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continued on the back inside cover

Cover: Emperor Tamarin *Saguinus imperator*: a look into a better world through the mustache lens – mixed media illustration. © Maya Santhanakrishnan.

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ARTICLE

Addition to the liverwort flora (Marchantiophyta) of Arunachal Pradesh, India

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Abstract: The present study identified 20 liverwort species from Tirap district, Arunachal Pradesh, India, marking the first ever documentation of bryophytes from the region. The specimens were collected from various locations within the study area and subsequently brought to the laboratory. Micromorphological and anatomical characteristics of the specimens were analysed and identified by consulting relevant literatures. Three species, viz. *Plagiochila himalayana* Schiffn., *P. khasiana* Mitt., and *Solenostoma lanigerum* (Mitt.) Váňa & D.G.Long, are newly reported for the first time from the state of Arunachal Pradesh. The species were found to be an integral part of ecosystem growing in association with various plant species, providing soil stability, and shelter for other organisms. The study is important for understanding bryophyte diversity and ecosystem health of the region. In addition, it will also help in planning conservation strategy and sustainable management of bryophytes, their habitat or host species and the overall biodiversity in the region.

Keywords: Bryophytes, conservation, diversity, eastern Himalaya, ecosystem, epiphytic, *Plagiochila himalayana*, *Plagiochila khasiana*, *Solenostoma lanigerum,* Tirap district.

Editor: Anonymity requested.

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Author details: Nonya Chimyang is a research scholar, currently pursuing her Ph.D. Pherkop Mossang is a research scholar, currently enrolled in the Ph.D. programme. Anshul Dhyani is a Ph.D. scholar. Heikham Evelin is an associate professor. Prem Lal Uniyal is a senior professor. Devendra Singh is a scientist. Meghna Paul and Sk Nasim Ali are research scholars.

Authors contribution: NC collected the specimens, prepared herbarium species, and examined detailed morphological and anatomical characters. PM, AD, MP, and SNA studied detailed morphological and anatomical characters. PLU and DS established and confirmed the identity of the species. HE conceptualized the study and guided throughout the entire research process.

Acknowledgements: The authors are thankful to Rajiv Gandhi University, Arunachal Pradesh, University of Delhi, Delhi and Botanical Survey of India, Kolkata for providing research facilities. NC and PM are grateful to the Ministry of Tribal Affairs, Government of India for providing National Fellowship for Tribal Students.

INTRODUCTION

Marchantiophyta is globally represented by about 7,486 species (Söderstorm et al. 2016) of which nearly 854 species have been recorded in India (Singh et al. 2016a; Majumdar & Dey 2021). A few studies reported the presence of liverworts in Arunachal Pradesh. Deo & Singh (2013, 2014, 2016, 2020), Singh & Singh (2016) documented bryophytes from West Siang district, Majumdar et al. (2013), Majumdar & Singh (2015, 2016, 2017) and Singh et al. (2016b) reported bryophytes from Anjaw district. Rawat & Verma (2014) and Rawat et al. (2017) collected bryophytes from Tawang District and Dey et al. (2009) from many areas of Arunachal Pradesh. In total, at present 84 species of liverworts from the state are recorded. However, the Tirap district of the state was bryologically unattended.

Tirap district is a part of the Eastern Himalayas, one of the biodiversity hotspots of the world. It is located in the southernmost part of the state and lies between the latitude 27.018 °N, 95.519 °E (District website of Tirap 2022, accessed on 22 September 2022). The elevation of the district ranges 200–4,000 m in the northwest to the Patkai hills. Tirap is bounded by Changlang district in the east, Assam state in the north, Longding district and Nagaland in the west, and Myanmar in the south (Wangpan et al. 2019). The district has an annual rainfall of 2,754 mm per year and temperature ranges 14–25 ^{0}C (World Data Atlas 2023). The vegetation of Tirap is primarily comprised of tropical and subtropical evergreen forests, with interspersed grasslands and temperate forests in the upper elevations. The temperature in Tirap is moderate to warm with frequent rainfall. The district offers a virgin area for the diverse and luxuriant growth of many plants including bryophytes. The inhabitants of Tirap, revere and offer prayers to nature for their reliance on plants for food, shelter, livelihood, and well–being. Wangpan et al. (2019) and Tangjang et al. (2011) documented flowering plants for various purposes such as food, medicine, and house construction. The district remained unattended for the lower plant groups like bryophytes and pteridophytes which provide the intricate relation with the higher plants. Therefore, the present study was undertaken to survey and document the bryoflora of the region (Figure 1).

MATERIALS AND METHODS

Liverwort samples were collected from the Tirap district, Arunachal Pradesh, India, during May 2021 and 2022. Field data, including habit, habitat, temperature, humidity, and soil types, were recorded for each species. The specimens were initially stored in zip-lock plastic bags, air-dried, and later transferred to paper bags in the laboratory. To aid in identification, the specimens were rehydrated in water until they regained their original shape. Micromorphological and anatomical characteristics were studied using a stereo zoom microscope (Zeiss Stemi 508) and a compound microscope (Zeiss Lab A.1). Identification was based on relevant literature. Voucher specimens were deposited in the Herbarium of Arunachal University (HAU) and the Delhi University Herbarium (DUH), following the classification system by Crandall-Stotler et al. (2009).

RESULTS

Throughout the study, 20 liverwort species from 15 genera and 11 families were documented in the Tirap district of Arunachal Pradesh, representing the initial record of bryophytes in this area (Table 1).

Among the recorded species, three species, viz, *Plagiochila himalayana* Schiffn., *P. khasiana* Mitt., and *Solenostoma lanigerum* (Mitt.) Váňa & D.G.Long., are noteworthy as they are recorded for the first time from Arunachal Pradesh.

A majority of these species were observed in damp, shady locations, thriving on both soil and rocks (e.g. *Solenostoma lanigerum, Notoscyphus darjeelingensis* Udar & Ad. Kumar var. *darjeelingensis, Plagiochila uniformis, P. khasiana*). Few species were epiphytic (*Frullania arecae, Spruceanthus semirepandus*), while some could be found on multiple substrates, including soil, rocks, and the roots and debris of other plants (*Riccardia inconspicua* (Steph.) Reeb & Bardat, *Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn.). The frequently recorded species in the study area are *Dumortiera hirsuta* (Sw.) Nees and *Targionia hypophylla* L., followed by *Ptychanthus striatus* (Lehm. & Lindenb.) Nees, *Riccardia inconspicua* (Steph.) Reeb & Bardatand and *Solenostoma lanigerum* (Mitt.) Váňa & D.G. Long. The species, which were found only in small patches are *Lejeunea tuberculosa* Steph. and *Notoscyphus darjeelingensis* var. *darjeelingensis***.** Image 1–Image 5. The reported species are enumerated here.

