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RESEARCH ARTICLE

New species and new records of lichen genus *Anisomeridium* (Müll. Arg.) M. Choisy (Monoblastiaceae) from India

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Abstract

A new species *Anisomeridium subphaeospermum* is described and illustrated in the present article from Uttar Pradesh, India. It is characterized by a UV− (Negative) thallus, 8-spored asci, biseriate, brown, transversally 1-septate and broadly elliptical ascospores. Additionally, 6 species namely *A. adnexum, A. americanum, A. quaternarium, A. subnectendum, A. tuckerae* and *A. uniseriale* are reported as new records for Indian lichen biota along with a key of 26 species of the genus currently known from India.

Keywords

Pyrenocarpous; taxonomy; biodiversity; lichenized fungi; India

Introduction

The genus *Anisomeridium* (Müll. Arg.) M. Choisy, is characterized by its crustose thallus, emergent to exposed perithecia, cylindrical-clavate asci with broad ocular chamber, anastomosing paraphysis above asci, 1(-3) and transversely septate ascospores (1, 2). The genus belongs to the family Monoblastiaceae with 90 species distributed worldwide (3). Altogether this family consists of 11 genera (4). Among the genera, *Acrocordia* and *Megalotremis* show close resemblance to *Anisomeridium* in having transversally 1 septate and ellipsoid ascospores (Fig. 1) but the genus *Acrocordia* differs in having ascospores with both cells equal in size and warted epispore, while, the genus *Megalotremis* differs in the absence of ocular chamber in the asci with profusely branched anastomosing paraphysis and larger ascospores (5, 6). Recently, a report had described *Anisomeridium guangdongensis* S.H. Jiang & C. Zhang and *A. guangxiensis* S.H. Jiang & C. Zhang, as new species from China (3). Similarly, another study had discovered *A. disjunctum* McCarthy and Kantvilas as new species from eastern Tasmania (7).

The species of the genus *Anisomeridium* generally grow on bark and sometimes on rocks in tropical to subtropical regions in the world. In India, researchers had described *Anisomeridium calcicolum* as new species found growing on lime plaster in central India (8). Another study listed 17 species of *Anisomeridium* from India (9), further, a group of authors provided an updated checklist for Indian lichen biota including 5 species of *Anisomeridium* (10). Recently, researchers studied pyenocarpous lichens from Goa state and provided taxonomic key including *Anisomeridium* species (11).

During a taxonomic investigation on more than 317 specimens of *Anisomeridium* housed at LWG herbarium, we found one new species of *Ani-*

Fig. 1. Morphology of ascospores: **A**, *Acrocordia* sp. (both end equal size); **B,** *Anisomeridium adnexum* R.C. Harris (granular ornamented); **C**, *A. subnectendum* (Nyl.) R.C. Harris (strongly submedium septum); **D**, *Megalotremis biocellata* Aptroot (filaments anastomoising paraphysis and spore constricted at the spetum). Scale bars: 10 µm (**A-D**).

someridium and 6 new records for the Indian lichen biota and are described here. In the present communication, a key for all the 26 species known from India is provided together with illustration and distribution maps.

Materials and Methods

The present study is based on examination of more than 300 specimens preserved in the herbarium of CSIR-National Botanical Research Institute (LWG), Lucknow. Morphological observation of the lichen sample was done under the stereo zoom microscope (Leica Journal Preproof S8APO). The hand-cut section of perithecia was prepared and studied under a compound microscope (Leica DM500). The anatomy-based characters were studied and spore measurements were taken in a water mount and 10 % KOH. All the photographs were taken with the attached camera (EC3) of the microscope. For the spot tests, the reagent of K, C and P were used and for identifying lichens substance, thin layer chromatography (TLC) was performed in solvent system C following the protocol (12) and observed thallus in UV chamber. The length, breadth and length/breadth ratio (l/b) of ascospores are given as (min –) {x̄-SD}–{x̄+SD} (– max) where 'min' and 'max' are extreme values, x̄ represent the arithmetic mean, SD represent standard deviation, followed by the number of measurements (n), for every sample approximately 20 spores were measured. The specimens were identified up to the species level with the help of previously published literature (1-5). The identified specimens were preserved at LWG herbarium, Lucknow. Google Earth and QGIS softwares were used for the preparation of distribution maps of species.

Results and Discussion

Taxonomic accounts

1. *Anisomeridium adnexum* (Müll. Arg.) R.C. Harris, More Florida Lichens, Incl. 10 Cent Tour Pyrenol. (New York): 143 (1995). (Fig. 2A-C, Fig.4A)

≡*Arthopyrenia adnexa* Müll. Arg. [as 'adnaex'] (1883), Flora, Regensburg 66(19): 304 (1883).

