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Cover Photo: **From top to clock wise direction.**

Male Flower of *Drypetes assamica* (Hook.f.) Pax & K.Hoffm. (PC: Yogendra Bikram Poudel)
Frullania ericoides (Nees) Mont. (PC: Nirmala Pradhan)
Schizophyllum commune Fr. (PC: Shiva Devkota)
Woodfordia fruticosa (L.) Kurz (PC: Mitra Lal Pathak)
Antimicrobial activity of rhizome extracts of *Thallictrum foliolosum* Hook.fil. & Thomson and *Thallictrum cultratum* Wall. against methicillin-resistant *Staphylococcus aureus* (MRSA) (PC: Pramesh Bahadur Lakhey)
Nephroma helveticum Ach. (PC: Chitra Bahadur Baniya)

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Editorial

It is our pleasure to bring out the current issue of Journal of Plant Resources, Volume 19, Number 1, Year 2021, a continuation of research publication by the Department of Plant Resources. Twenty one peer reviewed articles based on original research have been incorporated in this issue. The articles have been categorized as taxonomy, ecology, ethnobotany, microbiology, anatomy and phytochemistry. Articles on new records for Nepal on angiosperm and fungi are also included.

This issue intends to cover the research activities of the department as well as other research organizations. We encourage the young researchers to pursue quality research and contribute to build scientific knowledge on plant resources. We like to establish a link between the inference of scientific research and societies through dissemination of knowledge and information. We believe that the research findings will be helpful to the scientific community as well as general public to update the information on recent activities & development of plant science in Nepal.

We would like to thank all peer reviewers whose critical comments and suggestions helped to improve the quality of the journal. We acknowledge the contribution of the contributors for their interest in publishing their valued work in this journal and looking forward to further cooperation and collaboration with this department.

We apologize in advance for any mistakes in this issue and at the same time promise to improve the future issues based on your valued input.

Drypetes assamica (Putranjivaceae): A New Record of a Tree Species for the Flora of Nepal

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Abstract

Drypetes assamica (Hook.f.) Pax & K.Hoffm. (Putranjivaceae), a tree species from the eastern lowland of Nepal is reported here as a new addition to the flora of Nepal. A detailed description, notes on habitat and ecology, and photographic plate are provided.

Keywords: *Drypetes*, Flora of Nepal, New report, Taxonomy

Introduction

The genus *Drypetes* Vahl belongs to the family Putranjivaceae, and the majority of the species in this genus are dioecious trees and shrubs. The genus *Drypetes* is represented by over 210 species in the world (Govaerts et al., 2000; Quintanar et al., 2020). It is distributed in moist tropical and subtropical forests of Asia, Africa, America and Australia. In Asia, it is mainly distributed in India, Bhutan, southeast China, Myanmar and Malaysia. In India, the genus is represented by 21 species (Balakrishnan et al., 2012). In Bhutan the genus has three species (*D. indica*, *D. assamica* and *D. subsessilis*) (Long, 1987). Similarly, in China the genus is represented by 12 species (Li & Gilbert, 2008).

In Nepal, the family Putranjivaceae is represented by a single species *Putranjiva roxburghii* Wall. (Rajbhandari & Rai, 2019). This report of *Drypetes assamica* from eastern lowland of Nepal brings the total number of genus and species to two in the family Putranjivaceae in Nepal. The species was collected in Jalthal forest in Jhapa district (Figure 1). Jalthal forest is a remnant tropical moist Sal (*Shorea robusta* Gaertn.) forest in the eastern lowland of Nepal, and is well known for its richness in native flora and fauna. *D. assamica* is a dioeciuos tree characterized by its simple alternate leaves; axillary inflorescence in small fascicles; unequal sepals; and 2-seeded drupe.

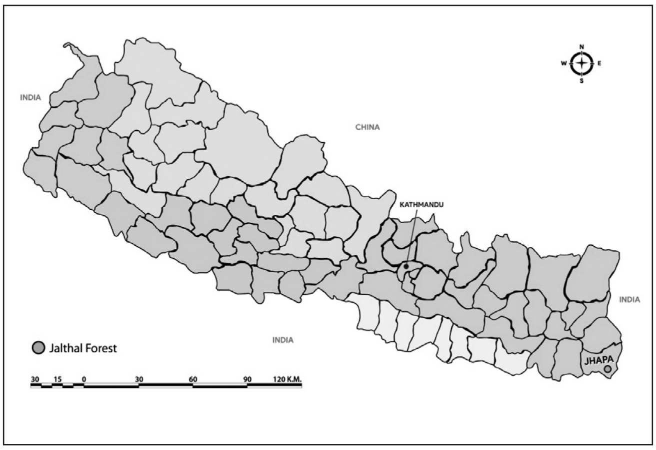

Figure 1: Map showing study area in Jhapa district.

Materials and Methods

Field surveys were conducted in the Jalthal forest of Jhapa district in March and November 2020. The species was recorded during vegetation surveys as well as forest transects walks conducted by authors and local people. Herbarium specimens with flowering and fruiting materials of the species were collected during several visits to the forest. The specimens along with photographs were studied and compared with related specimens at Royal Botanic Garden Edinburgh Herbarium (E), Tribhuvan University Central Herbarium (TUCH), and National Herbarium and Plant Laboratories (KATH). The specimens were checked against the relevant floras and checklists (Long, 1987; Press et al., 2000; Li & Gilbert, 2008; Balakrishnan et al., 2012; Rajbhandari & Rai, 2019) to confirm its identification. Local flora like flora of eastern Terai by Siwakoti & Varma (1999), a checklist of Jalthal forest (Bhattarai, 2017), and list of trees in National Forest Resources Assessment (FRA/DFRS, 2014) were also checked. The subject expert was consulted personally for the information about the species.

Taxonomic treatment

Drypetes assamica (Hook.f.) Pax & K.Hoffm., Pflanzenr. (Engler) Euphorb.–Phyllanthoid.–Phyllanth.147, 15 (Heft 81): 241. 1992.

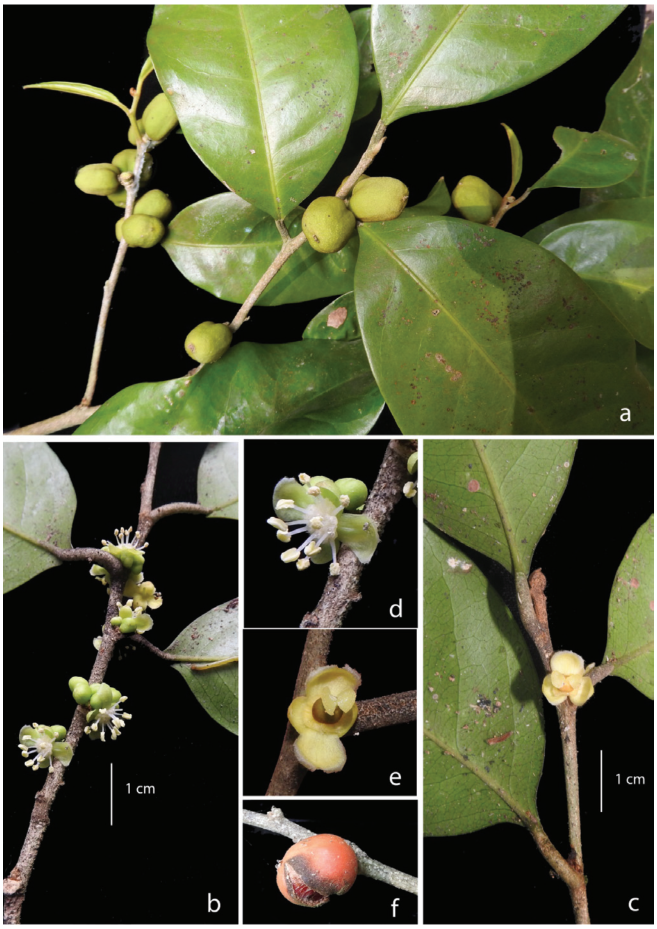

Figure 2: *Drypetes assamica*. a. Fruiting branch. b. Flowering branch with male flowers. c. Flowering branch with female flowers. d. Male flower (enlarged). e. female flower (enlarged). f. Ripe fruit.

Basionym: *Cyclostemon assamicus* Hook.f.

Evergreen trees to 12 m, diameter at breast height (DBH) up to 15 cm, dioecious. Bark grey, smooth. Petioles up to 1 cm, rusty tomentose mainly on groove. Leaves alternate, lanceolate to elliptic, 12–16 × 4–8 cm, base broadly cuneate or rounded, apex acuminate, margin entire or subentire, coriaceous, glabrous, pinnately veined, midrib prominent, lateral veins 9–15 on each side of midrib. Inflorescence axillary in small fascicles. Male flowers ca. 8 mm in diameter, pedicellate; pedicel ca. 3 mm long; sepals 4, orbicular or obovate, unequal, glabrous above, pubescent beneath, pale green; outer 2 smaller, ca. 3×3 mm; inner 2 slightly bigger, ca. 4×4 mm; petals absent; stamens 8–12(–14); filaments glabrous, white, ca. 3 mm; anthers basifixed, ca. 1.5 mm. Female flowers pedicellate; pedicel ca. 3 mm; sepals 4, obovate or orbicular, unequal, glabrous above, pubescent beneath, pale green; outer 2 smaller, ca. 3×3 mm; inner 2 slighter bigger, ca. 3.5×5 mm; petals absent; disk present; ovary globose, pubescent, 2×2 mm; style 2, very short; stigma ca. 2×3 mm, fan-shaped. Drupes ellipsoid, 1.8×1.4 cm, coriaceous, shallowly furrowed, appressed pubescent, hairs brown, 2–seeded. Seeds 1.4×0.6 cm.