ANEURACEAE

Riccardia inconspicua (Steph.) Reeb & Bardat, Cryptog. Bryol. 35(1): 61. 2014.

Habitat: Terrestrial and epilithic, growing on soil and

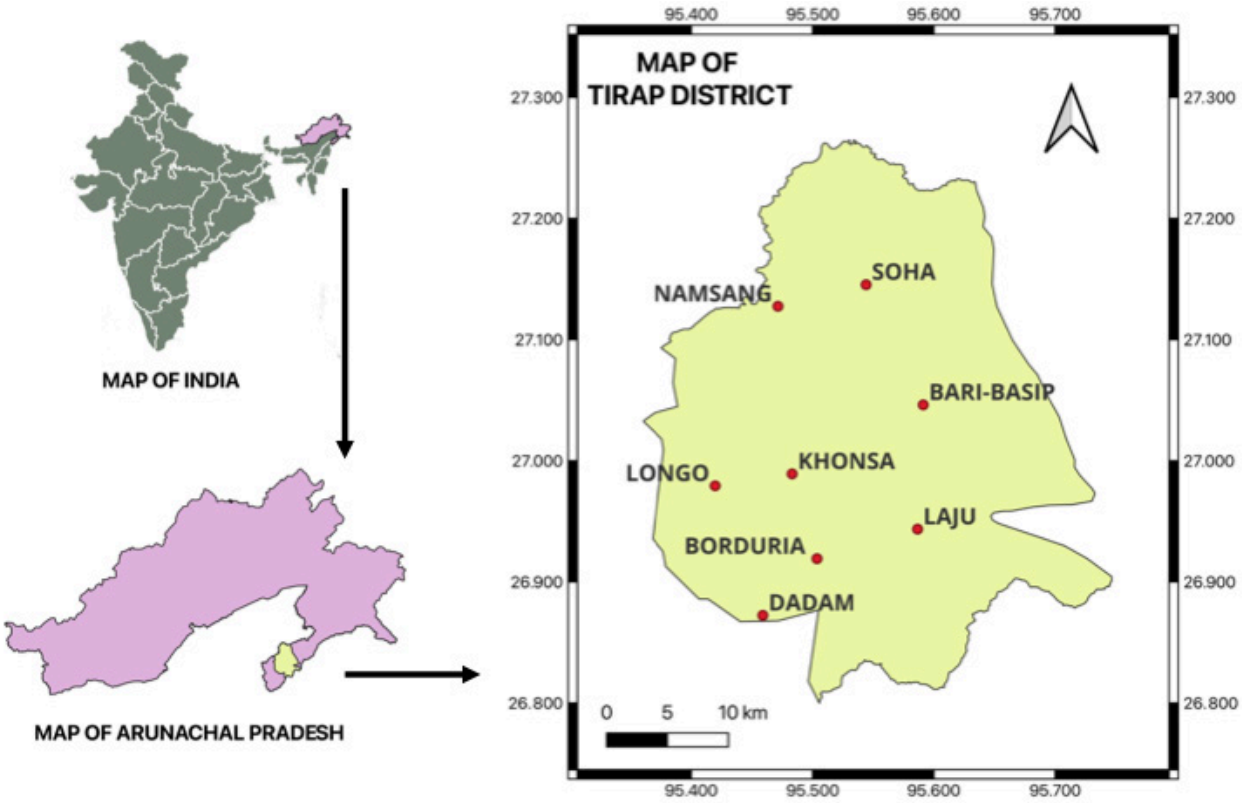

Figure 1. Map of Tirap district, Arunachal Pradesh, India.

rock in association with moss species in moist and shady areas. The species was in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Khonsa Circle. Lapnan–Hydel Road. 26.996 °N; 95.489 °E; elevation 580 m. HAU/AN- 1866; DUH15116.

Distribution: India [Andhra Pradesh, Arunachal Pradesh, Assam, Himachal Pradesh, Kerala, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Indonesia, Malaysia, Nepal, Singapore (Sahu & Asthana 2022; Sahu et al. 2023).

Riccardia multifida (L.) Gray, Nat. Arr. Brit. Pl. 1: 684. 1821.

Habitat: Epixylic, growing on rotten wood. The species was found in the reproductive stage with gynoecium and androecium branches.

Specimen examined: India, Arunachal Pradesh, Tirap District, Namsang Circle. 27.099 °N; 95.472 °E; elevation 265 m. HAU/AN- 1868; DUH15521.

Distribution: India [Andhra Pradesh, Arunachal Pradesh, Assam, Kerala, Maharashtra, Meghalaya, Sikkim - East and West districts, Tamil Nadu, Tripura, Uttarakhand, West Bengal], China, Hawaii, Russia, Sri Lanka, Taiwan, Turkey, Africa, Europe, Micronesia, North America (Singh & Singh 2023).

DUMORTIERACEAE

***Dumortiera hirsuta* (Sw.)** Nees, Nova Acta Phys.-Med. Acad. Caes. Leop. -Carol. Nat. Cur. 12(1): 410. 1825.

Habitat: Terrestrial, growing on soil in moist and shady areas. The species was in the reproductive stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Khonsa Circle. Lapnan Village. 26.988 °N; 95.487 °E; elevation 809 m. HAU/AN- 1939; DUH15128.

Distribution: India [Arunachal Pradesh, Assam, Chhattisgarh, Goa, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Manipur, Meghalaya, Mizoram, Nagaland, Odisha, Tamil Nadu, Uttarakhand, West Bengal], Africa**,** Europe, Hawaii, Japan, Nepal, New Zealand, North America (Singh & Singh 2023).

FRULLANIACEAE

Frullania arecae (Spreng.) Gottsche Mexik. Leverm. 236. 1863 var. ***arecae***

Habitat: Epiphytic, growing on bark of *Saurauia roxburghii* Wall. together with *Ptychostomum capillare* (Hedw.) D.T.Holyoak & N.Pedersen, *Porella caespitans* var. *cordifolia* (Steph.) S.Hatt. ex T.Katag. & T.Yamag, *Spruceanthus semirepandus* (Nees) Verd. The species was found in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.871 °N; 95.457 °E; elevation 1,805 m. HAU/AN- 1940; DUH15513.