Diagnosis

Thallus corticolous, crustose, greyish-white or greyish-green, ecorticate; ascomata immersed to emergent, 0.25 to 0.5 mm, perithecia black, 1 – 2 mm in diameter, globose, entire, ostiole apical distinct, thinner at the base; asci 8-spored, 100 × 20 – 22.5 µm; ascospores hyaline, 1 septate, ornamented, elliptical to broadly elliptical, constricted at middle, upper locule longer and wider than the lower locule (23.03–) 27.15 – 36.05 (–37.26) × (12.14–) 13.77–18.35 (–19.08) µm. Pycnidia not observed.

Chemistry

Thallus K-, KC-, P-, UV-; no lichen substance detected in TLC.

Distribution and ecology

Previously, the species was reported from Brazil and Hong Kong (1). This is a new record for Indian lichen biota which was found growing on *Heritiera fomes, Hopea ponga, Mangifera indica* and *Prosopis* sp., in tropical regions of the states of Gujarat, Karnataka, Uttar Pradesh and Uttarakhand.

Remark

A. adnexum is similar to *A. biforme* (Borrer) R.C. Harries, in having apical ostiole, 8-spores asci and UV- thallus but *A. biforme* differs in having smooth and smaller ascospores (10–18 × 4 – 7 µm). *A. adnexum* is also close to *A. americanum* in having ornamented and 8-spored asci but *A. americanum* differs in eccentric ostiole and sometime with septum submedian.

Specimens examined

India: Gujarat: Junagadh district, Sasan Gir, Gir Wildlife Sanctuary, Andasi Vistar, on bark, 21/2/2015, *K.K. Ingle* 15-025554 (LWG). Karnataka: Uttara Kannada district, Sirsi taluk, near Vibhooti falls, on bark of *Hopea ponga,* 05/4/2014, *S. Dudani* 14-024431/A (LWG). Uttar Pradesh: Bulandshahar district, Narora up stream, alt. 201 m, on bark, 07/06/2015, *R. Bajpai* 15-026713 (LWG); Hardoi district, Sandila area, Som forest, on bark of *Prosopis*, 02/10/2022, *D.K. Upreti* & *R. Bajpai* 11-009099 (LWG); Raebareli district, Unchahar TPP, Sarain Tula Ram near Gopapur, alt. 98 m, on bark of *Mangifera indica*, 13/03/2016, *N. Gupta* 16-031742 (LWG); Kanpur district, Ram nagar, on bark of *Mangifera indica*, 12/10/2007, *Satya* and *Roshni* 07-015115 (LWG), Panki TPP, Amilina near Choubepur Kalan, alt. 128 m, on bark of *Mangifera indica*, 11/10/2014, *N. Gupta* 14-025384 (LWG). Uttarakhand: Udham Singh Nagar district, Gadarpur before Kelakhera, on bark of *Mangifera*