Notes: *D. assamica* is morphologically close to *D. subsessilis* (Kurz) Pax & K.Hoffm. but easily differentiated by its male flower with 8–12(–14) stamens (vs. 3–4 in *D. subsessilis*). The pedicels in male and female flowers are smaller (2–3 mm) on Nepalese specimens compared with specimens from Bhutan and India (>3).

Flowering: October–November;
Fruiting: November–April

Ecology: Near streams and gullies as understory tree in moist Sal (*Shorea robusta* Gaertn.) forest.

Distribution: Tropical and subtropical forests of Nepal, India, Bangladesh, Bhutan, Myanmar, and Thailand. In India, it occurs in North eastern states up to 1400 meter above sea level (Efloraindia, 2021).

Specimen examined: Eastern Nepal, Jhapa district, Haldibari rural municipality–4, Jalthal, 26.45°N, 88.02°E, 90 m, 20 March 2020, L.N. Sharma & Y.B. Poudel J03 (TUCH, KATH); Eastern Nepal, Jhapa district, Haldibari rural municipality–4, Jalthal, 26.50°N, 88.027°E, 88 m, 17 November 2020, Y.B. Poudel & L.N. Sharma J04 (TUCH, KATH).

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We would like to acknowledge Mr. Bharat Dhakal, Bikram Baral, Om Krishna Kharel, Shyam Lal Meche and Shanta Lal Meche for assisting us in our fieldwork in Jalthal forest. We would also like to thank Tapas Chakrabarty for providing information about the species. Curators of National Herbarium and Plant Laboratory (KATH), Tribhuvan University Central Herbarium (TUCH), and Royal Botanic Garden Edinburgh (E) are acknowledged for allowing us to access the herbarium specimens. The Royal Botanic Garden Edinburgh is supported by the Scottish Government's Rural and Environment Science and Analytical Services Division, and players of the People's Postcode Lottery through the Postcode Earth Trust. Two anonymous reviewers are acknowledged for suggestions in the previous version of this MS. Field research for this paper was supported by Darwin Initiative UK funded project (ref 26–022).

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Stellaria pallida (Dumort.) Crép. (Caryophyllaceae): A New Record of a Herb Species for the Flora of Nepal

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Abstract

Stellaria pallida (Dumort.) Crép., a herb species from Kathmandu valley is reported as a new record for the flora of Nepal. This species is found growing in the cultivated fields, lawns, roadsides, and sidewalk cracks. The species is a small herb with flowers without petals, and smaller, light brown seeds with short conic tubercles.

Keywords: Bifid petal, Cleistogamous, Tubercles, Reflexed stigmas

Introduction

Genus *Stellaria* L. species are commonly called as Chickweeds or Starworts and belongs to Subfamily Alsinoideae and Tribe Alsineae in Caryophyllaceae, (Harbaugh et al., 2010). *Stellaria* is cosmopolitan and characterized by annual or perennial herbs; leaves sessile or petiolate; petals bifid up to base with 2 or 3 styles; capsule valves 6; and seeds many. The species are autogamous and are isolated due to sterility barriers.

Based on the phylogenetic analysis Sharples (2019) and Sharples & Tripp (2019) have circumscribed Core *Stellaria* L. that consist approximately 112 species. Within the core *Stellaria, Stellaria media* group have been identified which is represented by annual herbs with terete stem, upper leaves sessile, lower leaves distinctly petiolate, leaves and bracts ovate or elliptical with round bases, usually with a single line of hairs along each internode, rarely with two lines or glabrous (Lepší et al., 2019; Sharples 2019). The group comprises three distinguished species: *S. media* (L.) Vill., *S. neglecta* Weihe. and *Stellaria pallida* (Dumort.) Crép however a recent biosystematic revision in *S. media* group by Lepší et al., 2019, added a new species *S. ruderalis* M. Lepší, P. Lepší, Z. Kaplan & P. Koutecký to this group and also considered *Stellaria pallida* (Dumort.) Crép as a distinct species.

The species is not included in the checklist by Hara et al. (1979) and Press et al. (2000) as well as in recent publications (Rajbhandari et al., 2017). According to Press et al. (2000), there are 18 species, 11 varieties and 2 forma of *Stellaria* L. in Nepal. The species are distributed from tropical to alpine region of Nepal. *S. wallichiana* Haines has been reported from Jhapa (105-110m) the tropical region and *Stellaria decumbens* Edgew. from Makalu (6135m) the alpine region (MOFSC, 2002) of Nepal.

Materials and Methods

This study is based on the field studies conducted in Budhanilkantha as well as in other areas of Kathmandu Valley from December 2019 to March 2021. A distinct population of *Stellaria media* group was found in the cultivated and paddy fields as well as in lawns and roadsides. Herbarium was prepared according to Bridson & Forman (1989) and photographs were taken. The detailed taxonomic study of the of the collected plant specimens was done and herbarium specimens of related taxa was observed and compared at National Herbarium and Plant Laboratories (KATH) and Tribhuvan University Central Herbarium (TUCH). The online type specimens and other related images were studied from Royal Botanic Gardens, Kew, Tropicos, and IPNI. The collected herbarium specimens were compared and checked with all relevant literatures (Don, 1825; Hara et al., 1979; Malla et al., 1986; Press et al., 2000; Rajbhandari, 2004; Rajbhandari et al., 2017) as well as databases such as Flora of Nepal Database and KATH online herbarium catalogue. All the specimens collected during the field work were deposited at TUCH and KATH herbarium.

Results and Discussion

Stellaria pallida (Dumort.) Crép., Man. Fl. Belgique, ed. 2: 19 (1866); Chater and Heywood Fl. Europaea 2(1):134(1993); Miller and West Fl. Victoria 3: 233 -240 (1996); Chen and Rabeler Fl. China 6:16(2001); Morton Fl. North America 5(2): 96-114(2005).

Synonyms: *Alsine pallida* Dumortier, Fl. Belg., 109. 1827; *Stellaria boraeana* Jord., Pug. 1852; *S. media* (Linnaeus) Villars subsp. *pallida* (Dumort.) Aschersonv & Graebner; *S. pallida* (Dumort) Pire, Bull. Soc. Roy. Bot. Belgique 2: 49(1863), nom. Inval.

Type: Poland. Siles: 120m, 1893-5-14, Friedrich-Schiller-UniversitÓt Jena (JE), JE0001147; Collector: Baenitz, SC.G, Herbarium Europaeum (C. Baenitz) s.n. (Isotype).

English name: Lesser Chickweed

Description

Plant annual, herbaceous, yellowish green or pale green. Root simple taproot. Stem decumbent rarely ascending, very much reduced (2.5-) to 15(-25) cm long, branched, 4-sided, purplish green/pale green with a line of fine hairs in internodes and pedicels. Leaves opposite, exstipulate, simple, petiolate long proximally and sessile distally, fine hairs at leaf base and petiole; leaf blade broad elliptic to ovate, 3-12 ×1-8mm, glabrous, mid vein distinct with sparse hairs, closed venation, base cuneate to round, margin entire sometimes undulate (dry state), apex acute to shortly acuminate. Inflorescence axillary and terminal dichasial cymes, condensed, 3-many flowered. Flower bisexual, actinomorphic, hypogynous, 3-3.5mm diameter; bracts leafy, herbaceous, lanceolate, 2-8×1-5mm, sessile, base narrowly cuneate with fine hairs, veins inconspicuous, glabrous, margin entire, acute at apex with purple mark. Pedicel 1-15mm long, diffuse, deflexed in fruit, densely hairy. Sepals 5, lanceolate to ovate-lanceolate, 3-4 ×1.2-1.4mm, mid rib distinct, veins obscure, abaxially hairy, adaxially glabrous, margin narrowly scarious, acute at apex. Petals absent or rarely very much reduced. Stamens 1-3, staminodes absent -2; filament 1-1.5mm , free, long and slender, dilated at base, white; anther ca.0.2mm, dithecous, introrose, grey-violet (young) and black (mature), subbasifixed. Ovary one loculed with many ovules, globose, 1.5-2.5mm, yellowish green; style 3, 0.3-0.5mm, ascending. Capsule pale yellowish green, ovoid to ellipsoid, 3-4(-5) mm, membranous, beak obtuse sometimes with persistent styles, apex recurved, 6-valved. Seeds numerous (8-16), reniform-flattened ellipsoid, yellowish brown-light brown, 0.5-0.8(-1) mm diam., tuberculated, short, round to obtuse apex, smooth.

Flowering Season: December-March

Ecology: Usually grown on sandy loam soil. Found as weeds in cultivated fields, lawns, roadsides, and sidewalk cracks.

Distribution: The species is native to Europe and distributed in the countries of America, Asia and Australia (Chen & Rabeler 2001; Morton, 2005; Miller & West, 2012).

