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Bryophytes of Suspa-Kshamawoti, Dolakha District, Central Nepal

Sangram Karki* and Suresh Kumar Ghimire
Central Department of Botany, Tribhuvan University, Kirtipur, Kathmandu, Nepal
Email: karki.sangram99@gmail.com

Abstract

The study was conducted to document the bryophytes of Suspa-Kshamawoti, Dolakha. Forty-three bryophyte species representing 31 genera and 27 families were recorded through repeated field surveys. Most of the species belong to the class Musci (26 species), followed by Hepaticae (15 species) and Anthocerotae (2 species).

Keywords: *Anthocerotae, Hepaticae, Hornworts, Liverworts, Moses, Musci*

Introduction

Bryophytes are the simplest and most primitive non-vascular land plants with a haplo-diplobiphasic life cycle and dominant gametophytic phase (Patiño & Vanderpoorten, 2018).The variation in life form and their ability to grown in diverse habitats such as damp soil, water, rock, fallen rotten woods, tree trunks favors the distribution of this group from the tropics to the polar region of the world (Andrew et al., 2003). On the basis of habitats they were grouped into different categories: corticolous, saxicolous, folicolous, lignicolous, terricolous and rupicolous (Daniels & Kariyappa, 2007). They prefer high humidity and precipitation and are also the pioneer group in plant succession (Murru et al., 2018). In the evolutionary history, bryophytes links vascular plants to their algal ancestor and mark themselves transition to the land (Kenrick & Crane, 1997). They are categorized into three classes: Hepaticae (Liverworts), Anthocerotae (Hornworts) and Musci (Mosses), based on their vegetative and reproductive structures (Smith, 1996).

Bryophytes contribute substantially to the global plant diversity and include about 20,000 species worldwide (Patiño & Vanderpoorten, 2018). Nepal represents 1215 species hitherto (Pradhan, 2018). The number of species may increase because many areas of Nepal are yet to be explored. Bryophytes are important group of land plants even with their small size. Liverworts and hornworts cover the soil and form the mats that check soil erosion by preventing the direct impact of rain water. Mosses in tropical and sub-tropical forest through accumulation of moisture, provides suitable substratum for the colonization of epiphytes, contributing to species richness. They also provide habitat, water and nesting materials for invertebrates and birds (Alvarenga et al., 2010). Although with great diversity and ecological value, bryophytes have been receiving much less attention than vascular plants in documentation and conservation in Nepal. As bryophytes are very sensitive to disturbances, activities like deforestation and habitat destruction are pushing many species towards extinction without documentation.

Studies on bryophytes from different parts of Nepal have been carried out by various researchers. The first man to collect bryophytes of Nepal was Fransis Buchaanan Hamilton (1802-1803), a British botanist who collected bryophytes from Kathmandu valley and its vicinity. Some remarkable studies on bryophytes of Nepal was done by Wallich, 1832; Mitten, 1861; Long, 1993, 2005; Pradhan, 2000a, b; Kattel, 2002; Pradhan & Joshi, 2007a, b; Pradhan, 2013; and Pradhan, 2018. Bryophyte flora of Suspa-Kshamawoti has not been explored till date. Thus, current study is aimed to record the bryophytes of the Suspa-Kshamawoti, Dolakha. The result of this study partly may support to the documentation of bryoflora of Nepal.

Materials and Methods

Study area

The study area Suspa-Kshamawoti, is located at its geographical position of 27°41'58.82'' N and 86°02'58.48'' E. It lies at the north-eastern part of Dolakha district, Central Nepal (Figure 1) and

characterized by sub-tropical to lower temperate climate. The nearest meteorological station at Charikot shows temperature varies from 10°C to 17°C in summer and (-3°C) to 7°C in winter. The area receives heavy precipitation during monsoon, making for rich bryoflora. The vegetation is sub-tropical *Schima-Castanopsis* forest, *Alnus* forest and lower temperate mixed Oak-Laurel forest. *Alnus* forest is discontinuous and patchy, usually restricted to unstable areas.