Distribution: India [Arunachal Pradesh, Meghalaya, Sikkim - East, West, North and South districts, Tamil Nadu, West Bengal], Bhutan, China, Fiji, Indonesia, Malaysia, Myanmar, Nepal, New Guinea, Pacific Is., Philippines, Sri Lanka, Taiwan, Thailand, Africa, Australia, North America, South America (Majumdar 2017; Singh & Singh 2023).

GEOCALYCACEAE

Notoscyphus darjeelingensis Udar & Ad.Kumar, J. Hattori Bot. Lab. 49: 250.1981. var. ***darjeelingensis***

Habitat: Terrestrial, growing on damp soil. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Dadam–Moktowa road. 26.926 °N; 95.470 °E; elevation 1,097 m. HAU/AN- 1946; DUH15120.

Distribution: India [Arunachal Pradesh, Manipur, Sikkim, Tamil Nadu, West Bengal] (Singh & Singh 2023).

HERBERTACEAE

Herbertus armitianus (Steph.) H.A.Mill., J. Hattori Bot. Lab. 28: 324. 1965.

Habitat: Terrestrial, growing on soil. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.870 °N; 95.456 °E; elevation 1,826 m. HAU/AN- 1941; DUH15520.

Distribution: India [Arunachal Pradesh, Nagaland, Sikkim - East, West, and North districts], Indonesia, Malaysia, Papua New Guinea, Philippines, Thailand, Vietnam (Singh & Singh 2023).

LEJEUNEACEAE

Spruceanthus semirepandus (Nees) Verd., Ann. Bryol., Suppl. 4: 153. 1934.

Habitat: Epiphytic, growing on tree bark of *Saurauia roxburghii* Wall. in association with *Ptychostomum capillare* (Hedw.) D.T.Holyoak & N.Pedersen, *Porella caespitans* var. *cordifolia* (Steph.) S.Hatt. ex T.Katag. & T.Yamag, *Frullania arecae* (Spreng.) Gottsche var. *arecae*. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.871 °N; 95.457 °E; elevation 1,805 m. HAU/AN- 1945; DUH15515.

Distribution: India [Arunachal Pradesh, Kerala, Manipur, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Bhutan, Cambodia, China, Indonesia, Japan, Laos, Malaysia, Myanmar, Nepal, Philippines, Sri Lanka, Taiwan, Thailand (Singh & Singh 2023).

Lejeunea tuberculosa Steph., Sp. Hepat. 5: 790. 1915.

Habitat: Epilithic, growing on rock. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Dadam–Moktowa road. 26.922 °N; 95.456 °E; elevation 1,205 m. HAU/AN- 1944; DUH15119.

Distribution: India [Andaman & Nicobar, Arunachal Pradesh, Assam, Kerala, Maharashtra, Manipur, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Africa, Bhutan, China, Indonesia, Nepal, Philippines, Sri Lanka, Thailand, Vietnam (Singh & Singh 2023).

Ptychanthus striatus (Lehm. & Lindenb.) Nees, Naturgesch. Eur. Leberm. 3: 212. 1838.

Habitat: Epiphytic, growing on branches of *Pouzolzia rugulosa* (Wedd.) Acharya & Kravtsova in association with *Pelekium investe* (Mitt.) Touw, *Pseudotrachypus convolvens* (Mitt.) W.R.Buck, *Meteoriopsis reclinata* (Müll.Hal.) M.Fleisch.

Specimen examined: India, Arunachal Pradesh, Tirap District, Laju Circle. Kolam village. 26.937 °N; 95.576 °E; elevation 1,588 m. HAU/AN- 1859; DUH15123.

Distribution: India [Andaman & Nicobar, Arunachal Pradesh, Assam, Goa, Himachal Pradesh, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Nagaland, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Africa, Australia. Bhutan, China, Fiji, Indonesia, Japan, Laos, Malaysia, Nepal, New Zealand, Papua New Guinea, Philippines, Samoa, Sri Lanka, Taiwan, Thailand, Vietnam (Singh & Singh 2023).

LEPIDOZIACEAE

Bazzania sumbavensis (Gottsche ex Steph.) Steph., Hedwigia 32: 204. 1893.

Habitat: Epilithic, growing on rock. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Namsang Circle. Namsang Village. 27.100 °N; 95.472 °E; elevation 257 m. HAU/AN- 1938; DUH15516.

Distribution: India [Arunachal Pradesh, Assam, Manipur, Meghalaya, Sikkim, West Bengal, Kerala], Bhutan, Java, Indonesia, Nepal, Papua New Guinea, Samoa, Thailand (Singh & Singh 2023).