Specimens Examined: Central Nepal. Kathmandu District: Kathmandu-13, Chhauni, Simana Marga, 27.70556°N, 85.29528°E, 1259.0m, 30 Dec 2019, R. Kafle RK001(TUCH, KATH); Kathmandu-32, Jeevan Smriti Marga, 27.70611°N, 85.29778°E, 1230.0m, 16 Jan 2019, R. Kafle RK002(TUCH, KATH); Budhanilkantha-5, In front of Budhanilkantha School, 27.77861°N, 85.35944°E, 1420.0m, 22 Jan 2020, R. Kafle, B. Shrestha, G. Lama, P. Dhungana & S. Limbu RK 003((TUCH, KATH); Budhanilkantha-3, ISKCON, 27.78350°N, 85.35627°E, 1421.0 m, 22 Jan 2020, R. Kafle, B. Shrestha, G. Lama, P. Dhungana & S. Limbu RK004(TUCH, KATH); Budhanikantha-3, 27.78504°N, 85.35933°E, 1428.0m, 27 Jan 2020, R. Kafle & Shrestha, B. RK005 (TUCH, KATH); Budhanilkantha-3, Chisenigaon 27.78223°N, 85.369296°E, 1430.0m, 27 Jan 2020; R. Kafle & B. Shrestha, RK 006 (Figure 1), (TUCH, KATH); Budhanilkantha-8, Chapali Substation, 27.76438°N, 85.35772°E, 1390.0m, 2 Jan 2021, Kafle, R. RK007 (TUCH, KATH). Budhanilkantha-3, 27.78519°N,

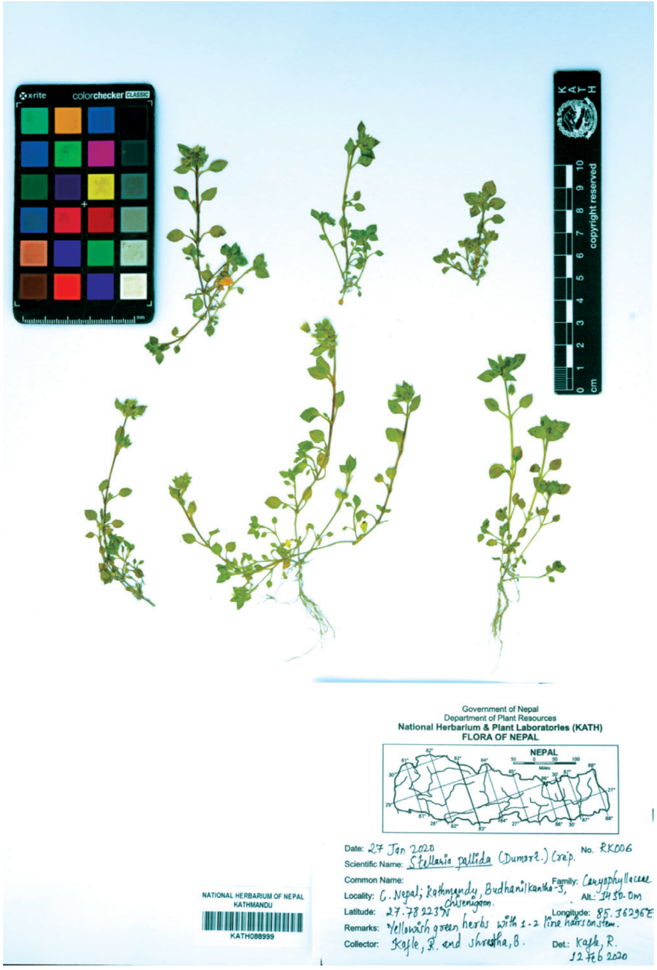

Figure 1: A Sample of voucher specimen of *S. pallida* (Dumort.) Crép. deposited at KATH.

85.35939°E, 1427.0 m, 11 Mar 2021, R. Kafle, RK008 (TUCH, KATH); Budhanilkantha-3, 27.78487°N, 85.35965°E, 1409.0 m, 11 Mar 2021, R. Kafle, RK009 (TUCH, KATH); Budhanilkantha-3, 27.78238°N, 85.36291°E, 1422.0 m, 11 Mar 2021, R. Kafle, RK010 (TUCH, KATH).

Keys to the Nepalese *Stellaria media* group:

1a. Inflorescence solitary, Flower tetramerous....... ....*S. wallichiana*.

1b. Inflorescence dichasial cyme, Flower pentamerous ....2.

2a. Petal absent or reduced; stamen or staminodes 1-3 or absent; seeds size less than 1 mm in diam... *S. pallida.*

2b. Petal present; stamen 3-10; seeds size equal to 1mm or more in diam. ....3.

3a. Plant size 5-30cm long; Flower 2.5-6 mm diam.; stamen 3-5;seeds 0.8-1.2mm diam. including semiglobose to round tubercles with obtuse apex ....*S. media.*

3b. Plant size (10-) 30-60cm; flower 5-8mm diam.; stamen 8-10; seeds 1-1.5mm diam. Including highly conic tubercles with acute apex .... *S. neglecta.*

Stellaria pallida (Dumort.) Crép. is taxonomically distinct species in *Stellaria media* group, but due to overlapping of characters with *S. media*, there is a confusion in identification. After a close observation it has been clear that the main characters such as yellowish green appearance of the herbs, small size (2.5-25cm) of the plant, smaller sepals, as well as reproductive characters like absence of petals or very much reduced petals in flower; less number of stamens/staminodes (1-3-(-4)); small sized seeds less than 1mm diam.(0.7-0.9(-1))mm, light brown seeds with short conical tubercles makes the plant distinct from *S. media* which shows similar results in various literatures (Whitehead & Sinha, 1967; Chater & Heywood, 1993; Chen & Rabeler, 2001; Morton, 2005; Miller & West, 2012). The cleistogamous flower is characteristic in *S. pallida* but observed rarely in case of *S. media* (Whitehead & Sinha, 1967; Chen & Rabeler, 2001; Atha et al., 2018). The species can be ecologically distinguished with their rudimentary habitat and distribution in sandy dune soil at roadside or in cultivated fields. In addition to these characters yellowish-green appearance of plant, condensed inflorescence with ascending and reflexed stigmas as well as the length of stigma and style less than 5mm in *S. pallida* which is completely different in *S. media* where length of stigma and style is 5mm or more and light brown seeds having short acute tubercles, which has also been mentioned in different literatures (Miller & West, 2012; Lepší et al., 2019). All these character discussed here shows the distinct characteristic feature of *S. pallid* from *S. media,* therefore*, Stellaria pallida* (Dumort.) Crép. is considered as a new record for Nepal.