The field study was carried out in August-October of 2016-2018 by the first author. Three sites were targeted mainly at areas thought to be bryophyte-rich for the documentation. They were Damarang, Fedi and Pahare. The sites were selected by discussions with local people (we made some criteria for e.g. areas with streams, moist and shady places and mature forest type). These three sites differ in altitude, forest types and microclimatic conditions. Damarang lies at altitude between 1520-1600 m, consists of north facing slope and dominated by tree species like *Alnus nepalensis* and *Engelhardia spicata*. Fedi lies at altitude between 1632-1800 m and mostly dominated by *Alnus nepalensis* and *Schima wallichii* forest and with cool and humid climate. Pahare situated between 1892-2500 m altitudes, is mainly dominated by *Quercus* and *Daphniphyllum* forest.

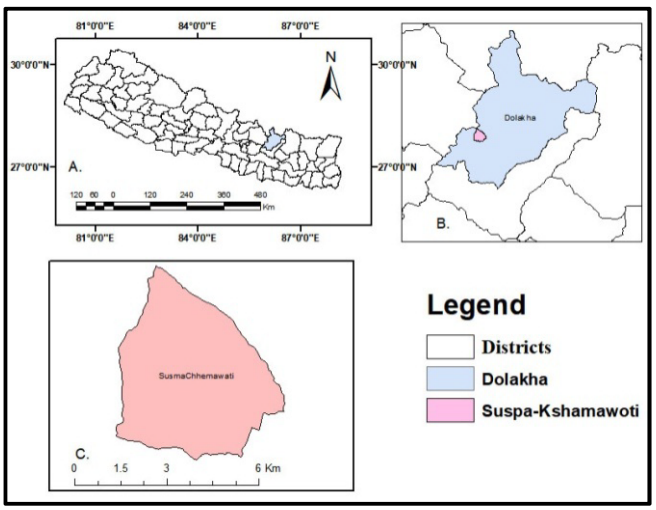

Figure 1: Location of study area in Nepal

Plant collection and identification

A simple knife was used to peel out specimens from the substratum or ground. The bryophytes seen in different habitats were photographed and collected. Bryophytes with sporophyte were taken for the herbarium preparation. The specimens were cleaned using brushes and placed in paper packets which were air-dried. Some common bryophytes were identified in the field using magnifying (5X-20X) hand lens. Field notes of samples were collected, including habit and habitat, collection date, locality, altitude, and taxonomic character. The unidentified specimens were taken to the Natural History Museum, Kathmandu for the identification. All the specimens were identified consulting literatures like Pradhan and Joshi (2007b); Pradhan and Joshi (2009); Pradhan (2013); Gangulee (1969-1980); Kashyap (1972) and experts' help. Stereo and light microscopes aid in identification of specimens. The nomenclatures of plants and author citation followed TROPICOS. All the identified specimens were mounted and labeled with field notes and deposited at Tribhuvan University Central Herbarium (TUCH).

Results and Discussion

This study enumerated 43 bryophyte species from Suspa-Kshamawoti, Dolakha representing 31 genera and 27 families (Appendix I). Class Musci shows high number of species (26 species) followed by Hepaticae (15 species) and Anthocerotae (2 species) (Figure 2). Bryaceae was largest family representing six species, followed by Aytoniaceae with five species. Families like Sphagnaceae, Pottiaceae, Ricciaceae were represented by single species each (Figure 3). Few species of liverworts and hornworts such as, *Marchantia polymorpha, M. emarginata*, *Asterella multiflora*, *Cyathodium tuberosum, Dumortiera hirsuta, Anthoceros erectus*; mosses-*Bryum argenteum*, *Macromitrium nepalense*, *Pogonatum aloides*, were frequently encountered in the field. The species like *Riccia fluitans*, *Lunularia cruciata* and *Anomobryum auratum* were occasionally encountered. The photographs of some recorded liverworts are shown in Photo 1, and mosses in Photo 2.

Among the genera, *Asterella*, *Bryum* and *Mnium* were the largest representing 3 species each, followed by *Fissidens, Plagiochasma* and *Marchantia* with 2 species each (Appendix I). Genera with single species were represented by *Anthoceros*, *Phaeoceros*, *Heteroscyphus*, *Conocephalum*, *Lunularia*, *Riccia*, *Cythodium*, *Targionia* etc. (Appendix I). According to the number of species, family Aytoniaceae was the

largest among liverworts and Bryaceae was the largest among mosses.