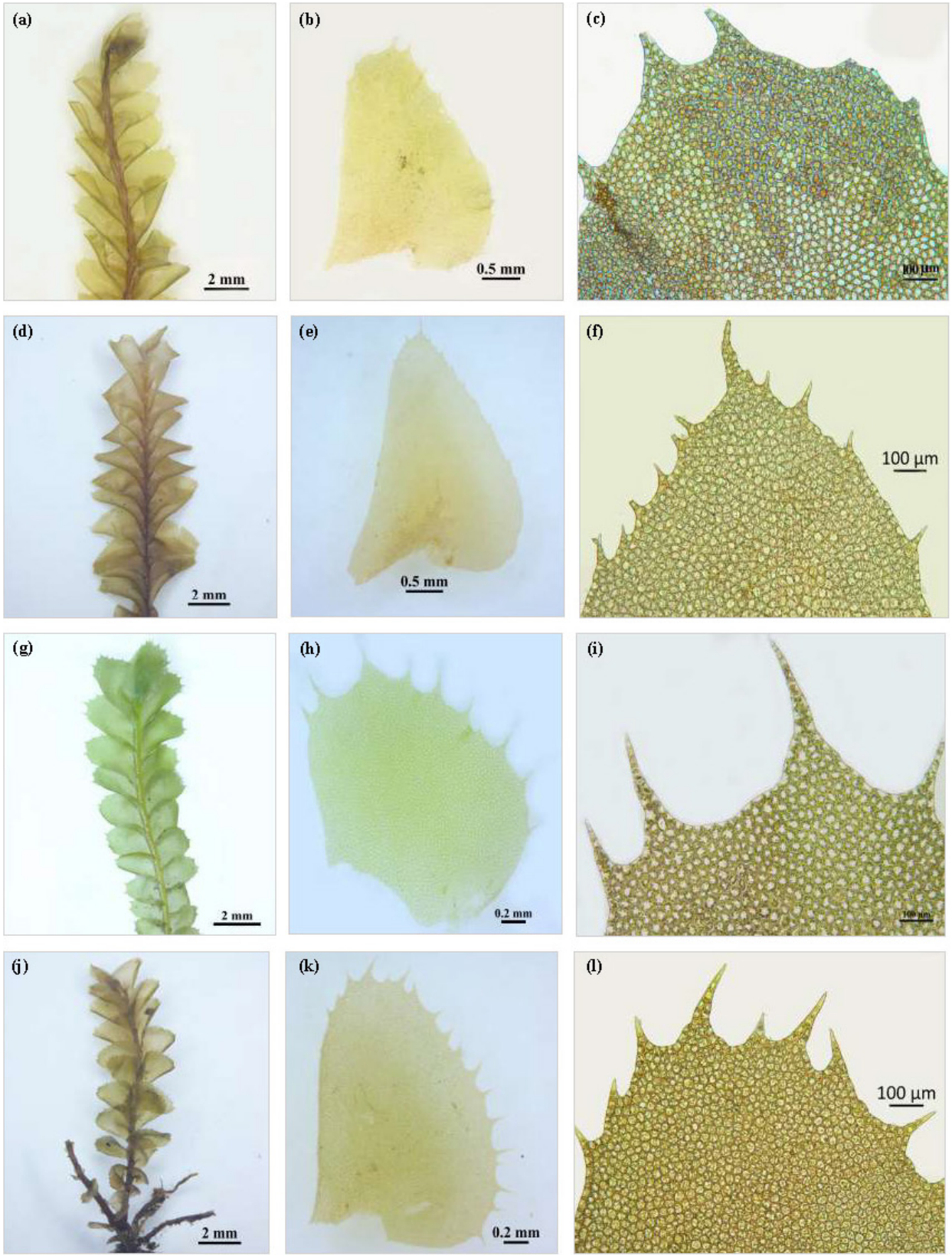

Image 1. Liverwort species collected from Tirap District: a–c—*Plagiochila himalayana* Schiffn.: a—whole plant | b—whole mount of leaf | c—leaf cells | d–f—*Plagiochila khasiana* Mitt..: d—whole plant | e—whole mount of leaf | f—leaf cells | g–i—*Plagiochila sciophila* Nees ex Lindenb.: g—whole plant | h—whole mount of leaf | i—leaf cells | j–l—*Plagiochila uniformis* Mitt.: j—whole plant | k—whole mount of leaf | l—leaf cells. © Nonya Chimyang.

LOPHOCOLEACEAE

Heteroscyphus argutus (Reinw., Blume & Nees) Schiffn., Oesterr. Bot. Z. 60: 172. 1910.

Habitat: Epilithic and Terrestrial. Growing on rock, soil and roots of ferns, and debris of other plants, in association with hornwort sp. and moss spp. at moist and shady area. The species was found in vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Khonsa Circle. Khonsa–Hydel Road. 26.996 °N; 95.489 °E; elevation 580 m. HAU/AN- 1947; DUH15113.

Distribution: India [Andaman & Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Manipur, Meghalaya, Odisha, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Australia, Bhutan, Cambodia, China, Fiji, Hawaii, Indonesia, Japan, Korea, Malaysia, Melanesia, Nepal, New Caledonia, New Zealand, Philippines, Singapore, South America, Sri Lanka, Thailand, Tonga, Vietnam (Singh & Singh 2023).

MARCHANTIACEAE

Marchantia linearis Lehm. & Lindenb., Nov. Stirp. Pug. 4: 8. 1832.

Habitat: Growing on soil and rock.

Specimen examined: India, Arunachal Pradesh, Tirap District, Khonsa Circle. Lapnan village. 26.989 °N; 95.483 °E; elevation 901 m. HAU/AN- 1949; DUH15519.

Distribution: India [Andaman & Nicobar, Andhra Pradesh, Arunachal Pradesh, Assam, Kerala, Madhya Pradesh, Maharashtra, Manipur, Meghalaya, Mizoram, Odisha, Punjab, Rajasthan, Sikkim, Uttar Pradesh, West Bengal], Indonesia, Malaysia, Nepal, Pakistan, Papua New Guinea, West Indies (Singh & Singh 2023).

Marchantia polymorpha L., Sp. Pl. 2: 1137. 1753.

Habitat: Growing on black, hard, rock-like soil together with *Pohlia crudoides* (Sull. & Lesq.) Broth. The species was found in the reproductive stage with male and female thalli bearing matured antheridia and archegonia.

Specimen examined: India, Arunachal Pradesh, Tirap District, Laju Circle. On the way to Pongkong village. 26.893 °N; 95.540 °E; elevation 1,337 m. HAU/AN- 1950; DUH15125.

Distribution: India [Arunachal Pradesh, Assam, Himachal Pradesh, Jammu & Kashmir, Kerala, Ladakh, Madhya Pradesh, Maharashtra, Meghalaya, Nagaland, Odisha, Punjab, Rajasthan, Sikkim - East and North districts, Tamil Nadu, Uttar Pradesh, Uttarakhand, West Bengal], widely distributed throughout the globe (Singh & Singh 2023).

PLAGIOCHILACEAE

Plagiochila himalayana Schiffn., Oesterr. Bot. Z. 49: 131. 1899.

Habitat: Epiphytic, growing on the tree. The species was found in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Dadam Village. 26.904 °N; 95.458 °E; elevation 1,080 m. HAU/AN- 1954; DUH15517.

Distribution: India [Arunachal Pradesh (Present Study), Kerala, Sikkim, West Bengal], Bhutan, China (Singh & Singh 2023).

Plagiochila khasiana Mitt., J. Proc. Linn. Soc., Bot. 5: 95. 1861 [1860].

Habitat: Epilithic, growing on rock. The species was found in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.870 °N; 95.453 °E; elevation 1,765 m. HAU/AN- 1955; DUH15122.