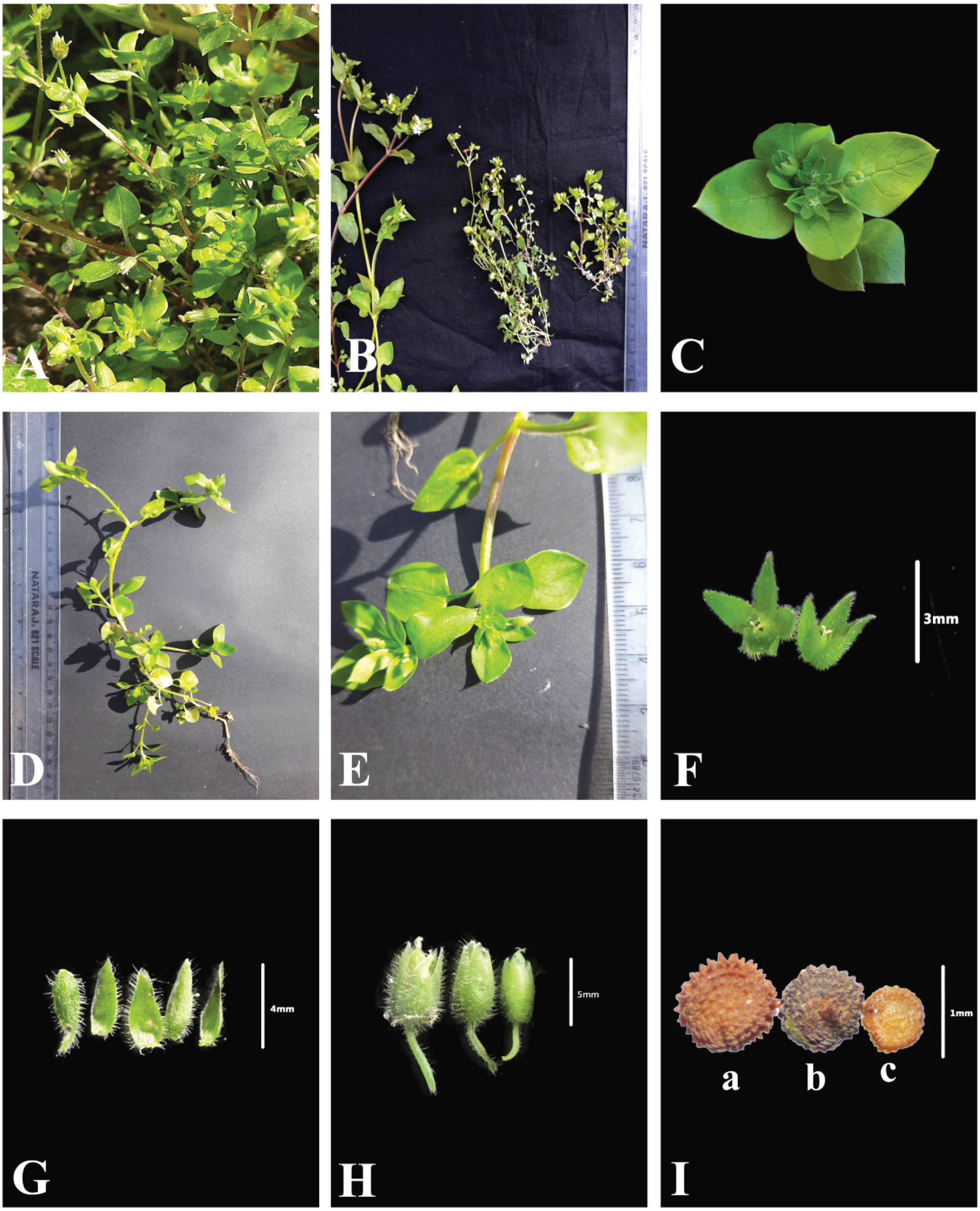

Figure 2: A. Habitat of plant; B. Comparison of habit with *S. neglecta* - left, *S. media*-middle & *S. pallida*-right; C. *S. pallida* in flower; D. Plant measurement; E. Leafy cyme with apetalous flower; F. Cleistogamous flower; G. Sepal; H**.** Flower; I. Seeds in 25X magnification of Streomicroscope (*S. neglecta* (a), *S. media* seed (b) & *S. pallida* seed (c).

Conclusion

Stellaria pallida (Dumort.) Crép. is considered as a new record of Nepal.

Acknowledgements

We would like to thank curators' of National Herbarium and Plant Laboratory (KATH), and Tribhuvan University Central Herbarium for giving access to their herbarium collections.

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Primula ianthina Balf.f. & Cave (Primulaceae): A New Record For Nepal

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Abstract

Primula ianthina Balf.f. & Cave (Primulaceae) known endemic to Sikkim is reported as a new record for Nepal.

Keywords: *Aleuritia ianthina,* Endemic, Ilam, New distribution record

Introduction

Primula L. is the largest genus belonging to the family Primulaceae, distributed mainly in temperate regions of the northern hemisphere (Richards, 2003). It comprises ca. 500 species with its greatest diversity in the mountain ranges of East Asia (Hu & Kelso, 1996) and with 61 species listed in Nepal (Hara et al., 1982). *Primula ianthina* Balf.f. & Cave was first described in 1916 from material collected by G. H. Cave from Sandakphu (a village located in the border of Nepal and India), Darjeeling Himalaya in 1914. *Primula ianthina* is not described as occurring in Nepal by Hara et al. (1982), Press et al. (2000), Bista et al., (2001) & Rajbhandari et al., (2012, 2017). This species is a new record for the Flora of Nepal.

Materials and Methods

This work is based on the herbarium specimens preserved at National Herbarium and Plant Laboratories, Godawari, Lalitpur (KATH). The available literatures were reviewed. The type specimen and other herbarium specimens preserved at different herbaria were studied (https://data.rbge.org.uk/search/herbarium). The specimen preserved at KATH was digitized and barcoded as KATH023548 which is available online on *plantdatabase.kath.gov.np*.

Results and Discussion

While working on the herbarium specimens of the *Primula* genus preserved at the KATH we found a specimen determined as *Primula floribunda* Wall. which was different from typical *Primula floribunda.* On further study and herbarium examination we identified it as *Primula ianthina* Balf.f. & Cave. The taxonomical description is given below.

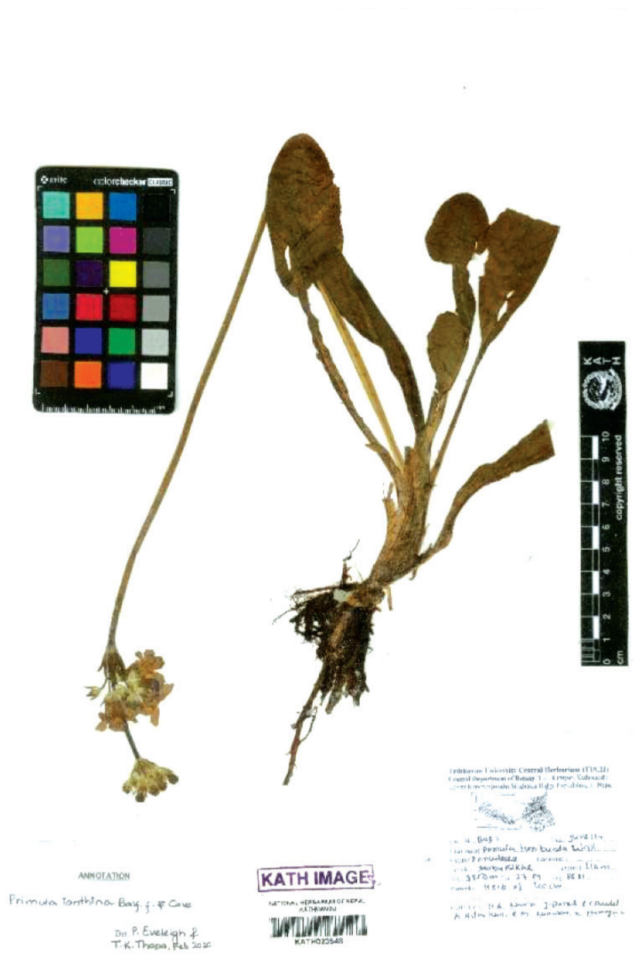

Figure 1: *Primula ianthina* Balf.f. & Cave

Primula ianthina Balf.f. & Cave in Notes Roy. Bot. Gard. Edinburgh, 9 (43):175-176 (1916); Smith, W. W. & Forrest, G. in Notes Royal Bot. Gard. Edinburgh, 16: 1-50 (1928) and in Journal Roy. Hort. Soc. London, 54:43 (1929); H. Hara in Spring Flora of Sikkim Himalaya 119. (1963); H. Hara in The Flora of Eastern Himalaya 1:248 (1966); A. J. C. Grierson, & D. G. Long in Flora of Bhutan 2(2):539 (1999); A.J. Richards *Primula* 221. (2003); Basak, et.al. The Genus *Primula* L. India: A Taxonomic Revision322. (2014). (Figure 1).

Synonym: *Aleuritia ianthina* (Balf. f. & Cave) Soják

A perennial farinose herb with thick fibrous roots. Bud scales absent at anthesis. Leaves forming a rosette, lamina oblong to oblanceolate, 3-20 x 1.5-3cm, base attenuate into winged petiole, apex rounded, and finely denticulate margin, glandular pitted especially on the lower surface. Scape to 40cm tall, 2 umbels, superimposed, 10-12 flowers in each umbel. Bracts yellow farinose, lanceolate, gibboseat base, acute apex, as many as pedicels, 0.5-1.5 x 0.1cm. Pedicels 1-2cm long, farinose. Calyx green, covered with dense yellow farina, bell shaped, parted to the middle into triangular deltoid teeth, 5-7 x 3-4mm, apex acuminate, sometimes toothed. Corolla salver shaped, purple, 1.5-1.9 x 1.5-2cm, heteromorphic; lobes emarginate; tube 1cm long. Stamens 5, in pin morph, inserted towards the base of corolla tube. While the style reaches the apex of the tube or slightly exserted.

Type: Sikkim, Sandakphu, 11,500ft, 29 July 1914, Cave, G.H. (*Lectotype:* E00024399 in E).

Distribution: 3200m; previously endemic to Sikkim has been now reported from Ilam District, East Nepal.

Ecology: In pasture and damp meadows.

Flowering: June-July.

Specimens Examined: Province 1, East Nepal, Mubu, Bikhe, Ilam District, 3,200m,14 June 2007,27.09N and 88.01E, *N. B. Khatri., J. Pandey., R. C. Paudel., B. Adhikari., R.M. Kunwar. & K. Humagain* B087 (KATH023548); India, Darjeeling Sandaphu-Garibans, 7.6.1960, 27°6'15" N and 88°0'4" E, *H. Hara, H. Kanai, G. Murata, M. Togashi, & T. Tuyama,* 5022 (KATH040625; KATH040626; KATH040627).

Notes: The species *Primula floribunda* differs from *Primula ianthina* having short, articulate-hairy, efarinose, yellow flowers in 1-6 umbels and grows at lower elevations of 500-2000m which is distributed from NW Himalaya to SW Nepal and Afghanistan. *Primula ianthina* is sometimes confused with *Primula prolifera* but the most obvious difference is flower color (*P. ianthina* is purple pink to violet whereas *P. prolifera* is yellow).

Conclusion

Primula ianthina, previously endemic to Sikkim has been now reported from Ilam District, East Nepal. This species is new addition for the Flora of Nepal.

Author Contributions

All the authors have equally contributed to bring this manuscript in its form.