The number of species varied significantly with different sites studied. Large numbers of species were recorded from Fedi site (1632-1800) and least from Pahare site (1520-1600) (Appendix I). The most abundant species of Fedi site were *Atrichium obtusulum*, *Fissidens crispulus*, *Cyathodium tuberosum*, *Macromitrium nepalense*, *Mnium rostratum, Marchantia emarginata* and rare species were *Riccardia cardotii*, *Riccia fluitans* and *Phaeoceros laevis.* Similarly, abundant species of Damarang site were *Anthoceros erectus*, *Bryum argenteum*, *Dumortia hirsuta*, *Marchantia emarginata*, *Pogonatum microstomum* and *Funaria hygrometrica,* and rare species were *Lunularia cruciata*, and *Anomobryum auratum*. The common species in both sites (Damarang and Fedi) were *Anthoceros erectus*, *Funaria hygrometrica, Marchantia emarginata* and *Heteroscyphus argutus*. The abundant species of Pahare site were *Marchantia polymorpha*, *Pogonatum aloides*, *Bryum uliginosum* and *Philonotis thwaitesii.*

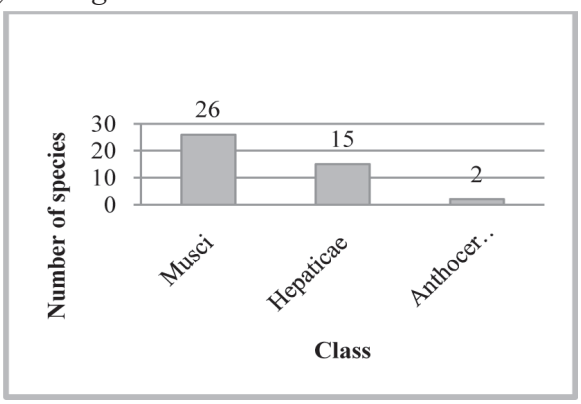

Figure 2: Number of species in three different classes

The Fedi site (1632-1800 m), lies on the streamside and provide a more humid, congenial environment for many species of bryophytes. There was more exposure of rocks near the streams, provided that more habitat niches, that supported the growth of many saxicolous and terricolous species e.g. *Anthoceros erectus*, *Fissidens* spp., *Mnium* spp., *Heteroscyphus argutus, Plagiothecium neckeroideum, Targionia hypophylla* etc. Damarang site (1520-1600 m) also mostly represented by both saxicolous and terricolous species e.g. *Anthoceros erectus*, *Heteroscyphus argutus*. However, Pahare site (above 1900 m) was mostly represented by epiphytic species and few saxicolous species, which was correlated with drier area, more disturbances like trampling and grazing. The drier forests are not very diverse and show very poor representation of bryophytes on the ground (Hodgetts et al., 2016). This region showed some epiphytic species like *Brothera* sp., *Rhodobryum giganteum* and *Bryum uliginosum.* On the moist habitat near streams, few saxicolous species like *Asterella wallichiana* and *Marchantia polymorpha* were recorded. This result indicates that distribution of bryophytes is correlated with forest types and microclimatic conditions like amount of humidity, temperature and moisture (Evans et al., 2012; Sun et al., 2013). Also it showed middle altitudes (1520-1800 m) were mostly preferred by bryophytes, supporting the result analyzed by Pradhan, (2013) in Panch Pokhari of Sindhupalchok district. Overall, the bryophyte flora of Suspa-Kshamawoti is still incompletely known. There are some areas yet to be explored, mainly at higher elevations.