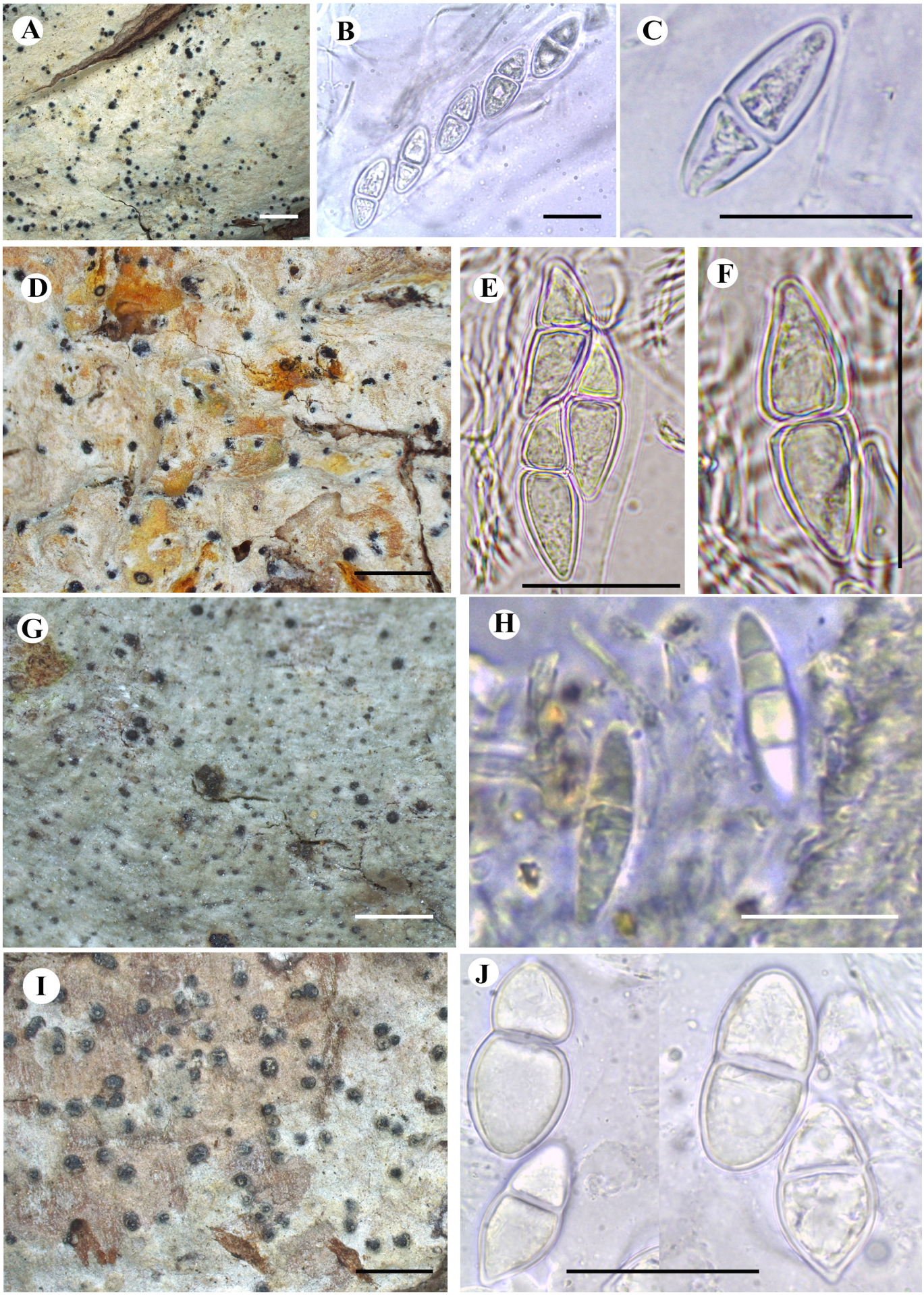

Fig. 2. A, Habitat of *A. adnexum*; **B**, Ascus; **C**, Ascospore; **D**, Habitat of *A. americanum;* **E**, Ascus; **F**, Ascospore; **G**. Habitat of *A. quaternarium;* **H**, Ascospore; **I**, Habitat of *A. subnectendem;* **J**, Ascospore. Scale bars: 5 mm (**A**); 10 µm (**B**); 20 µm (**C**); 5 mm (**D**); 20 µm (**E**); 40 µm (**F**); 5 mm (**G**); 20 µm (**H**); 5 mm (**I**); 20 µm