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New Record of Two Parasitic Fungi on *Malva sylvestris* L. from Nepal

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Abstract

Present paper deals with two species of parasitic fungi found parasitic on the leaves of *Malva sylvestris* L. collected at Bhanimandal, Lalitpur, Nepal. One is *Erysiphe malvae* Heluta (Ascomycota, Erysiphales: Erysiphaceae) and another is *Puccinia malvacearum* Bertero ex Mont. (Basidiomycota: Uredinales: Pucciniaceae). They are recoded as new to the Nepalese mycoflora. They are described and illustrated below.

Keywords: Malva, Mycoflora, Powdery mildew, Rust

Introduction

Malva sylvestris L., is an ornamental horticultural plant cultivated throughout the world including Nepal. It is not an indigenous species to Nepal. The seeds and or plant of this species are imported from India and abroad. This species is cultivated as an ornamental plant everywhere in Kathmandu valley. During investigation, this plant parasitized by two fungal species, was found cultivated in the promises of Bhanimandal, Lalitpur, Nepal. The examination revealed two fungal species, which were *Erysiphe malvae* Heluta and *Puccinia malvacearum* Bertero ex Mont. *Erysiphe malvae* Heluta produces white cottony growth on the upper side of the leaf, while *Puccinia malvacearum* Bertero ex Mont, produces dark brown circular pustules on the lower surface of the leaf. The spots of rust were also found infecting the stems.

The major literatures on the fungi of Nepal are Adhikari (2009) "*Researches on the Nepalese mycoflora: Revised account on the history of mycological explorations",* Adhikari (2017) "*Researches on the Nepalese mycoflora: Erysiphales from Nepal.- 3"* and Ono et al., (1995) "*An annotated list of the rust fungi (Uredinales) of Nepal".* Likewise other literatures concerning on the powdery mildews of Nepal are those of Adhikari (1997, 2018, 2020), Adhikari (2020) "*Researches on the Nepalese mycoflora – 4, "* Shin et al.(2018) and U. Braun & R. T. A. Cook (2012). Rest of the references is cited in the text below. However, the diversity of the fungi in Nepal is still little known. Numerous new records are still expected to prevail.

Materials and Methods

The present study was based on the host *Malava sylvestris* L. found at Bhanimandal (27°40" Latitude and 85°18" Longitude), Lalitpur, Nepal. Photographs were taken. The specimens were examined using a light microscope, and micrographs were taken with a camera. The microscopic description and distribution of the fungi in the globe are provided below. The specimens gathered are housed in National Herbarium & Plant Lab (KATH), Godawari.

Enumeration of species

1. **Powdery mildew on *Malva sylvestris***

Erysiphe malvae Heluta, *Ukrayins'k. Bot. Zhurn.* 47(4): 75, 1990, Fig. 452

Mycelium on stems and leaves, effuse or in patches, white, *hyphae* 4-10 µm wide, hyaline; *hyphal appressoria* almost nipple-shaped: *conidiophores* erect, arising from top and mostly towards one end of mother cell, up to 190 ìm long, *foot-cells* cylindrical, straight, 35-70 × 6-11 µm, followed by 1-3 cells, shorter or relatively long,; *conidia* cylindrical, singly, ellipsoid-cylindrical, 30-40 × 12-18 µm. *Chasmothecia* immature, scattered, hemispherical, blackish, 100-140 µm diam.; *peridium cells* irregularly shaped, *appendages* numerous, mycelioid, Host – on cultivated ornamental *Malva sylvestris* L. leaves, Bhanimandal, Lalitpur, Nepal. 2077. 2. 8, Adhikari, no. 2077.2.2 (KATH)

Here, new to Nepal has been claimed based on the publications of Shin et al. (2018); Pawsey (1989); Pandey & Adhikari (2005); Manandhar & Shah (1975); Lama (1976, 1977); Khadka & Shah (1967); Khadka et al., 1968); Bhatt (1966); Braun & Cook (2012); Adhikari et al. (1983, 1984, 1987 90, 1997, 2001, 2005, 2008, 2018); Adhikari & Durrieu (2016) and Adhikari (1990, 2012ab, 2014, 2018, 2020), where there is no record of this fungus.

Distribution - Iran, Israel, Europe (Ukraine). and Nepal

2. Rust on *Malva sylvestris*

Puccinia malvacearum Bert. ex Mont., *Historia Física Política Chile Botánica.Flora Chilena* 8: 43 (1852) [Synonym - *Leptopuccinia malvacearum* (Bert. ex Mont.) Rostr. (1902); *Micropuccinia malvacearum* (Bertero ex Mont.) Arthur & Jacks. (1921)]

The spots are yellow to yellow-orange on the upper leaf surface, while the lower surface has blister-like dark orange raised pustules. Leaves shrivel and defoliate prematurely. Teliosori blackish brown to chestnut brown. Teliospores, 80-112 x 40-65 µm, smooth, yellow to cinnamon-brown,, mostly two-celled, occasionally 1-3 to 4 celled, oblong , both upper and lower cells are variable in shape and size, generally tapering toward both ends. teliospore wall is 1-3 µm thick, apex 5-7 µm slightly papillate type. Pedicel hyaline, thick walled, more than 80 µm long (some up to twice the length of the spore).

Host - It is an obligate, autoecious microcyclic rust, causing disease on many species of Malvaceae family. Rust on cultivated ornamental *Malva sylvestris* L. leaves, Bhanimandal, Lalitpur, Nepal 2077.2.8, Adhikari, no. 2077.2.1 (KATH)

Here, new to Nepal has been claimed based on the publications of Sivanesan (1970); Singh & Nisha (1976); Singh (1968); Parajuli et al. (1999, 2000); Ono et al., (1988, 1990ab, 1995); Manandhar (1977, 2007, 2009); Kaneko, Kakishima & Ono (1993); Durrieu (1975ab, 1976, 1977ab, 1979, 1980, 1987); Cotter et al., (1986, 1987); Classen et al. (2008); Balfour – Browne (1955, 1968); Arthur (1934); Adhikari et al. (1985, 1988, 2005, 2006, 2008, 2013) and Adhikari (1998, 2016, 2019) , where there is no record of this fungus.

Distribution – Worldwide (where the plant is cultivated) and Nepal

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Rust

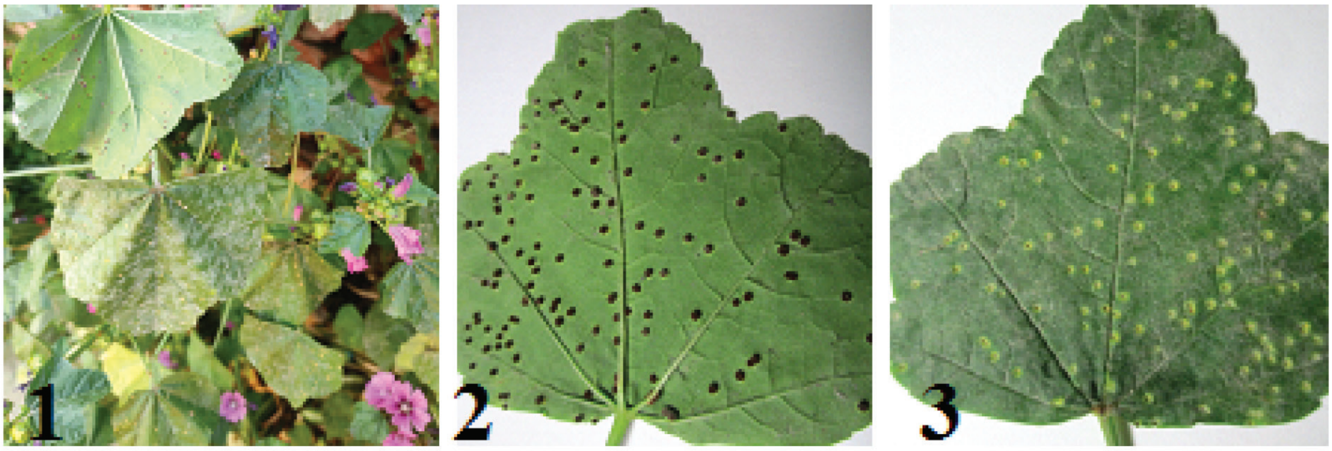

Figure 1: Host- *Malva sylvestris* **2:** Lower side of leaf with rust postul **3:** Upper side of leaf with yellow spots

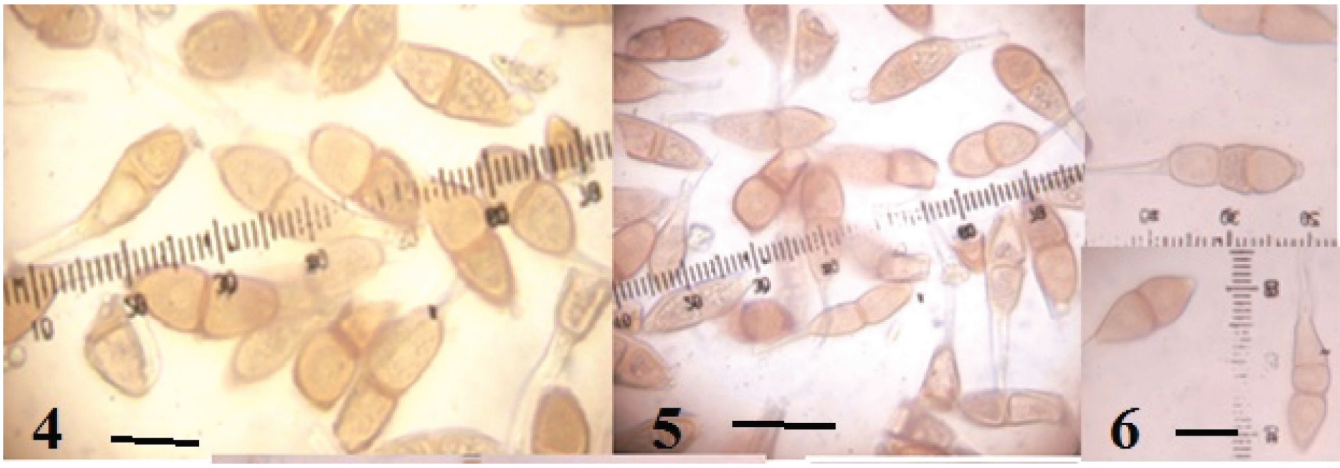

Figure 4-5: Bicelled teliospores (Bar =25 µm) **6:** Two celled (21 µm) and threed celled teliospores