Distribution: India [Arunachal Pradesh (present study), eastern Himalaya, Kerala, Meghalaya, Tamil Nadu, Uttarakhand, West Bengal, western Himalaya], Bhutan, China, Nepal, Sri Lanka, Taiwan, Thailand, Vietnam (Singh & Singh 2023).

Plagiochila sciophila Nees ex Lindenb., Sp. Hepat. (Lindenberg) (fasc. 2–4): 100. 1840.

Habitat: Epilithic, growing on rock. The species was in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Khonsa Circle. Lapnan village. 26.988 °N; 95.487 °E; elevation 809 m. HAU/AN- 1956; DUH15114.

Distribution: India [Andaman & Nicobar, Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Kerala, Manipur, Meghalaya, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], Australia, Bhutan, China, Indonesia, Japan, Korea, Malaysia, Nepal, Pakistan, Papua New Guinea, Philippines, Samoa, Singapore, Sri Lanka, Taiwan, Thailand, Vietnam (Singh & Singh 2023).

Plagiochila uniformis Mitt., J. Proc. Linn. Soc., Bot. 5: 98. 1861 [1860].

Habitat: Epilithic, growing on rock. The species was found in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.870 °N; 95.452 °E; elevation 1,730 m. HAU/AN- 1957; DUH15518.

Distribution: India [Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Manipur, Meghalaya,

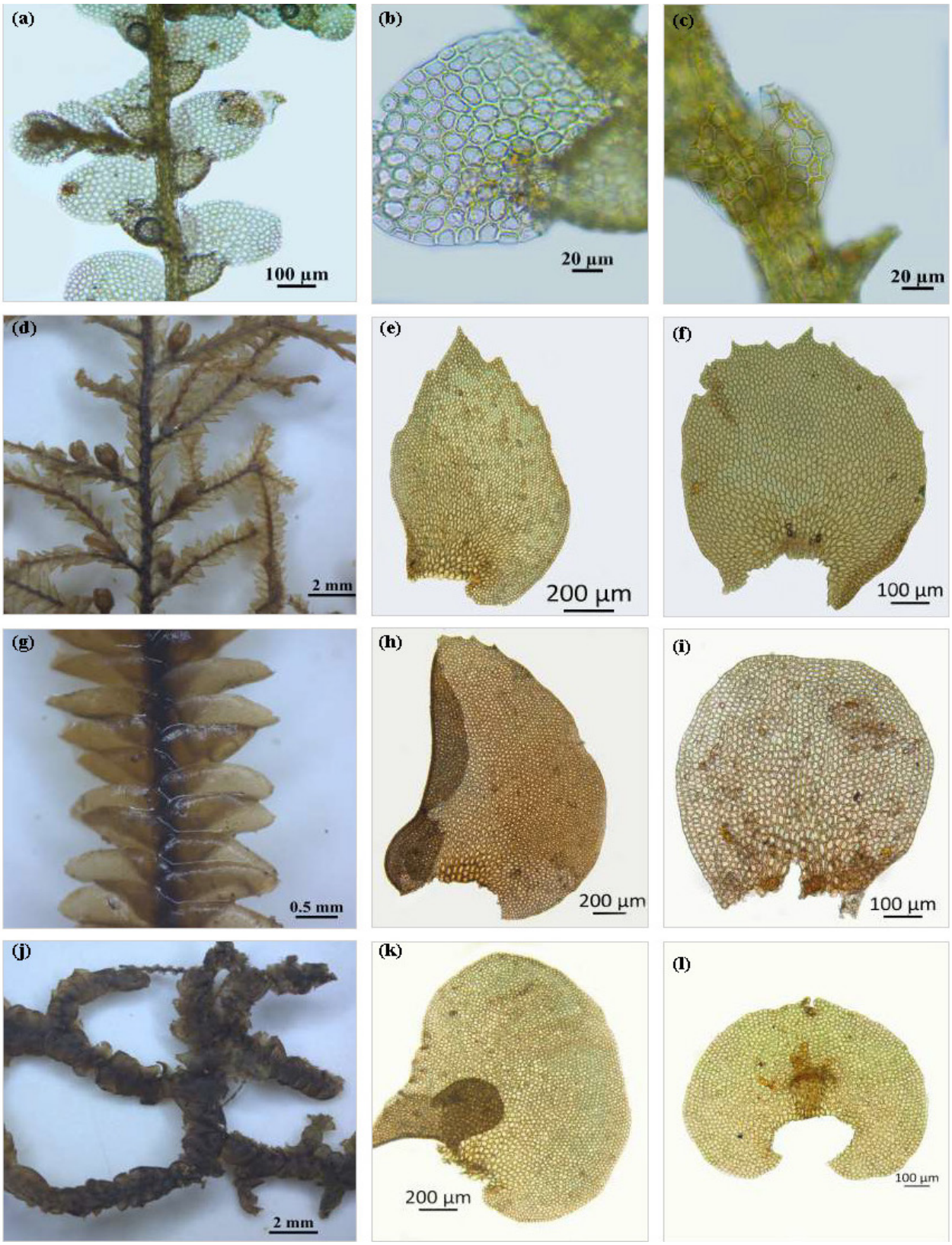

Image 2. Liverwort species collected from Tirap district. *Lejeunea tuberculosa* Steph.: a—Whole plant | b—whole mount of leaf | c—whole mount of underleaf; *Ptychanthus striatus* (Lehm. & Lindenb.) Nees | d—Whole plant | e—whole mount of leaf | f—whole mount of underleaf; *Pruceanthus semirepandus* (Nees) Verd. | g—Whole plant | h—whole mount of leaf | i—whole mount of leaf underleaf; *Frullania arecae* (Spreng.) *Gottsche* var. *arecae* | j—Whole plant | k—whole mount of leaf | l—whole mount of underleaf. © Nonya Chimyang.