indica, 03/09/2015, *S. Mishra* & *G.K. Mishra*,

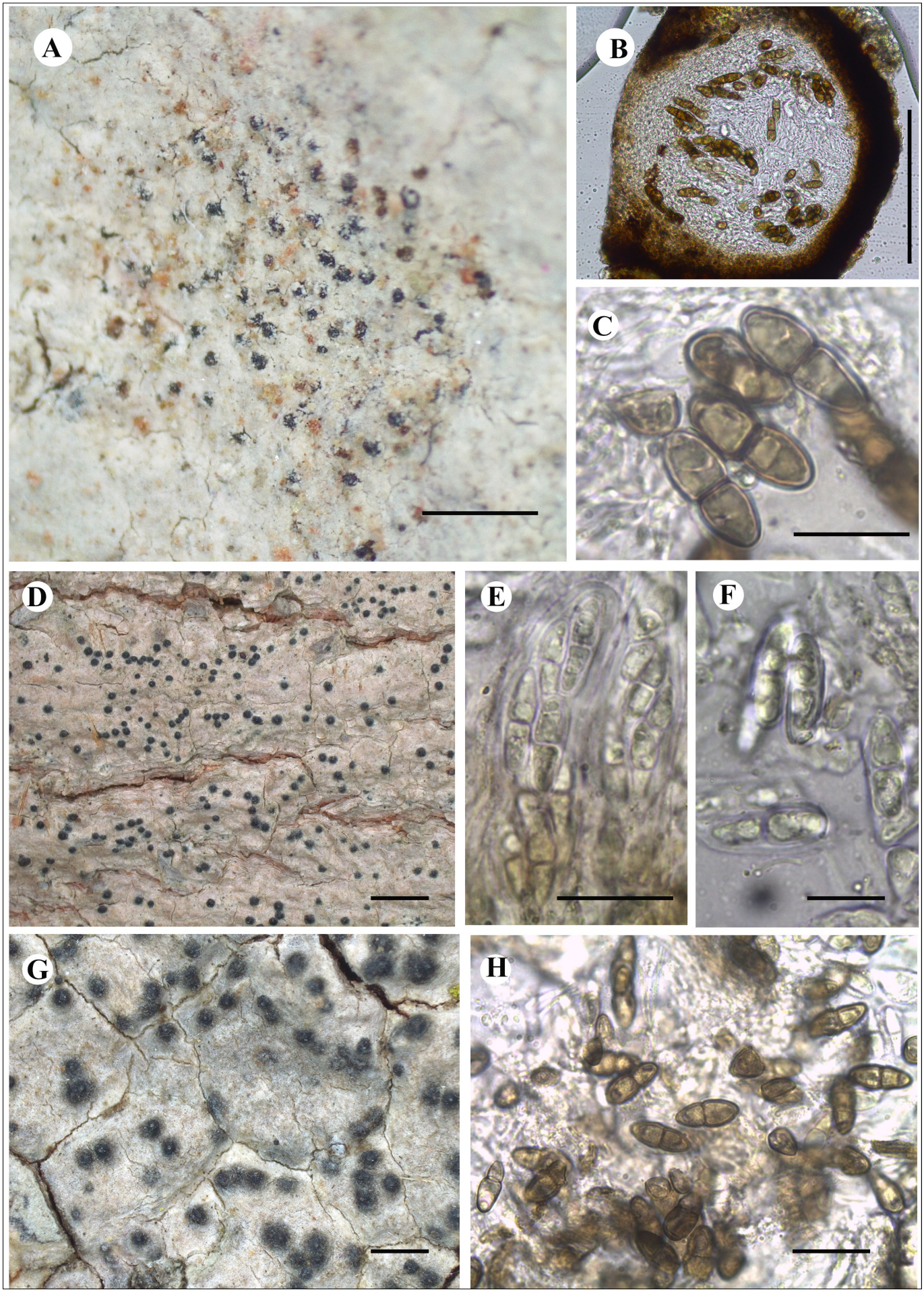

Fig. 3. A, Habitat of *A. subphaeospermum;* **B**, T.S. of perithecia; **C**, Ascospore; **D**, Habitat of *A. tuckerae;* **E**, Ascus; **F**, Ascospore; **G**, Habitat of *A. uniseriale;* **H**, Ascospore. Scale bars: 10 mm (**A**); 50 µm (**B**); 10 µm (**C**); 10 mm (**D**); 30 µm (**E**); 15 µm (**F**); 10 mm (**G**); 20 µm (**H**).