Powdery mildew

Figure 1: Host- *Malva sylvestris* **2:** Coonidiopore and spores (30 µm) **3:** Spores (23 µm) **4:** Chasmothecia

Exploration of Lichen in Nepal

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Abstract

Lichens are great part of our healthy nature. They have a great contribution to mankind and environment directly and indirectly. Understanding each of their taxonomy and publish them is primary urgency in term of biodiversity registry. Exploration of different forms of biodiversity has taken place after Nepal opened for foreign countries. Interests on lichens are no more exception. This work has been put forwarded to revise literature about work done and published related on Nepalese lichens both by foreign as well as native lichenologists. Based on compilation of the previous works done in different geographical regions of Nepal, a total of 873 taxa (805 species, 46 varieties, 10 subspecies, 12 forma) belonging to 185 genera and 61 families having Parmeliacaea as dominant family were reported so far until now. Central Nepal is found the most explored region of the country followed by eastern and western Nepal. Much work done were concerned about documentation and identification by foreign lichenologists and deposited in their own herbaria. This review tries to figure out exploration of lichen in different time period, total lichen taxa of Nepal and to present area of interest of lichenologist in recent period.

Keywords: Central Nepal, Host specificity, Lichen richness, Life forms

Introduction

Lichens, the non-vascular cryptogams and an excellent example of symbiotic association between mycobiont and photobiont, are broadly categorized into crustose, foliose and fruticose life-forms on the basis of their general morphology As the mycobiont is unique in the symbiotic association and usually dominates the association, lichen are classified as life form of fungi (Rankovie & Kosanic 2015). Lichens are one of the most successful organisms to colonize at extreme environments such as cold arctic and alpine environments where a few other plants can establish (Schroeter et al. 1994; Kappen et al. 1996). They can grow at almost every type of terrestrial habitats and fewer of them were also recorded from freshwater streams (e.g. *Peltigera hydrothyria*) and in the marine intertidal zone (e.g. *Lichina* spp.) (Hawksworth 2000). Lichens are dominant autotrophs in many polar and sub-polar ecosystems (Longton 1988). Rogers (1977) estimated about 20,000 species of lichen in the world. Lichens dominate approximately 8% of the Earth's land surface (Nash, 2008). At higher latitudes, the number of lichen species exceeds the number of vascular plant species (Nash, 2008). Global number of currently recognized lichens range was estimated between 13,500 (Hawksworth et al., 1996) and nearly 20,000 when "orphaned" species were included (Sipman & Aptroot 2001). It was estimated that about 50% of the tropical lichen mycobiota were still unknown (Aptroot & Sipman 1997). In Asia, the Himalayan habitats are rich for lichens (Upreti 1998). Sharma (1995) estimated 2,000 species of lichen in Nepal representing only 10% of the total lichens species likely occurred in the world. *Carborea voryticosa* reported from the world's highest altitude that was from Nepalese Himalayan at 7400m asl (Baniya et al., 2010). Baniya et al. (1999) described a gross distribution pattern of lichens with physiographic zones in Nepal and reported that lower elevation was rich in crustose lichen; middle elevation was rich in foliose lichen while higher elevation was rich in fruticose form of lichen.

In context of Nepal, lichens from the lowland Terai and Siwalik hills are much less known, and those of western Nepal remain largely unexplored (Bhuju et al., 2007). Among terrestrial photosynthetic organisms they are the major group that is least investigated in Nepal (Baniya et al., 2010). Lichens are difficult to recognize as compared to other vascular plants due to their small size, being non-flowering and due to lack well-illustrated and well pictured flora. They are identified by their external morphological characters, internal anatomy and chemical constituents. Color spot test usually applied on thallus and thin layer chromatography conducted to identify chemistry of each thallus helped to identify lichen species. In addition, structural character and ontogeny of apothecia are also taken as most stringent character to separate individual genera as well as species. In Nepal, many publications have dealt with taxonomic exploration of specific generic records as well as lichen flora of specific region or the whole country Nepal. However a comprehensive review of all publications is lacking. Thus this present work has attempted to review works performed on Nepalese lichens at different intervals of time. Although in this study we have attempted to cover all of the available literature on lichen flora of Nepal published till 2020, inaccessibility of some literature is no more exception. This study in one hand might provide knowledge on research works done in Nepal and in other hand could highlight major gaps in lichen research of Nepal.

Materials and Methods

This present review is information about lichen species related research work done in Nepal, especially lichen explorations in different parts of the country at different time periods by foreign as well as Nepalese lichenologists. They published their findings in different journals, books and reports. All available information was gathered via searching scientific databases including Elsevier, Springer, Google Scholars, and Cyberliber etc. Also related thesis works, books, project reports and other available periodicals were reviewed. Global biodiversity information facility (GBIF) was followed to check accepted names and for author citation.

Results and Discussion

Historical Study of Nepalese Lichen till 1950

Lichenological research in Nepal was primarily initiated by western lichenologists followed by Indians and Japanese. For the first time in Nepal, the knowledge about lichen was introduced by Wallich's collection done during 1820-26. His collections were mainly from the eastern and central regions of the country (Thapa & Rajbhandary 2012). Nylander in 1860 published some Nepalese Lichen specimens collected by Sir Joseph Dalton Hooker and Thompson on "Synopsis Methodica Lichenum". Likewise, Paulson (1925) described 31 lichen taxa collected by Sommervella in 1924, from Mt. Everest, Nepal.

Mid period (1950- 2000)

In Mid period, major contribution to the lichenological exploration of Nepal was provided by foreign lichenologist. Nakao collected lichen species from different parts of eastern Nepal during the expedition to the Nepal Himalaya in 1952-53 (Thapa & Rajbhandary, 2012). Based on his collection, Asahina (1955) described 62 species of lichen and Abbayes (1958) reported distribution of Cladonia species from Nepal Himalayas. For the first time, Awasthi (1957), based on his own collection done in eastern Nepal, reported Nepalese lichen and included 38 species in his publication. Among which *Cetraria nepalensis*, *Cetraria pallid* and *Physcia melanotricha* were new species. D. D. Awasthi was regarded as father of Indian Lichenologist. Based on collection of R. S. Rao, botanist member of the Indian expedition to Cho-Oyu in east Nepal, Awasthi (1960) described 38 species of lichens among which five species were reported as new reports for the Himalayas.

Professor J. J. Poelt was the most famous lichenologist who conducted a series of lichen expeditions to Nepal. His first Himalayan expedition was held in 1962 in the southern flank of the Mount Everest region of Solu Khumbu. His second Himalayan expedition was held in Langtang region, Central Nepal. Most of his collections were housed at Botanische Staatssammlung Munchen (M) and Graz University Herbarium (GZU) respectively. Results of his expedition's represented 39 new taxa to science. His herbarium collections have been maintaining by University Gratz, Austria together with collections made from Tibet of China. Poelt

(1974) revised the genera *Physica* and *Physconia* of the himalayan region. Out of the 19 species of *Physica*, 4 were new to science, and 15 species were new report from Nepal, and 2 species of *Physciopsis* and *Physoconia* were also reported. Vezda & Poelt (1974) reported *Dimerella lutea* and described *Pachyphiale himalayensis* new to science from Nepal. Poelt (1977) described 12 species of *Umbilicaria* from Nepal. Poelt & Mayrhofer (1988) published the new taxa of *Bryonora selenospora, B. reducta and B. rhypariza* var. cyanotropha collected from Langtang area, Central Nepal.

Asahina & Kurokawa (1966) reported 62 species of lichens new to science out of a total of 133 species collected from eastern Nepal. Kurokawa (1967) enumerated 53 species of lichens from Rolwaling region among which 26 species were new to Nepal. Yoshimura (1971) reported *Lobaria subretigera* from Rolwaling expedition, a lichen species new to science but later found that was a synonym of *L. pseudopulmonaria*. He further reported four species of *Lobaria* from Nepal in his monographic study of Eastern Asian *Lobaria.* Among these four species he reported *L. pseudopulmonaria* (= *L. isidiosa*) from Panchthar district, east Nepal. Bystrek (1969) described 12 species of *Alectoria* from eastern Nepal among them 3 taxa: *A. perspinosa, A.poeltii* and *A. variabilis* were new to science. Lamb (1977) stated that the occurrence of 10 species of *Stereocaulon* in Nepal. Hertel (1977) described 24 saxicolous species from Nepal among which 7 species were new to Science.