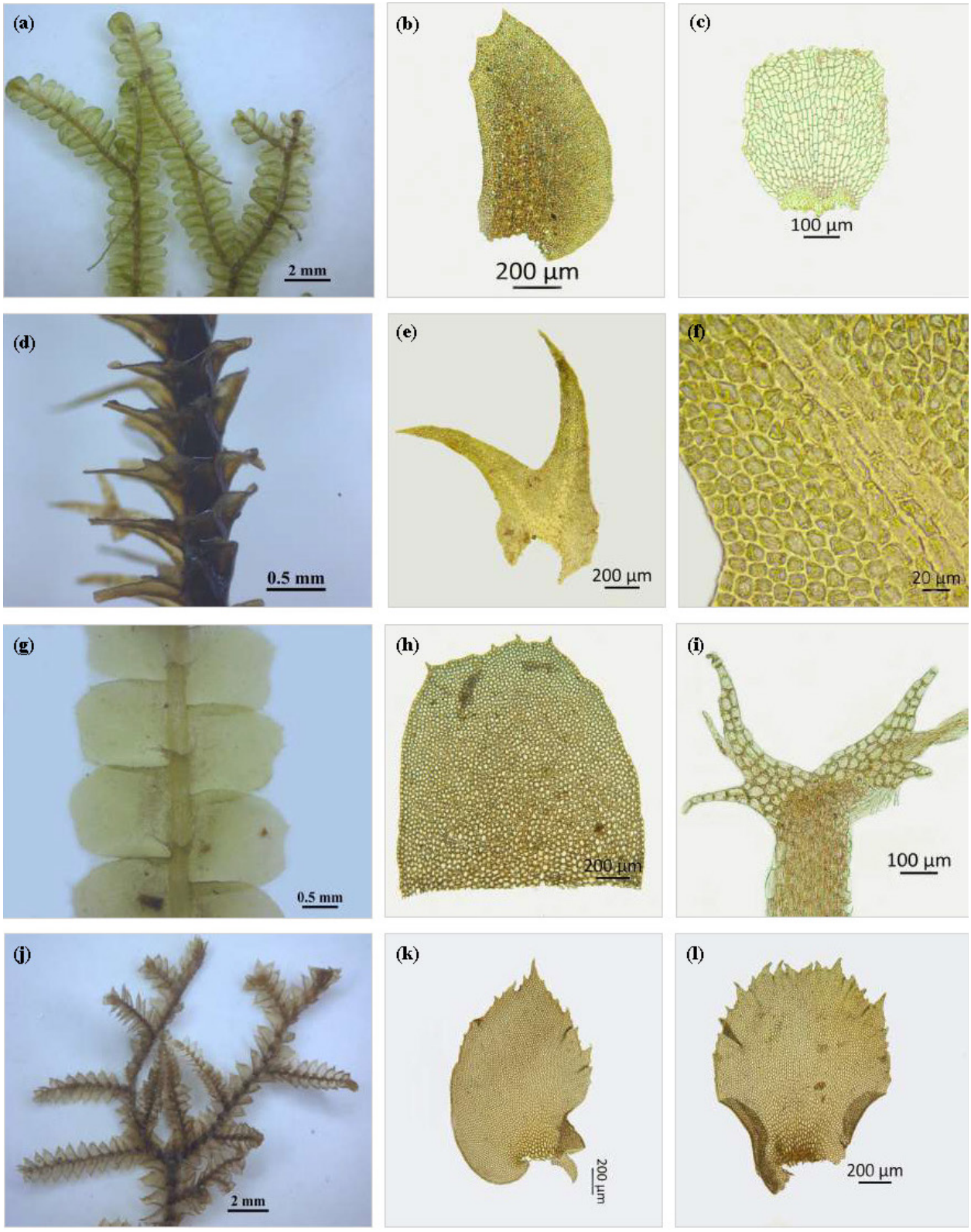

Image 3. Liverwort species collected from Tirap district. *Bazzania sumbavensis* (Gottsche ex Steph.) Steph.: a—Whole plant | b—whole mount of leaf | c—whole mount of underleaf; *Herbertus arminatus* (Steph.) H.A. Mill. | d—Whole plant | e—whole mount of leaf | f—leaf cells; *Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn | g—Whole plant | h—whole mount of leaf | i—whole mount of underleaf; *Porella caespitans* var. *cordifolia* (Steph.) S. Hatt. ex T. Katag. & T. Yamag. | j—Whole plant | k—whole mount of leaf | l—whole mount of underleaf. © Nonya Chimyang.