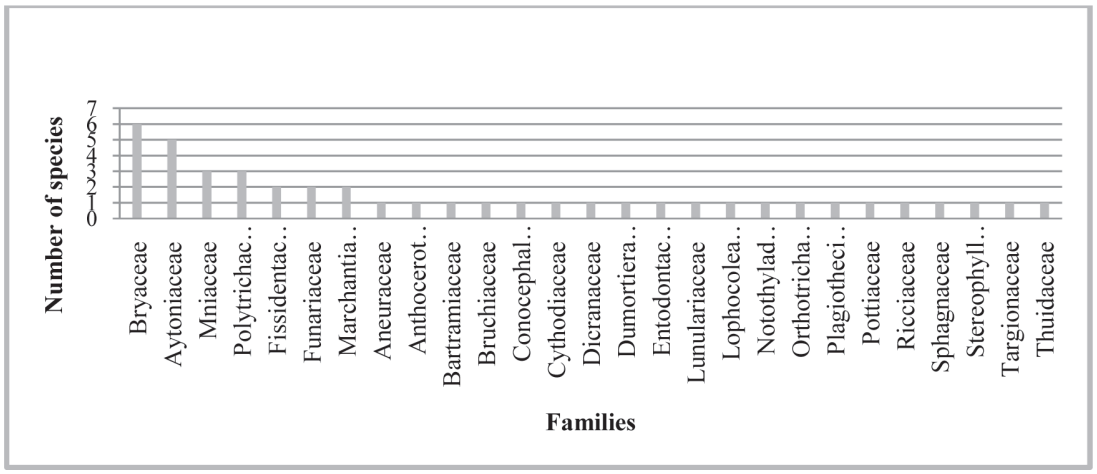

Figure 3: Number of species in different families

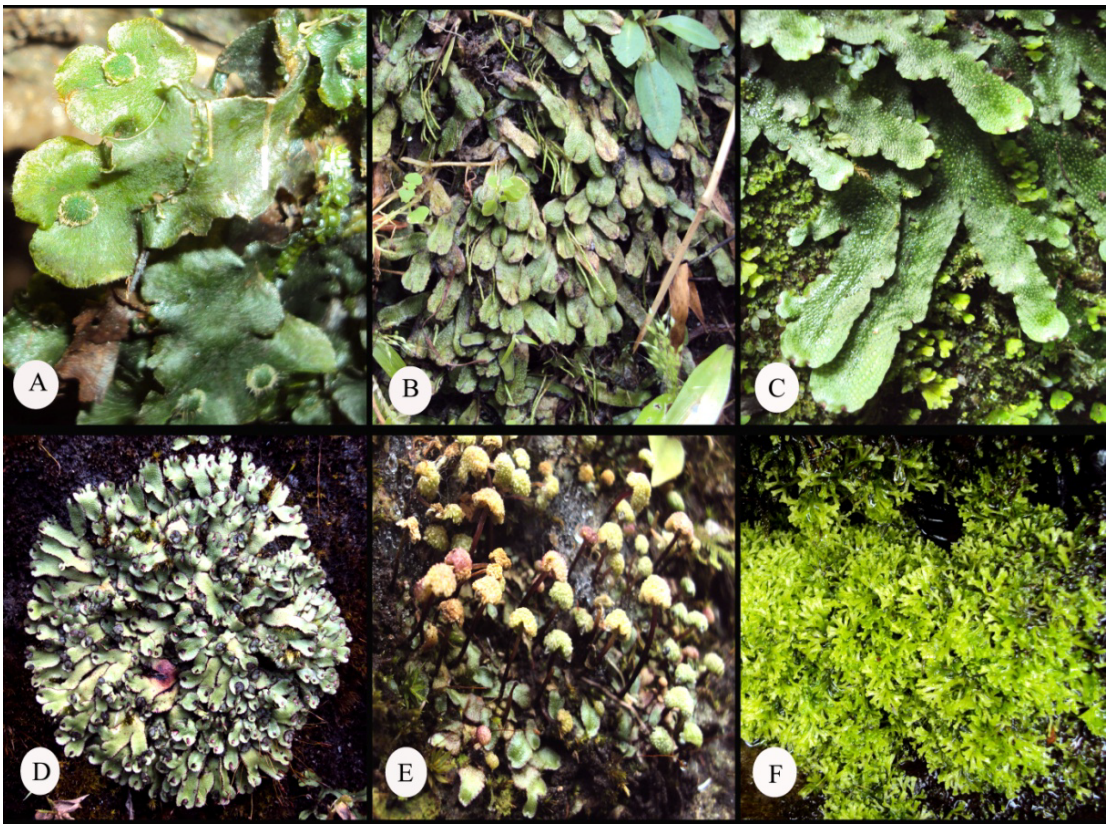

Photo 1: Liverworts A. *Dumortiera hirsute* B. *Targionia hypophylla* C.*Conocephalum conicum* D. *Plagiochasma pterospermum* E. *Asterella wallichiana* F. *Riccia fluitans*

Photo 2: A. *Anomobryum auratum* B. *Atrichium obtusulum* C. *Philonotis thwaitesii* D. *Trematodon longicollis* E. *Macromitrium nepalense* F. *Entodon rubicundus* G. *Bryum argenteum* H. *Sphagnum cuspidatum* I. *Fissidens crispulus*

Appendix I. Species list

All the species of bryophytes recorded from Suspa-Kshamawoti during survey is enumerated below with names of class alphabetically and, again, family and species under each class alphabetically. Each species is provided with their locality of collection, altitude, collection number and date, habit and habitat and local status.