Similarly, Awasti & Awasti (1985) studied lichen genera *Alectoria, Bryoria* and *Sulcaria* from India and Nepal. Vitikainen (1986) reported *Peltigera dolichospora*, a new lichenicolous fungus from eastern Nepal. Their altitudinal range was 3000-4100 m. Isotype of *P. dolichospora* was preserved in the Leningrad herbarium (LE). Awasthi & Mathur (1987) published lichen genera *Usnea, Bacidia, Badimia, Fellhanera* and *Mycobilimbia* collected from Nepal. Upreti (1987) prepared a key to 62 species of lichen genus *Cladonia* reported from India and Nepal.

Kurokawa (1988) reported 38 species of genera *Parmelia* (24 species) and *Anaptychia* (14 species) from Kathmandu valley. Similarly, Sharma & Kurokawa, (1990) reported 10 species of *Anaphychia* and 21 species of *Parmelia* from Nepal among which *Parmelia erumpnse* and *Parmelia sinuosa*were new to Nepal. Poelt, (1990) presented a list of roughly 280 lichen taxa as an attached (and commented) list in the doctoral thesis of Georg Miehe, (1990) dealing with vegetation ecology in Langtang area. Another publication, Esslinger &Poelt,(1991) dealing with a soil inhabiting *Parmelia* contains the new description of *Parmelia masonii* (based on specimens of the Langtang and Khumbu region). Altitudinal range of that species was from about 3000m to 5100m and very common to Langtang area and specimens were also collected from Khumbu and Kali Gandaki area of Nepal. Their specimens were preserved in Graz University Herbarium.

Upreti (1987) prepared key to 62 species of lichen genus *Cladonia* reported from Nepal and India. Awasthi (1991 & 2007) consolidated the taxonomic information through detail keys and taxonomic diagnostics for both micro-as well as macrolichens from Nepal, India and Sri Lanka. Pant & Upreti (1993) reported five species of *Diploschistes* from Nepal. These species were *D. bisporus*, *D. muscorum*, *D nepalensis*, *D. rampoddensis* and *D. scruposus*. Sharma (1995) consolidated a checklist of lichens of Nepal including 465 species belonging to 79 genera. Baniya (1996) enumerated 99 taxa of lichens from Shivapuri and Sikles, out of which 33 species were new record to Nepal. Shakya et al. (1997) listed 471 species of lichens of Nepal. Likewise, Pathak (1998) enumerated 52 species of lichens from Hetauda and Dang. Devkota (1999) enumerated 55 species of lichens from Namobuddha, Kavrepalanchok and studied the antibiotic properties of *Heterodermia diademata, Parmelia nepalensis* and *Parmelia reticulata*.

Recent period (2000-2020)

Lichen diversity along elevation gradient has been analyzed intensively in recent years (Baniya & Gupta 2002; Devkota, 2008; Baniya et al., 2010; Rai et al., 2017) as well as lichen diversity along land-use gradients (Nag et al., 2011; Chongbang et al., 2018) and relationship between land use related canopy openness and lichen species richness studied by Chongbang et al. (2018).

A total of 77 lichens species belonging to 28 genera and 25 families and 78 lichen species belonging to 17 genera and 15 families were enumerated by Baniya & Gupta (2002) from an elevation of 2,900 to 3,400 m in Thodimai region of Annapurna conservation area (ACA), and from an elevation of 1,100 to 2,300 m in between Arun river bridge to Tashigaun, buffer zone of Makalu-Barun National Park respectively. From different altitudinal gradients of Phulchoki, extending from 1500 to 2700m above sea level, a total of 32 species of lichens were identified on basis of their morphology, anatomy, color reaction, thin layer chromatography and micro-crystallography (Devkota 2008). Baniya et al. (2010) studied distribution pattern of lichen along the Nepalese Himalayan elevation gradient between 200m to 7400 m from a total of 525 lichen species among which 55 were endemic to Nepal. All growth forms showed unimodal relationship with elevation, crustose lichens showed peak at 4100- 4200m while foliose lichens peaked at 2400-2500m and fructiose lichens peaked at 3200m (Baniya et al., 2010).

Jorgensen & Olley (2010) reported a new species of cyanolichen genus, *Leptogium sphaerosporum* from Langtang region of central Nepal. It was different from other species of genus on having distinctly stalked apothecia, delicate thallus with phyllidia and spheroid ascopores. Holotype was preserved in Royal Botanic Garden Edinburgh Herbarium (E). Similarly, Maccune et al. (2012) reported 17 species of the genus *Hypogymnia* in the Himalayan region of India and Nepal. Olley & Sharma, (2013) published a provisional checklist of the lichens of Nepal, including 792 species belonging to 187 genera.

Baral (2015) identified and reported 68 species of lichens among 448 collected specimens and 13 species among 173 collected specimens from Sagarmatha National Park and Manaslu Conservation Area respectively. From the community forest of Dadeldhura districts, twenty-eight new records of lichenized fungi belonging to 13 families were reported (Rai et al., 2017). These new records were *Acarospora fusca, Arthonia recedens, Bacidia subannexa, Buellia aethalea, Buellia disciformis, Buellia disjecta, Canoparmelia pustulescens, Chrysothrix candelaris, Cladonia coniocraea, Collema cristatum, Endocarpon subrosettum, Graphis chlorotica, Graphis proserpens, Hafellia tetrapla, Herpothallon isidiatum, Heterodermia albidiflava, Heterodermia hypochraea, Hyperphyscia adglutinata, Lecanora luteomarginata, Leptogium platinum, Myelochroa indica, Pyrenula complanata, Pyxine berteriana, Pyxine farinose, Rinodina sophodes, Verrucaria acrotella, Verrucaria margacea* and *Xanthoparmelia australasica*.

From Annapurna Conservation Area, Jha et al. (2017) reported 84 lichen species. Combining with earlier publications on Lobariaceae and based on the specimens collected during three major lichenological field expeditions in 2007, 2009 and 2011-2014, Devkota et al. (2017a) summarized two genera *Lobaria* and *Sticta* each with seven and six species respectively from ten different districts of Nepal viz. Taplejung, Solukhumbu, Rasuwa, Gorkha, Manang, Kaski, Myagdi, Panchthar, Dolakha, and Doti district of Nepal and reported *L. adscripturiens, L. fuscotomentosa* and *S. limbata* as new records for the lichen flora of Nepal. Most of the Lobariaceae species were distributed within the temperate zone of Nepal. *L. isidiosa* had the largest altitudinal range (2662-5004 m), followed by *L. retigera* (2141-4200 m) and *S. praetextata* (2036- 3908 m).

Olley & Sharma (2013) reported *Sticta limbata* from Kyanjin valley (3180 m), Langtang area. Except some species like *L. isidiosa*, which was found in the nival zone (above 5000 m), *L. retigera* and *L. pindarensis*, which was are found in the alpine zone (4000-5000 m) and *Sticta weigelii* and *Lobaria discolor* which were found in subtropical zone (1000-2000 m), the remaining species were found from the temperate to subalpine zone (2000-4000 m). Karmacharya et al. (2018) reported 18 new species belonging to Graphidaceae out of a total 24 documented species of Graphidaceae. Those 18 new species were *Diorygma hieroglyphicum,* *Diorygma junghuhnii, Graphis antillarum, Graphis breussii, Graphis cincta, Graphis cleistoblephara, Graphis galactoderma, Graphis leprographa, Graphis lineola, Graphis paradisserpens, Graphis pertricosa, Graphis pinicola, Graphis stenotera, Graphis subvelata, Pallidogramme chrysenteron, Pallidogramme divaricoides* and *Phaeographis leiogrammodes*. Chongbang et al. (2018) reported 229 lichen species belonging to 71 genera on Ghunsa valley of Eastern Nepal.

Nag et al. (2011) reported 27 epiphytic lichen genera belonging to 13 families from ten land use types of the Dadeldhura community forest, west Nepal. According to Nag et al. (2011) foliose parmeloid were most abundant group, found inhabiting all the phorophytes. Majority of the epiphytic lichens were found influenced by *Quercus leucotrichophora* trees and some lichen genera, such as *Heterodermia* sp., *Parmotrema* sp., *Lepraria* sp. and *Lecanora* sp., were highly confined to *Q. leucotrichophora* trees only. Older stand of *Quercus* harbored maximum diversity of parmeloid lichens while younger stands usually harbored crustose lichens. This difference might be because of difference in bark characteristics of younger and older stand of *Quercus* sp. Similarly, Rai et al. (2017) reported that *Q. leucotrichophora* tree stand of Dadeldhura community forest provided the best habitat for maximum corticolous lichen. They stated that community forests harbor native vegetation of biodiversity conservation and need of further exploration in western Nepal as a region remains largely unexplored and suitable for lichen growth. Nag et al. (2011) concluded that lichen diversity was comparatively higher in primary forest and was increased from outer fringes of the forest to the core whereas Chongbang et al. (2018) reported highest numbers of foliose lichens were from exploited forests followed on natural forests, but the highest number of corticolous species were recorded from natural forests followed by exploited forests. High richness of corticolous lichen in natural forest might be because of high diversity of trees in their natural form in natural forest that could provide semi-shaded habitats and high moisture to corticolous lichen. Chongbang et al. (2018) further added high saxicolous lichen richness in meadows, might be because of a high abundance of rocks which were exposed on meadows. Distribution of lichen communities is significantly affected by substrate types that in turn were dependent on land-use types as well as canopy openness (Chongbang et al., 2018). Total species richness of lichens and richness of specific growth forms, specific substrate types and specific photobiont types, except richness of leprose, muscicolous, terricolous lichens, showed a unimodal relationship with elevation (Bruun et al., 2006; Grytnes et al., 2006; Baniya et al. 2010). However, a significant monotonic increase of total richness of lichens and richness of specific growth forms, specific substrate types and richness of photobiont types with elevation was reported by Chongbang et al. (2018). Difference in pattern may be because of difference in scale of study as they differed in range of elevation gradient. Latter study was confined at a smaller and former study was at a larger elevational gradient. Thus in recent period along with identification and documentation, lichenologist were also interested to study affect of various factors like land use type, canopy openness and closeness, elevation gradient on lichen diversity.