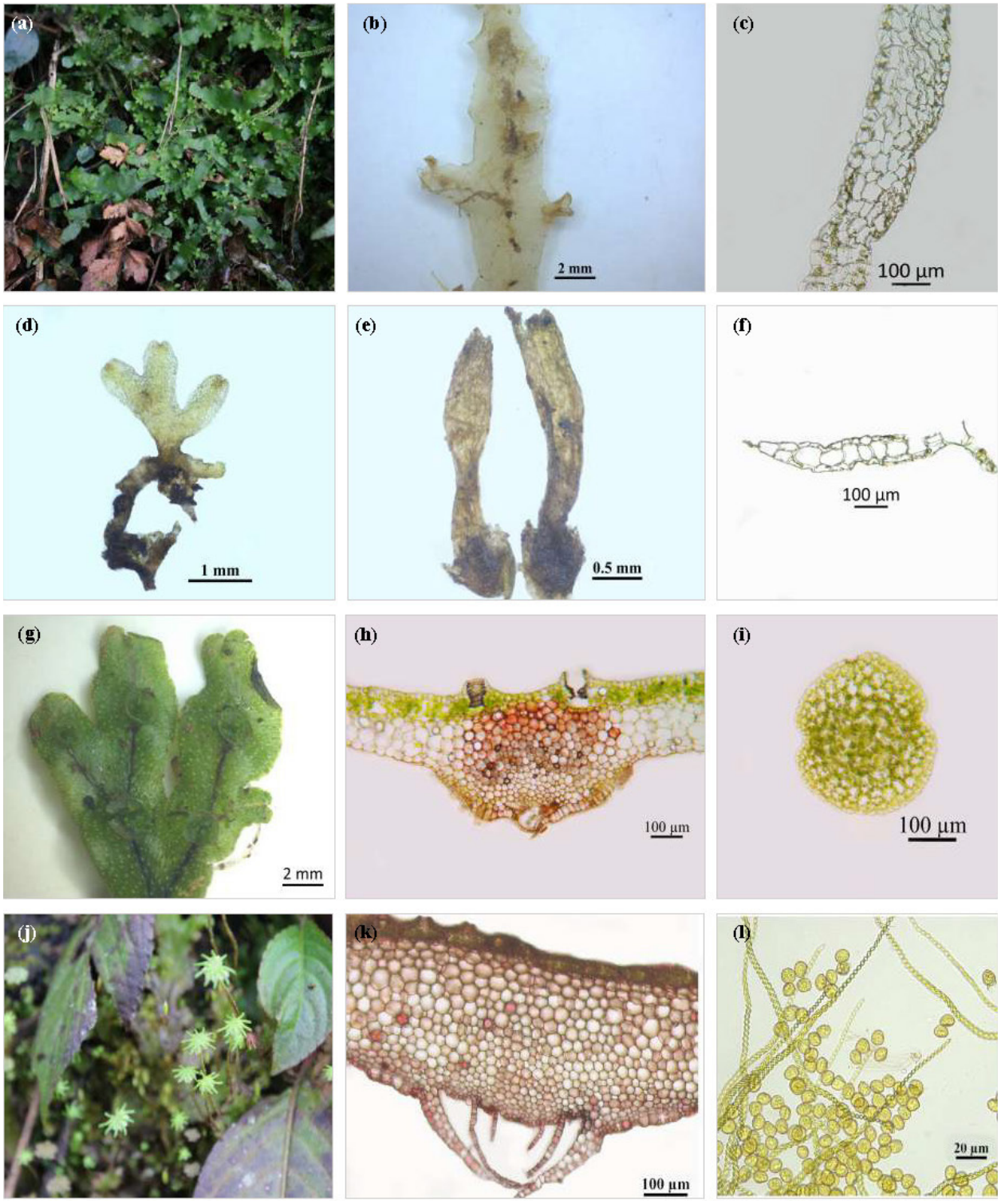

Image 4. Liverwort species collected from Tirap district. *Riccardia inconspicua* (Steph.) Reeb & Bardat: a—Habit | b—whole mount of leaf | c—T.S of thallus; *Riccardia multifida* (L.) Gray | d—Whole plant | e—Archegonia | f—T.S of thallus; *Marchantia linearis* Lehm. & Lindenb. | g—Thallus | h—T.S of thallus | i—Gemma; *Marchantia polymorpha* L. | j—Habit | k—T.S of thallus | l—Spores and Elaters. © Nonya Chimyang.

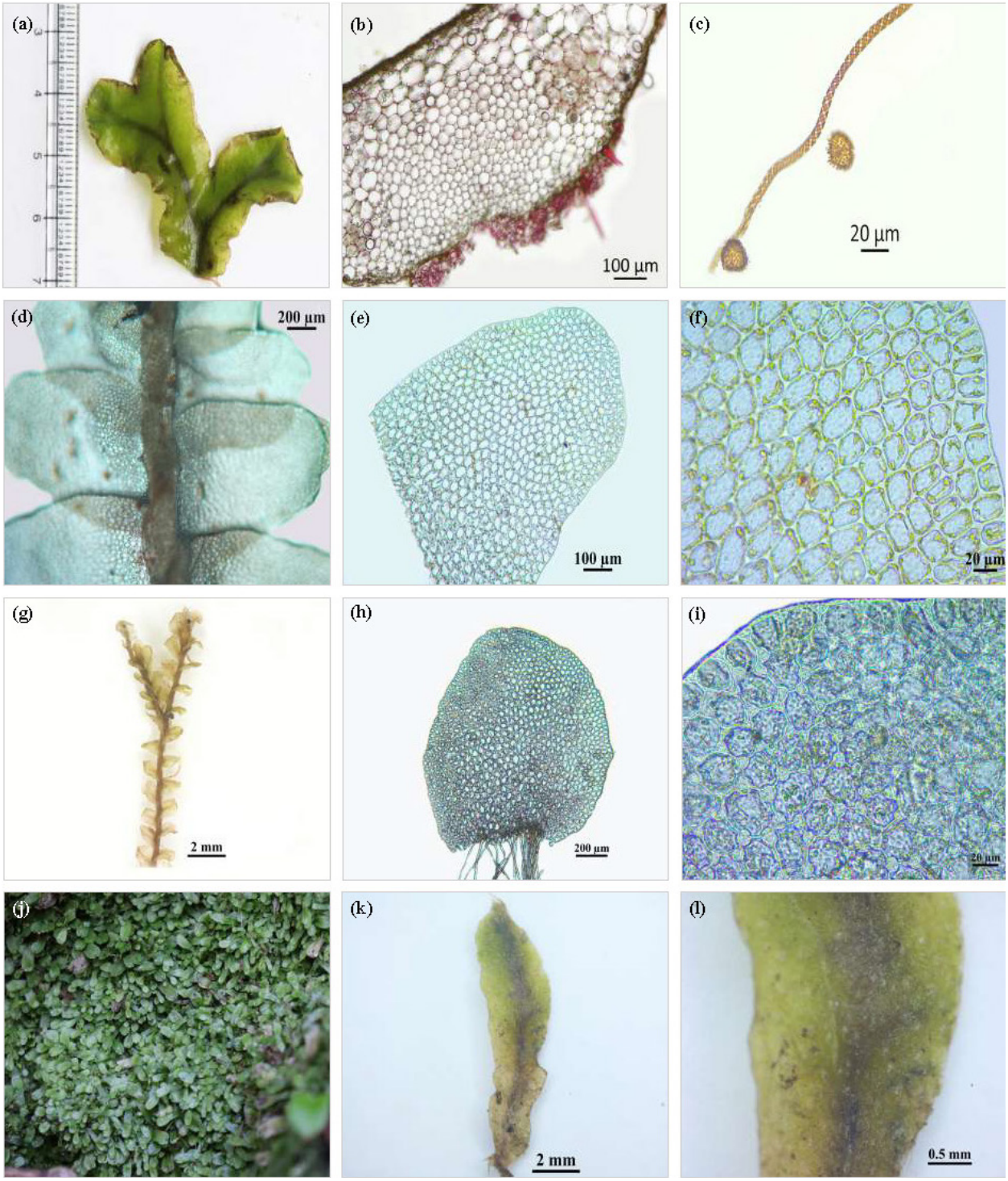

Image 5. Liverwort species collected from Tirap district. *Dumortiera hirsuta* (Sw.) Nees (a) Thallus, (b) T.S of thallus, (c) spores and elater; *Notoscyphus darjeelingensis* Udar & Ad. Kumar var. *darjeelingensis* (d) Whole plant, (e) whole mount of leaf, (f) leaf cells; *Solenostoma lanigerum* (Mitt.) Váňa & D.G. Long (g) Whole plant, (h) whole mount of leaf, (i) leaf cells; *Targionia hypophylla* L. (j) Habit; (k) Thallus; (l) A portion of thallus showing air pores. © Nonya Chimyang.