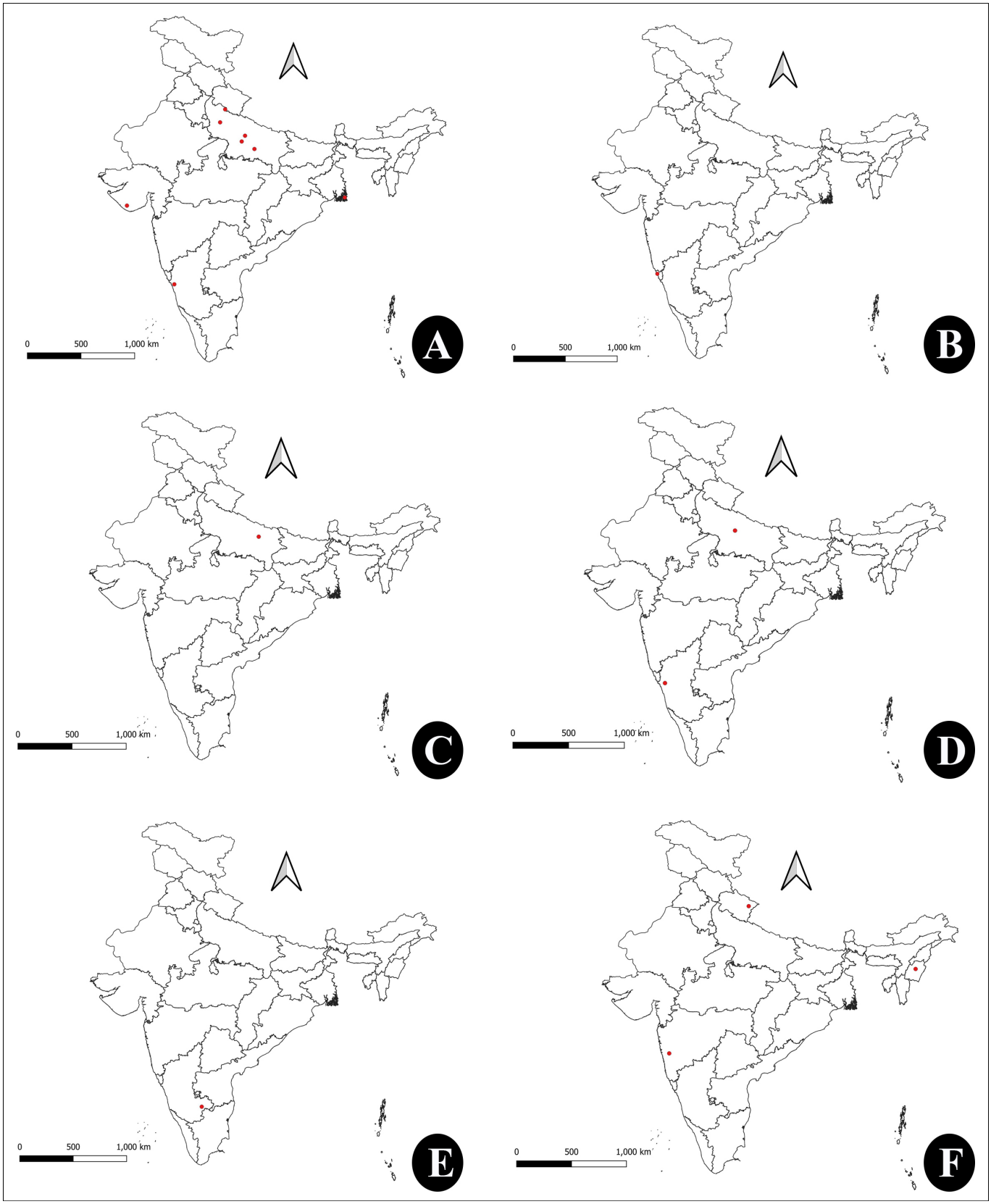

Fig. 4. Distribution maps of *Anisomeridium* species: **A**, *A. adnexum*. **B**, *A. americanum*. **C**, *A. quaternarium*. **D**, *A. subnectendum*. **E**, *A. tuckerae*. **F**, *A. uniseriale* in India.

15-027739/A (LWG), Kashipur, Bazpur road, on bark of *Mangifera indica*, 03/09/2015, *S. Mishra* & *G.K. Mishra* 15 -027741 (LWG), Jaspur, on twig of *Mangifera indica*, 03/09/2015, *S. Mishra* & *G.K. Mishra* 15-027740 (LWG).

2. *Anisomeridium americanum* (Massal.) R.C. Harris, More Florida Lichens, Incl. 10 Cent Tour Pyrenol. (New York): 144 (1995). (Fig. 2D-F, Fig. 4B)

=*Arthopyrenia Americana* A. Massal., Ric. auton. lich. crost. (Verona): 170 (1852).

Diagnosis

Thallus corticolous, crustose, whitish grey, ecorticate; ascomata emergent, perithecia black, globose, ostiole eccentric; asci 8-spored, KI-, ascospores uniseriate, hya-

line, 1- septate, fine granular ornamented, fusiform, with median/submedian septum (32.37) 33.05 – 39.53 (–42.86) × (9.46–) 9.93 – 11.58 (–12.48) µm. Pycnidia not found.

Chemistry

Thallus K-, KC-, P-, UV-; no lichen substance detected in TLC.

Distribution and ecology

Found growing on bark of trees in Goa University Campus Goa. Previously, the species was known from Australia, Ceylon and Cuba (1) and is a new record for Indian lichen biota.

Remark

Anisomeridium americanum is closely related to *A. terminatum* (Nyl.) R.C. Harries, in having fusiform ascospores, but the latter species differs in having smaller ascospores measuring 19 –30 × 5–8 µm in size.

Specimen examined

India: Goa: North Goa, Goa University campus, on bark, 02/10/2016, *P. Randive*, GU 385 (LWG).

3. *Anisomeridium quaternarium* (R.C. Harris) R.C. Harris, More Florida Lichens, Incl. 10 Cent Tour Pyrenol. (New York): 130 (1995). (Fig. 2G-H, Fig. 4C)

≡*Ditremis quaternaria* R.C. Harris (1990), Some Florida Lichens (New York): 34 (1990).

Diagnosis

Thallus corticolous, crustose, greenish to greyish-white, ecorticate; perithecia black, ostiole apical; ascus 8-spored; ascospores biseriate to irregular, hyaline, 3 septate, fusiform, (15.79 –) 16.37 – 10.15 (– 21.25) × (3.85 –) 4.01 – 5.38 (– 5.75) µm. Pycnidia not seen.

Chemistry

Thallus K-, KC-, P-, UV-; no lichen substance detected in TLC.

Distribution and ecology

Previously, the species was known from Louisiana (1), now recorded as new record to Indian lichen biota found growing on *Mangifera indica* bark in the state of Uttar Pradesh.