CLASS: I ANTHOCEROTAE

Anthocerotaceae:

1. ***Anthoceros erectus* Steph.**
   C. Nepal, Dolakha, Fedi, 1765 m, 10/3/2016, S. Karki D1 (TUCH)
   Terricolous (on soil); locally Abundant

Notothyladaceae

2. ***Phaeoceros laevis* (L.) Prosk.**
   C. Nepal, Dolakha, Fedi, 1672 m, 10/3/2016, S. Karki D2 (TUCH)
   Terricolous and Saxicolous (on rocks); locally Rare

CLASS: II HEPATICAE

Aneuraceae:

3. ***Riccardia cardotii* (Steph.) S.C. Srivast. & Udar**
   C. Nepal, Dolakha, Fedi, 1723m, 10/6/2016, S. Karki D17 (TUCH)
   Saxicolous, locally Rare

Aytoniaceae:

4. ***Asterella khasyana* (Griff.) Grolle**
   C. Nepal, Dolakha, Damarang, 1520 m, 10/3/2016, S. Karki D4 (TUCH)
   Terricolous and Saxicolous; locally Rare
5. ***Asterella multiflora* (Steph.) Pandé, K.P. Srivast. & Sultan Khan**
   C. Nepal, Dolakha, Fedi, 1630 m, 8/17/2017, S. Karki D5 (TUCH)
   Terricolous and Saxicolous; locally Abundant
6. ***Asterella wallichiana* (Lehm. & Lindenb.) Grolle**
   C. Nepal, Dolakha, Pahare, 1910 m, 10/3/2016, S. Karki D6 (TUCH)
   Terricolous; locally Abundant
7. ***Plagiochasma pterospermum* C. Massal.**
   C. Nepal, Dolakha, Damarang, 1522 m, 10/10/2016, S. Karki D7 (TUCH)
   Terricolous and Saxicolous; locally Abundant
8. ***Plagiochasma appendiculatum* Lehm. & Lindb**
   C. Nepal, Dolakha, Damarang, 1562 m, 10/4/2017, S. Karki D8 (TUCH)
   Terricolous and Saxicolous; locally Abundant

Conocephalaceae:

9. ***Conocephalum conicum* (L.) Dumort.**
   C. Nepal, Dolakha, Fedi, 1723 m, 10/4/2017, S. Karki D9 (TUCH)
   Terricolous and Saxicolous; locally Abundant

Cythodiaceae:

10. ***Cyathodium tuberosum* Kashyap**
    C. Nepal, Dolakha, Fedi, 1755 m, 10/6/2016, S. Karki D14 (TUCH)
    Terricolous and Saxicolous; locally Abundant

Dumortieraceae:

11. ***Dumortiera hirsuta* (Sw.) Nees**
    C. Nepal, Dolakha, Fedi, 1620 m, 10/6/2018, S. Karki D16 (TUCH)
    Terricolous and Saxicolous; locally Abundant

Lophocoleaceae:

12. ***Heteroscyphus argutus* (Reinw., Blume & Nees) Schiffn.**
    C. Nepal, Dolakha, Damarang, 1500 m, 10/10/2016, S. Karki D3 (TUCH)
    Terricolous and Saxicolous; locally Abundant

Lunulariaceae:

13. ***Lunularia cruciata* (L.) Dumort. ex Lindb.**
    C. Nepal, Dolakha, Damarang, 1560 m, 10/10/2016, S. Karki D10 (TUCH)
    Saxicolous; locally Rare

Marchantiaceae:

14. ***Marchantia emarginata* Reinw., Blume & Nees**
    C. Nepal, Dolakha, Fedi, 1643 m, 8/31/2017, S. Karki D11 (TUCH)
    Saxicolous; locally Abundant
15. ***Marchantia polymorpha* L.**
    C. Nepal, Dolakha, Fedi, 1833 m, 8/30/2017, S. Karki D12 (TUCH)
    Saxicolous; locally Abundant