Table 1. Liverwort species of Tirap District, Arunachal Pradesh, India.

	Species	Family
1	*Riccardia inconspicua* (Steph.) Reeb & Bardat	Aneuraceae
2	*Riccardia multifida* (L.) Gray	Aneuraceae
3	*Dumortiera hirsuta* (Sw.) Nees	Dumortieraceae
4	*Frullania arecae* (Spreng.) Gottsche var. *arecae*	Frullaniaceae
5	*Notoscyphus darjeelingensis* Udar & Ad.Kumar var. *darjeelingensis*	Geocalycaceae
6	*Herbertus armitanus* (Steph.) H.A.Mill.	Herbertaceae
7	*Lejeunea tuberculosa* Steph.	Lejeuneaceae
8	*Ptychanthus striatus* (Lehm. & Lindenb.) Nees	Lejeuneaceae
9	*Spruceanthus semirepandus* (Nees) Verd.	Lejeuneaceae
10	*Bazzania sumbavensis* (Gottsche ex Steph.) Steph.	Lepidoziaceae
11	*Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn.	Lophocoleaceae
12	*Marchantia linearis* Lehm. & Lindenb.	Marchantiaceae
13	*Marchantia polymorpha* L.	Marchantiaceae
14	*Plagiochila himalayana* Schiffn. *	Plagiochilaceae
15	*Plagiochila khasiana* Mitt. *	Plagiochilaceae
16	*Plagiochila sciophila* Nees ex Lindenb.	Plagiochilaceae
17	*Plagiochila uniformis* Mitt.	Plagiochilaceae
18	*Porella caespitans* var. *cordifolia* (Steph.) S.Hatt. ex T.Katag. & Yamag.	Porellaceae
19	*Solenostoma lanigerum* (Mitt.) Váňa & D.G.Long *	Solenostomaceae
20	*Targionia hypophylla* L.	Targioniaceae

Note: The superscript '*' in the names of some bryophytes represents the new records for the state.

Sikkim, Uttarakhand, West Bengal], Bhutan, Myanmar, Nepal, Pakistan, Thailand (Majumdar 2017; Singh & Singh 2023).

PORELLACEAE

Porella caespitans (Steph.) S.Hatt. ex T.Katag. & T.Yamag., Bryol. Res. 10(5): 133. 2011. var. ***cordifolia***

Habitat: Epiphytic, growing on the bark of *Saurauia roxburghii* Wall. together with *Frullania arecae* (Spreng.) Gottsche var. *arecae, Rosulabryum capillare* (Hedw.) J.R. Spence, *Spruceanthus semirepandus* (Nees) Verd. The species was in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Moktowa Village. 26.871 °N; 95.457 °E; elevation 1,805 m. HAU/AN- 1953; DUH15514.

Distribution: India [Arunachal Pradesh, Himachal Pradesh, Jammu & Kashmir, Kerala, Sikkim, Uttarakhand], Bhutan, China, Nepal, Russia, Taiwan (Singh & Singh 2023).

SOLENOSTOMACEAE

Solenostoma lanigerum (Mitt.) Váňa & D.G.Long, Nova Hedwigia 89: 503. 2009.

Habitat: Terrestrial, growing on soil. The species was in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Dadam Circle. Dadam Village. 26.904 °N; 95.458 °E; elevation 1,070 m. HAU/AN- 1960; DUH15132.

Distribution: India [Arunachal Pradesh (present study), Meghalaya, Sikkim, Uttarakhand, West Bengal], China, Nepal, Pakistan (Singh & Singh 2023).

TARGIONIACEAE

Targionia hypophylla L.**,** Sp. Pl. 2: 1136. 1753.

Habitat: Terrestrial and epilithic, growing abundantly on soil and rock. The species was in the vegetative stage.

Specimen examined: India, Arunachal Pradesh, Tirap District, Laju Circle. Kolam Village. 26.938 °N; 95.577 °E; elevation 1,527 m. HAU/AN- 1961; DUH15124.

Distribution: India [Andhra Pradesh, Arunachal Pradesh, Gujarat, Himachal Pradesh, Jammu & Kashmir, Karnataka, Kerala, Madhya Pradesh, Maharashtra, Meghalaya, Odisha, Rajasthan, Sikkim, Tamil Nadu, Uttarakhand, West Bengal], widely distributed throughout the globe (Singh & Singh 2023).

DISCUSSION

The study area represents a diverse species of liverworts, owing to its mild temperature, high humidity, and frequent rainfall. *Dumortiera hirsuta* and *Targionia hypophylla* were the most frequently recorded species in the area, while *Lejeunea tuberculosa* and *Notoscyphus darjeelingensis* var. *darjeelingensis* were found only in small patches. The species were found inhabiting different habitats, for example, in damp shady locations, thriving on various substrates such as soil, rocks plant debris, etc. The prevalence of species in various habitats highlights the adaptability and resilience of liverworts in diverse environmental conditions. The observation of epiphytic species and those found on multiple substrates further emphasizes the ecological versatility of liverworts in colonizing different microhabitats. The frequently recorded species indicate their ecological importance and potential role in the local ecosystem. In addition, the species found in small patches signal the necessity to take conservation actions in order to safeguard them from the risk of extinction.

Many of the presently collected bryophyte samples were found growing exclusively on certain

tree species. These host trees must be considered in conservation efforts as they serve as essential habitats for various species. Bryophytes enhance water-holding capacity, nutrient status, and soil particle aggregation. Consequently, other plant species associated with bryophytes may also benefit from them. Additionally, Tirap's hilly terrain makes it highly susceptible to landslides. The widespread practice of Jhum cultivation in the area leads to deforestation, destroying natural habitats, and increasing soil erosion. Bryophytes, with their ability to naturally cover and restore disturbed habitats, can potentially play a crucial role in mitigating these environmental challenges in the region.

Therefore, this study contributes to the scientific understanding of liverwort diversity as well as the ecological importance of these understudied bryophytes in maintaining the balance and resilience of the region's ecosystem. Continued research and conservation efforts are crucial to further unravel the intricate relationships between liverworts and their environment, ensuring the preservation of this unique botanical heritage in the eastern Himalaya.

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