Remark

In having 3 septate ascospore, *A. quaternarium* showed close resemblance with *A. quadricoccum* R.C. Harris but the latter species differs in having bigger ascospore measuring 21–24 × 6–8 µm size.

Specimen examined

India: Uttar Pradesh: Faizabad district, Azamgarh road, Purabazar, Barauli on trunk of *Mangifera indica*, 19/03/2014, *V. Gupta* 014-022614 (LWG).

4. *Anisomeridium subnectendum* (Nyl.) R.C. Harris, More Florida Lichens, Incl. 10 Cent Tour Pyrenol. (New York): 150 (1995). (Fig. 2 I-J, Fig. 4D)

≡*Verrucaria subnectenda* Nyl., in Nylander and Crombie, J. Linn. Soc., Bot. 20: 61 (1883)

Diagnosis

Thallus corticolous, crustose, greyish, ecorticate; ascomata emergent, perithecia black, globose, ostiole apical; asci 8-spored, ascospores uniseriate, hyaline, 1 septate, not ornamented, ovoid to broadly ovoid, with strongly submedian septum (20.84 –) 21.05 – 29.71 (–34.28) × (7.16 –) 8.46 – 10.98 (– 12.48) µm. Pycnidia not found.

Chemistry

Thallus K-, KC-, P-, UV-; no lichen substance detected in TLC.

Distribution and ecology

Previously, the species was known from Australia, Brazil, Malaysia and U.S.A. (1), it is a new addition to the lichen biota of India reported from Karnataka, a part of Western Ghats, found growing on *Syzygium travancoricum* bark in moderate dense forest.

Remark

The species is characterized by 8-spored, biseriate asci and ovoid to broadly ovoid ascospore with strongly submedian septum. *A. subnectendum* is closely associated with *A. leptospermum* (Zahlbr.) R.C. Harris, in having ovoid to broadly ovoid ascospores but the later species differs in having smaller ascospores measuring 18–23 × 9– 14 µm in size.

Specimens examined

India: Karnataka: Uttara Kannada district, on bark of *Syzygium travancoricum*, 22/03/2013, *S. Dudani* 13-023384/A, 13-023384/B (LWG). Uttar Pradesh: Kamipur Forest, on bark of *Prosopis*, 02/10/2022, *D.K. Upreti* & *R. Bajpai* 11-009056 (LWG).

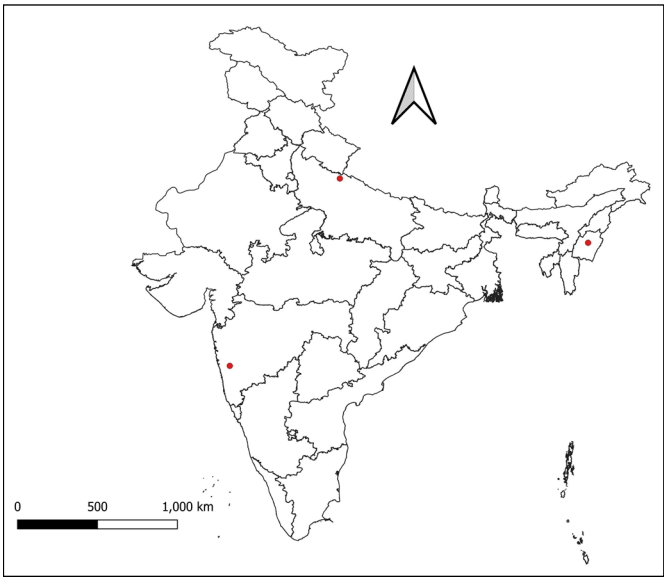

Fig. 5. Distribution map of *A. subphaeospermum* in India.

5. *Anisomeridium subphaeospermum* G.K. Mishra, Upreti & Nayaka sp. nov. (Fig. 3A-C, Fig. 5) *Mycobank:* 851258

Description

The new species differs from A. *phaeospermum* by its UV- thallus, 8-spored asci and larger ascospores.

Type

India: Uttar Pradesh: Pilibhit district, Maala Forest area, 1 km after Richhola, on Sal bark, 23/04/2014, *K.K. Ingle*, 14-024420 (Holotype: Isotype LWG).

Diagnosis

Thallus corticolous, crustose, pale greenish whitish to grey, ecorticate, dull, minutely rough, lacking prothallus. Photobiont green alga; Ascomata perithecioid, hemispherical to conical, ostiole apical, rounded, black, often indistinct; ascomatal wall 30–80 µm thick, brown to black; exciple 28–45 µm, dark to black; hymenium 120–150 × 180–200 µm; subhymenum 20–35 µm; asci broadly clavate, 50–70 × 12–17 µm, 8 spored, KI-; ascospore biseriate, brown, 1- spetate, smooth, broadly ellipsoid or oblong ellipsoid, sometime upper cell larger than the lower cell (11.97–)19.98–24.38 (–29.34) × (6.41–) 6.96–8.79 (–10.37) µm. Pycnidia not seen.

