it in the field!). The book essentially follows a style and pattern that has been previously used in *Handbook of European Freshwater Fishes*, an extremely popular and highly cited ichthyology masterpiece!

Freshwater Fishes of the Arabian Peninsula is organized into four sections. The first section discussing 'field methods' is an excellent source of information, and a must-read, for early career ichthyologists and taxonomists. The authors have covered fundamental aspects of a range

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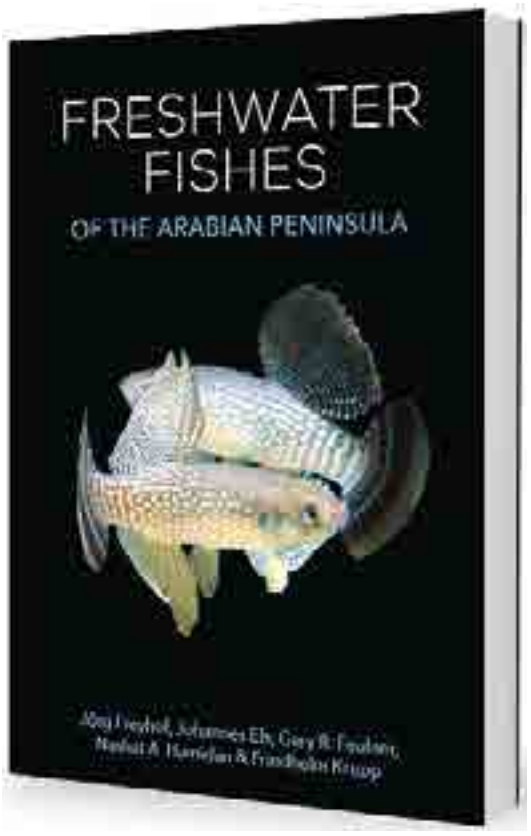

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of subjects, from 'organizing field work' to 'sampling techniques', 'photography', 'preservation' and most importantly 'methods and techniques for morphometrics and meristics'. It has been often argued that inadequate resources for fish taxonomy including limited literature on standard taxonomic methods and techniques is a major impediment to the progress of ichthyology, particularly in the biodiversity-rich tropical countries. In this context, the first section of *Freshwater Fishes of the Arabian Peninsula* will certainly help bridge this resource-gap, not just for ichthyologists of the Arabian Peninsula, but also elsewhere in the tropics. The second section of the book deals with essential concepts in taxonomy and biogeography and includes general topics such as 'species and populations', 'species concepts', 'nomenclature', and an account of the geological history and biogeography of the Arabian Peninsula. The information on geology and historical biogeography of the region from Oligocene to the present day, which has been discussed in the context of aquatic taxa, will be of immense use to researchers working on questions related to systematics and biogeography, both in Asia and Europe.

Towards the end of the second section, we are introduced to the grim fact that almost half (47%) of the native freshwater fish species of the Arabian Peninsula is threatened – thanks to a range of stressors including water extraction and dams, habitat loss and degradation, pollution, alien species and climate change. This is certainly bad news as almost 75% of the region's ichthyofauna is endemic, and further declines in the quantity and quality of habitats will only push these species towards an imminent extinction. Of particular concern are three species listed as Critically Endangered on the IUCN Red List, the Arabian Bream (*Acanthobrama hadiyahensis*) (endemic and restricted to two locations in Saudi Arabia), Andhur Garra (*Garra sindhae*) and Hasik Garra (*Garra smartae*) (both endemic to Oman). While the authors mention that legal protection for fish species are in place in most areas, they do not provide further details, except about an ex-situ conservation breeding program for three threatened species (one of which is *G. smartae*) taking place at Sharjah, UAE. An interesting discussion on the eradication of alien tilapias (p93) could be useful information for biodiversity and fisheries managers throughout the Asia-Pacific, where tilapias are becoming a major threat to native fish diversity.

The core of *Freshwater Fishes of the Arabian Peninsula* is certainly the section that covers species accounts of all of the 31 native freshwater fishes occurring in the Arabian Peninsula. From pages 106 to 219, this section features concise text that will aid the field-level identification, excellent colour images depicting every species (many for the first time), and accurate distribution maps. Species accounts are presented family-wise (7 families) where the authors begin by introducing the family, and providing basic information on the diversity, distribution, ecology and biology of the members of the family, besides a key to the species that occur in the Arabian Peninsula. Detailed species accounts follow, including high quality images depicting every species (and in some case males and females, and in others juveniles and adults), a diagnosis, information on distribution (both within the Arabian Peninsula and beyond), habitat, biology, threats and conservation status. The authors have also provided a catchment-scale distribution map, as well as images of typical habitat/s of the species. The book ends with a similar section featuring 10 alien fish species (three species of tilapia, two species of catfishes, and five species of poeciliids) that have now established populations in the Arabian Peninsula. The bibliography is extensive, and lists all relevant literature on the freshwater fishes of the region, updated until 2020.

As a freshwater ichthyologist, I consider *Freshwater Fishes of the Arabian Peninsula* as an impressive piece of work, and therefore have little criticisms and suggestions. I was of course, concerned by the large amount of text that has been reproduced verbatim from *Handbook of European Freshwater Fishes*. For example, the entire text that forms the basis of Sections 1 and 2 in pages 22–28, 48–53, 55–63, 71–72, and information provided in boxes on pages 57, 68 and 69 in *Freshwater Fishes of the Arabian Peninsula*, are all reproduced verbatim from the introduction chapter of *Handbook of European Freshwater Fishes*. While the authors admit this fact in their acknowledgments, I think it would certainly have been better to include modified (and additional) text in many cases. For suggestions, I would have loved to see a map depicting the current distribution of the 10 alien species in the Arabian Peninsula (especially since there are other maps depicting distribution of endemic and threatened fish species), and a separate map that shows overlaps in the distribution of endemic/threatened, and alien fish species. These could have added more value to the conservation element of the book.

Freshwater Fishes of the Arabian Peninsula would definitely have been a challenging project to accomplish, but I am sure the authors are immensely satisfied with the final product – a standard reference that is an invaluable for anyone interested in understanding the fishes of Arabian Peninsula, or for that matter anyone interested in 'freshwater fish'! I strongly recommend this book.

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