Ricciaceae:

16. ***Riccia fluitans* L.**
    C. Nepal, Dolakha, Fedi, 1730 m, 10/4/2016, S. Karki D13 (TUCH)
    Aquatic; locally Rare

Targionaceae:

17. ***Targionia hypophylla* L.**
    C. Nepal, Dolakha, Pahare, 2262 m, 10/3/2018, S. Karki D15 (TUCH)
    Saxicolous, locally Abundant

CLASS: III MUSCI

Bartramiaceae:

18. ***Philonotis thwaitesii* Mitt.**
    C. Nepal, Dolakha, Pahare, 1820 m, 10/10/2016, S. Karki D20 (TUCH)
    Epiphyte and Saxicolous; locally Abundant

Bruchiaceae:

19. ***Trematodon longicollis* Michx.**
    C. Nepal, Dolakha, Fedi, 1726 m, 10/4/2016, S. Karki D19 (TUCH)
    Terricolous and Saxicolous; locally Abundant

Bryaceae:

20. ***Anomobryum auratum* (Mitt.)A.Jaeger**
    C. Nepal, Dolakha, Damarang, 1532 m, 10/10/2016, S. Karki D21 (TUCH)
    Terricolous and Saxicolous; locally Rare
21. ***Bryum argenteum* Hedw.**
    C. Nepal, Dolakha, Damarang, 1522 m, 10/12/2017, S. Karki D22 (TUCH)
    Epiphyte and Saxicolous, locally Abundant
22. ***Bryum uliginosum* (Brid.) Bruch & Schimp.**
    C. Nepal, Dolakha, Pahare, 2123 m, 10/12/2017, S. Karki D23 (TUCH)
    Epiphyte; locally Abundant
23. ***Bryum coronatum* Schwägr.**
    C. Nepal, Dolakha, Fedi, 1600 m, 8/10/2016, S. Karki D24 (TUCH)
    Epiphyte and Saxicolous; locally Abundant
24. ***Pohlia* sp.**
    C. Nepal, Dolakha, Fedi, 1736 m, 10/10/2016, S. Karki D25 (TUCH)
    Epiphyte; locally Abundant
25. ***Rhodobryum giganteum* (Schwägr.) Paris**
    C. Nepal, Dolakha, Pahare, 2400 m, S. Karki D26 (TUCH)
    Epiphyte; locally Abundant

Dicranaceae:

26. ***Brothera* sp.**
    C. Nepal, Dolakha, Pahare, 2500 m, 10/12/2017, S. Karki D18 (TUCH)
    Epiphyte; locally Abundant

Entodontaceae:

27. ***Entodon rubicundus* (Mitt.) A. Jaeger**
    C. Nepal, Dolakha, Fedi, 1650 m, 10/3/2016, S. Karki D34 (TUCH)
    Epiphyte and Saxicolous; locally Abundant

Fissidentaceae:

28. ***Fissidens* sp.**
    C. Nepal, Dolakha, Fedi, 1670 m, 10/3/2016, S. Karki D30 (TUCH)
    Saxicolous; locally Abundant
29. ***Fissidens crispulus* Brid.**
    C. Nepal, Dolakha, Fedi, 1640 m, 10/3/2016, S. Karki D31 (TUCH)
    Saxicolous; locally Abundant

Funariaceae:

30. ***Entosthodon wallichii* Mitt.**
    C. Nepal, Dolakha, Fedi, 1650 m, 10/6/2016, S. Karki D32 (TUCH)
    Terricolous; locally Abundant
31. ***Funaria hygrometrica* Hedw**.
    C. Nepal, Dolakha, Fedi, 1800 m, 10/17/2018, S. Karki D33 (TUCH)
    Terricolous; locally Abundant

Mniaceae:

32. ***Mnium integrifolium* Brid.**
    C. Nepal, Dolakha, Fedi, 1700 m, 10/15/2016, S. Karki D27 (TUCH)
    Epiphyllous (on leaves) and Saxicolous; locally Abundant
33. ***Mnium rostratum* Schrad.**
    C. Nepal, Dolakha, Fedi, 1640 m, 10/3/2016, S. Karki D28 (TUCH)
    Epiphyllous and Saxicolous; locally Abundant
34. ***Mnium succulentum* Mitt.**
    C. Nepal, Dolakha, Fedi, 1630 m, 10/3/2016, S. Karki D29 (TUCH)
    Epiphyllous and Saxicolous; locally Abundant