Chemistry

Thallus K-, KC-, P-, UV-; no lichen substance detected in TLC.

Etymology

The name of the species is based on name of similar species *A. phaeospermum.*

Distribution and ecology

The new species is found growing frequently on *Memecylon edule* and *Shorea robusta* trees in localities of the states of Manipur and Uttar Pradesh in open thin out forest.

Remarks

The new species is characterized by UV- thallus, apical ostiole, 8 spored asci, biseriate, brown, 1 septate, broadly elliptical ascospores. Both *A. phaeospermum* R.C. Harris and *A. uniseriale* (Zahlbr.) R.C. Harris, exhibit similarity with new taxa in having brown ascospores and apical ostiole but the new species differ in having UV- thallus and bigger ascospores.

Specimens examined

India: Manipur: Imphal East district, Keikol, alt. 800 m, on bark, 08/06/2018, *S. Nayaka, S. Joseph & R. Ngangom* 18-028498/A (LWG). Uttar Pradesh: Pilibhit district, Maala Forest area, 1 km after Richhola, on Sal bark, 23/04/2014, *K.K. Ingle* 14-024420/A (LWG), 4 km after Sakariya, alt. 183 m, on Sal bark, 23/04/2014, *K.K. Ingle* 14-024421, 14-024421/A (LWG).

6. *Anisomeridium tuckerae* R.C. Harris [as 'tuckeri'], Bryologist 83(1): 4 (1980). (Fig. 3D-F, Fig. 4E)

Diagnosis

Thallus, corticolous, crustose, greyish-white, ecorticate; perithecia black, ostiole apical; ascus 8-spored; ascospores hyaline, 1 – septate, fusiform, with median septa, (15.25 –) 18.34 – 24.84 (– 28.45) × (2.63 –) 3.41 – 5.09 (– 6.11) µm. Pycnidia not seen.

Chemistry

Thallus K-, KC-, P-, UV+ yellow; lichexanthone detected in TLC.

Distribution and ecology

The species is new to Indian lichen biota and was found growing on *Tobulia* bark in state of Karnataka. Previously, the species was known from Florida (1).

Remarks

Based on published literature (1) *A. tuckerae* is a distinct species with cylindrical macroconidia, while all of the other species of *Anisomeridium* have globose or subglobose macroconidia. Also, presence of lichexanthone occurs in only a few other species in the genus providing a ready means of identification of macroconidia cannot be located. *A. tuckerae* is closely resemblance to *A. biormoides* R.C. Harries in having UV+ yellow thallus but latter species differs in broadly elliptical and smaller ascospores measuring 10–15 × 6– 9 µm on size.

Specimen examined

India: Karnataka: Bangalore city, IISc Campus, alt. 900 m, on bark of *Tobubia*, 16/09/2007, *S. Nayaka* 07-013174 (LWG).

7. *Anisomeridium uniseriale* (Zahlbr.) R.C. Harris, More Florida Lichens, Incl. 10 Cent Tour Pyrenol. (New York): 151 (1995). (Fig. 3G-H, Fig. 4F)

≡*Microthelia uniserialis* Zahlbr., Annals Cryptog. Exot. 5(3-4): 199 (1932).

Diagnosis

Thallus corticolous, crustose, whitish-grey, ecorticate; perithecia black, ostiole apical; ascus cylindrical, 8 – spored; ascospores uniseriate, brown, 1 – septate, elliptical, with sometime median septum (9.39–) 11.20–14.22 (–14.65) × (4.15–) 4.79–6.05 (–6.22) µm. Pycnidia not seen.

Chemistry

Thallus K-, KC-, P-, UV+ light yellow; lichexanthone present in TLC.

Distribution and ecology

Previously, the species was reported from South Africa (1); it is a new record for Indian lichen biota and found growing on bark of *Euphorbia fruticosa* and *Quercus semecarpifolia.*

Remark

In having brown ascospore and apical ostiole the species shows resemblance with *A. subphaeospermum* and *A. phaeospermum*. However, *A. subphaeospermum* differ in UV– thallus while *A. phaeospermum* has broadly elliptical ascospore measuring 16–20 × 8–9 µm size. *A. uniseriale* is similar to *A.* in having brown ascospores but *A. uniseriale* has UV- thallus and bigger ascospores (11–29 × 6–10 µm), with medium septum.

Specimens examined

India: Manipur: Imphal East district, Keikol alt. 800 m, on bark, 08/06/2018, *S. Nayaka, S. Joseph & R. Ngangom* 18-028498/C (LWG). Uttarakhand: Pithoragarh district, Mun-

siyari, Khalia Top, alt. 2700-3000 m, on *Quercus semecarpifolia*, 17/11/2006, *Y. Joshi* & *R. Bajpai* 06-007055 (LWG).

Key to the species of Anisomeridium in India

1. Thallus growing on rock..... *A. calcicolum*

–Thallus growing on bark..... 2

2. Ascospores brown and 1-septate..... 3

– Ascospores hyaline and 1 or 3 septate..... 4

3. Thallus UV–, ascospores 11 – 30 × 6 – 10 µm long. .....*A. subphaeospermum*

–Thallus UV+, ascospores 9 – 11 × 5 – 6 µm long..... *A. uniseriale*

4. Thallus having lichexanthone (UV+) 5

–Thallus lacking lichexanthone (UV-) 10

5. Ostiole apical 6

–Ostiole eccentric..... 9

6. Asci biseriate 7

–Asci uniseriate 8

7. Ascospores subglobose to globose, 23 – 30 × 7 – 10 µm..... .....*A. ubianum*

–Ascospores fusiform, 15.25 – 28.45 × 2.63 – 6.11 µm..... .....*A. tuckerae*

8. Ascospores fusiform, 24 – 33 × 8 – 12 µm ....*A. ambiguum*

–Ascospores elliptical to broadly elliptical, 25 – 30 × 9 – 13 µm..... *A. consobrinum*

9. Ostiole ringed with orange pigment, ascospores 37 – 52 × 15 – 20 µm.....*A. aureopunctatum*

–Ostiole not ringed with orange pigment, ascospores 20 – 27 × 8 – 11 µm..... *A. angulosum*

10. Ostiole apical 11

–Ostiole eccentric 21

11. Ascospores 3 – septate 12

–Ascospores 1 – septate 13

12. Ascospores fusiform and longer 15.79 – 21.25 × 3. 85 – 5.75 µm..... *A. quaternarium*

–Ascospores ovoid and smaller 14 – 20 × 4 – 6 µm .....*A. polypori*

13. Ascospores ornamented and ovoid to pyriform .....*A. adnexum*

–Ascospores smooth and ovoid or otherwise 14

14. Ascospores biseriate 15

–Ascospores uniseriate 20

15. Ascomata completely immersed, ascospores broadly ovoid, 42 – 52 × 20 – 24 µm .....*A. nidulans*

–Ascomata exposed or semi – immersed, ascospores ovoid to otherwise..... 16

16. Ascospores fusiform 17

–Ascospores ovoid to broadly ovoid 18

17. Ascospores slightly sub-medium septum and 26 – 34 × 8 – 11 µm .....*A. subnexum*

–Ascospores almost cylindrical without sub-medium septum and 12 – 24 × 4 – 8 µm..... *A. tamarindi*

18. Ascospores ovoid to broadly ovoid with strongly sub-medium septum 18 – 28 × 9 – 14 µm ..*A. leptospermum*

–Ascospores ovoid only 19

19. Ascospores smaller 9 – 15 × 4 – 5 µm ..... *A. albisedum*

–Ascospores longer 15 – 22 × 6 – 8 µm ...*A. anisolobum*

20. Ascospores broadly ellipsoid to ovoid, 10 – 18 × 4 – 7 µm .....*A. biforme*

–Ascospores ovoid to broadly ovoid, 20 – 34 × 7 – 12 µm .....*A. subnectendum*

21. Ascospores ornamented 22

–Ascospores smooth 23

22. Ascospores 26 – 42 × 9 – 12 µm..... *A. americanum*

–Ascospores 19 – 30 × 5 – 7 µm ..... *A. terminatum*

23. Asci 1 – 4 spored, ascospores 58 – 70 × 12 – 17 µm .....*A. monosporum*

–Asci 8 – spored, ascospores smaller 24

24. Asci uniseriate and ascospores fusiform with pointed end ..... *A. glaucescens*

–Asci biseriate, ascospores ovoid to oblong ellipsoid.. 25

25. Ascospores 16 – 22 × 6 – 9 µm .....*A. concameratum*

–Ascospores 23 – 30 × 7 – 10 µm ..... *A. palavanum*

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Authors' contributions

GKM carried out all taxonomic studies and drafted the manuscript. AKM provided hand-cut sections and prepared the plate. SN thoroughly reviewed the manuscript and DKU has authenticated the specimens as well as re-

viewed the manuscript.

Compliance with ethical standards

Conflict of interest: Authors do not have any conflict of interests to declare.

Ethical issues: None.

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