Orthotrichaceae:

35. ***Macromitrium nepalense* (Hook. & Grev.) Schwagr.**
    C. Nepal, Dolakha, Fedi, 1740 m, 10/5/2016, S. Karki D38 (TUCH)
    Epiphyte; locally Abundant

Plagiotheciaceae:

36. ***Plagiothecium neckeroideum* Schimp.**
    C. Nepal, Dolakha, Pahare, 1920 m, 10/10/

2017, S. Karki D35 (TUCH)
Epiphyte and Saxicolous; locally Abundant

Polytrichaceae:

37. ***Pogonatum aloides* (Hedw.) P.Beauv**
C. Nepal, Dolakha, Above Pahare, 2350 m, 10/15/2017, S. Karki D39 (TUCH)
Epiphyte and Terricolous; locally Abundant
38. ***Pogonatum microstomum* (R. Br. ex Schwägr.) Brid.**
C. Nepal, Dolakha, Damarang, 1540 m, 10/17/2017, S. Karki D40 (TUCH)
Terricolous; locally Abundent
39. ***Atrichum obtusulum* (Mull. Hall.) A. Jaeger**
C. Nepal, Dolakha, Damarang, 1531 m, 10/3/2016, S. Karki D41 (TUCH)
Terricolous; locally Abundant

Pottiaceae:

40. ***Hydrogonium arcuatum* (Griff.) Wijk & Margad**
C. Nepal, Dolakha, Fedi, 1660 m, 10/3/2016, S. Karki D42 (TUCH)
Terricolous and Saxicolous; locally Abundant

Sphagnaceae:

41. ***Sphagnum cuspidatum* Ehrh. ex Hoffm.**
C. Nepal, Dolakha, Fedi, 1625 m, 10/5/2016, S. Karki D43 (TUCH)
Terricolous and Saxicolous; locally Abundant

Stereophyllaceae:

42. ***Entodontopsis wightii* (Mitt.) W.R. Buck & Ireland**
C. Nepal, Dolakha, Fedi, 1700 m, 10/4/2016, S. Karki D36 (TUCH)
Lignicolous, locally Abundant

Thuidaceae:

43. ***Thuidium cambifolium* (Dozy & Molk.) Dozy & Molk.**
C. Nepal, Dolakha, Fedi, 1730 m, 10/3/2016, S. Karki D37 (TUCH)
Epiphyte and Saxicolous; locally Abundant

Conclusions

Altogether 43 bryophyte species representing 31 genera and 27 families were recorded from Suspa-Kshamawoti, Dolakha. Mosses have represented large number of species than liverworts and hornworts. The commonly found bryophytes species of the area were *Marchantia polymorpha*, *Cyathodium tuberosum* and *Pogonatum aloides*. Similarly, species like *Phaeoceros laevis* and *Lunularia cruciata* were encountered occasionally. The lower elevation of the study area was mostly represented by liverworts and higher elevation was represented by mosses. The study area has been facing deforestation by expansion of roads, and other construction activities that are rapidly increasing since 2-3 years. These activities led to the loss of suitable habitats of many bryophyte species. Therefore, emphasis should be given to the conservation and documentation of bryophytes.

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References

Andrew, N.R., Rodgerson, L. & Dunlop, M. (2003). Variation in invertebrate-bryophyte community structure at different spatial scales along altitudinal gradients. *Journal of Biogeography*. *30*, 731-46.

Alvarenga, L.D.P., Porto, K.C. & De Oliveira. J. (2010). Habitat loss effects on spatial distribution of non-vascular epiphytes in a Brazilian Atlantic forest. *Biodiversity and Conservation, 19*, 619-635.

Daniels, A.E.D., & Kariayappa, K.C. (2007). Bryophyte diversity along a gradient of human disturbance in the Southern Western Ghats. *Current Science*, *93*(7), 976-982.

Evans, S.A., Halpern., C.B. & McKenzie, D. (2012). The contributions of forest structure and substrate to bryophyte diversity and abundance in mature

coniferous forests of the Pacific Northwest. *Bryologist*, *115,* 278-94.

Gangulee, H.C. (1969-1980). Mosses of Eastern India and Adjacent Regions. *Fasc. 1*(8), 1-2145.

Hodgetts, N.G., Essilfie, M.K., Adu-Gymphi, A., Akom, E., Kumadoh, J. & Opoku, J. (2016). Bryophytes of Atewa Forest, Eastern Region, Ghana. *Journal of Bryology*, *38*(3), (DOI:10.1080/03736687.2016.1145525).

Kashyap, S.R. (1972). *Liverworts of Western Himalayas and Punjab Plain* I & II. Dehli, India: Research Co. Pubs.

Kattel, L.P. (2002). *Liverworts of Nepal*. Saraswatinagar, Chabahil, Kathmandu, pp. 1-82.

Kenrick, P., & Crane, P. R. (1997). *The Origin and Early Diversification of Land Plants: A Cladistic Study*. Washington, DC, USA: Smithsonian Institution Press.

Long, D.G. (1993). Notes on Himalayan Hepaticae I: *Sphaerocarpos* subg. *Austrosphaerocarpos* Schust. in the Nepal Himalaya. *Journal of Hattori Botanical Lab., 74*, 77-81.

Long, D.G. (2005). Notes on Himalayan Hepaticae 2: new records and extensions of range for some Himalayan leafy liverworts. *Cryptogamie*, *Bryologie, 26*(1), 97-107.

Mitten, W. (1861). Hepaticae Indiae Orientalis: an enumeration of the species of east Indies. *Proceedings of Linnean Society of London, 5*, 89-129.

Murru, V., Marignani, M., Acosta., ATR., & Cogoni, A. (2018). Bryophytes in Mediterranean coastal dunes: ecological strategies and distribution along the vegetation zonation. *Plant Biosystems- An International Journals Dealing with all Aspects of Plant Biology*, *152*(5), (https://doi.org/10.1080/11263504.2017.1418452).

Patiño, J. & Vanderpoorten, A. (2018). Bryophyte Biogeography. *Critical Reviews in Plant Sciences*, (DOI: 10.1080/07352689.2018.1482444).

Pradhan, N. (2000a). *Materials for a Checklist of Bryophytes of Nepal.* London, UK: The Natural History Museum, pp. 1-89.

Pradhan, N. (2000b). Bryophytes of Phulchoki, Central Nepal. *Journal of Natural History Museum*, *19*, 57-81.

Pradhan, N. & Joshi, S.D. (2007a). Tropical bryoflora of Nepal. *In*: *Current Trends in Bryology* (Eds.) Nath, V. and Asthana, A.). Bishen Singh and Mahendra Pal Singh, (pp.17–36) Dehradun, India.

Pradhan, N. & Joshi, S.D. (2007b). Species diversity of hornworts (Anthocerotae: Bryophyta) in lowland Nepal with an account of *Foliocerus assamicus* D.C. Bhardwaj, a new report to the country. *Our Nature, 5*, 31–36.

Pradhan, N. & Joshi, S.D. (2009). Liverworts and Hornworts of Nepal: a synopsis. *Botanica Orientalis*, *6*, 69-75.

Pradhan, N. (2013). Diversity and status of Bryophytes in Panch pokhari region of the northern Sindhupalchok district of central Nepal. *Journal of Natural History Museum, 27*, 45-58.

Pradhan, N. (2018). Records of Bryophytes from Godawari-Phulchoki Mountain Forest of Lalitpur District, Central Nepal. *Journal of Plant Resources, 16*(1), 22-38.

Smith A.J.E. (1996). *The Liverworts of Britain and Ireland.* Cambridge, UK: Cambridge University Press.

Sun, S.Q., Wu, Y.H., Wang, G.X., Zhou, J., Yu, D.,Bing, H.J., & Luo, J. (2013). Bryophyte species richness and composition along an altitudinal gradient in Gongga Mountain China. *PLoS ONE, 8*(3), 77-88.

Wallich, N. (1832). *A Numerical List of Dried Specimens of Plants in the East India Company's Museum, Collected under the Superintendence of Dr. Wallich of the Company's Botanic Garden at Calcutta*. London, UK: The Natural History Museum.