Number of taxa published by time period

Compilation from published literature showed total lichenized-fungi found in Nepal is 873 (805 species, 46 varieties, 10 subspecies, 12 forma) belonging to 185 genera and 61 families. (Olley & Sharma 2013; Rai et al. 2017; Devkota et al. 2017 & Karmacharya et al. 2018) (Table 1). Most dominant family is Parmeliaceae (222 taxa) followed by Physciaceae (90 taxa), Lecanoraceae (62 taxa), Teloschistaceae (53 taxa), Cladoniaceae (42 taxa), Caliciaceae (40 taxa), Collemataceae (38), Graphidiaceae (36 taxa), Ramalinaceae (28 taxa), Lecideaceae (24 taxa), Stereocaulaceae (20 taxa) and so on (Figure 3). However, documentation of each taxon needed to be reconfirmed as data given by Olley & Sharma (2013) in article is different than the no. of taxa given in list belonging to same article. In this review, no. of taxa given by Olley and Sharma (2013) in list has been followed. Similarly three species (*Heterodermia albidiflava, Hyperphysica adglutinata* and *Pyxine berteriana*) reported by Rai et al. (2017) as new records of Nepal were already given by Olley and Sharma (2013) in Provisional Checklist of Lichens of Nepal. In addition, based on previous published research work, it was found that majority of lichen exploration were done in Central Nepal followed by Eastern and Western part of Nepal. Little work was done in Western part of Nepal. Lichens from the lowland Terai and Siwalik hills were also largely missing. Record of twenty eight new species from a single community forest of Dadeldhura district by Rai et al., (2017) can be discussed in light of less explored and lichen rich Western region of Nepal. So lichen exploratory work in Western region as well as lowland Terai is necessary.

All published literature revealed that there was a progressive increase in number of lichen species as a common trend to other fields of study. In Nepal, lichen diversity published was from 465 taxa belonging to 79 genera in 1995 (Sharma 1995) to 828 taxa belonging 179 genera in 2013 (Olley and Sharma, 2013) and 873 taxa belonging to 185 genera in 2020 (Olley and Sharma, 2013, Rai et al., 2016, Devkota et al. 2017, Karmacharya et al. 2018, Figure 1). Among total recorded lichen species foliose was the most dominant (45%) life form followed by crustose (39%) and fruticose lichen (17%) (Baniya 2020, Figure 2). Occurrence of higher percentage of foliose lichen might be of large number of temperate broad-leaved and coniferous trees with bark differing in roughness, moisture retention capacity and pH that present a wide variety of habitats in middle elevation range. Foliose lichens are found in middle elevation (Baniya et al., 1999) where temperate zone with extremely large local variations in water availability and the accompanying gradients in vegetation cover favors lichen growth. The zone with maximum lichen richness also represents the temperate zone (Baniya et al., 2010).

In context of Nepal, little work was done analyzing lichen at different land use types, different canopy openness and in field of lichen host specificity which are very important to incorporate in research work to conserve lichen diversity. Lichen species, although had wider distribution than vascular and other cryptogams, were influenced greatly by changes in land-use (Stofer et al., 2006) and among the various growth forms, foliose (i.e. parmeloid lichens) was considered as most sensitive to land-use changes (Saipunkaew et al., 2007). Rapid land use change for agriculture and urbanization results deforestation and habitat fragmentation following habitat degradation are among the various

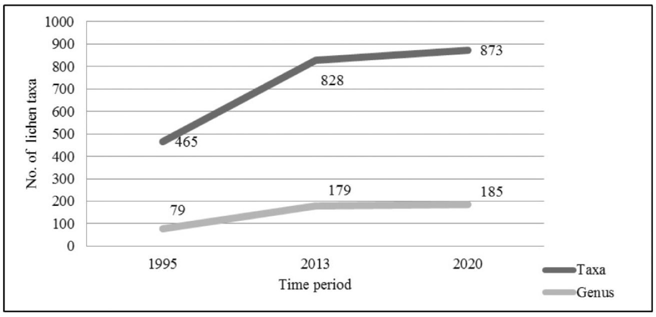

Figure 1: Increase in number of lichen species and genera in different time periods

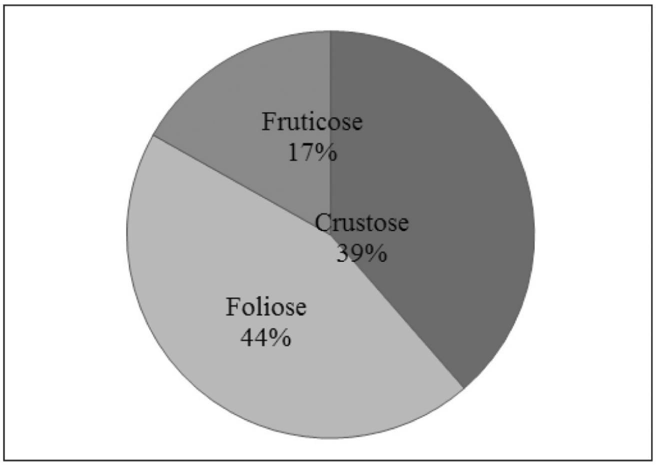

Figure 2: Different life-form of lichen published (Baniya 2020)

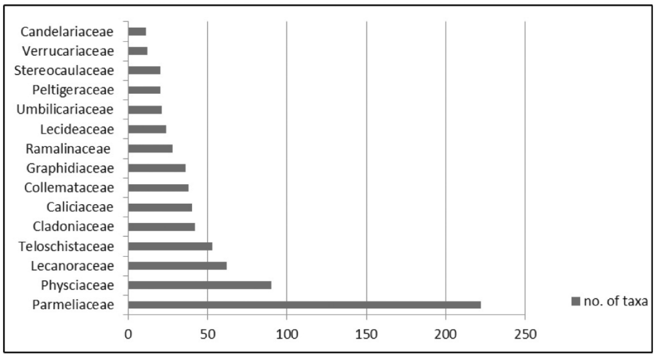

Figure 3: Lichen exploration in different developmental regions of Nepal

causes which were responsible for rapid depletion of lichen diversity (Vinayaka 2016). Epiphytic lichen diversity was found variously influenced by phorophyte age, ambient air quality, and change in neighborhood land-cover (Saipunkaew et al., 2005; Pinokiyo et al., 2008). Research on the occurrence of lichens in relation to host species seemed very urgent in Nepal (Baniya et al., 1999). According to Nag et al., (2011), the preferential distribution of lichens on any phorophyte is indicative of dominant status of this tree species and its lichen-supporting bark characteristics (e.g. pH, roughness and water retention capacity). But further works on bark characteristics of phorophyte was lacking. Research work on lichen and their host specificity might help to know which host plant is habitat of different lichen species, which host plants are most important for rare corticolous lichens and thus it will contribute in scientific management of forest through recommendation of these plants during afforestation program as well as provide scientific reason to restrict to cut particular plants from forest and thus might contribute to conserve and enhance lichen diversity.

Lichens are one among the protected medicinal plant. According to Kala (2003) lichens were one of the major traded MAPs of Baitadi till 2011. For the regulation of lichen trade from Nepal, the Government of Nepal has imposed many provisions. According to Rule 11 of Forest Regulations, 1995, for collection of lichen from any forest area, application to the authorized officer should be submitted mentioning area of collection, the quantatity and the purpose of collection. As mentioned in Annex 3 of Forest Regulation, 1995, charges for lichens collection is 10/ kg. The Authorized Officer tally the lichen collected according to the Licence issued for their, check their quantities and collect fees as prescribed in Annex-3. Despite the present regulations on lichen collection, illegal coolection and trade of lichens with no documentation of population sizes, carrying capacity of forests or species identities, and no application of scientific tools or management are going on (Devkota et al., 2017b).

Conclusion

Present study reviewed lichen research works done in Nepal till 2020. Many geographical parts of Nepal especially the lowland Terai, Siwalik Hills and almost whole western Nepal remain largely unexplored. Although, in early and mid period of lichen exploration, major contribution was given by foreign lichenologists, in recent period many Nepalese lichenologists are active to explore different parts of Nepal. However many research works are limited up to collection, identification and documentation. Altogether 873 taxa including 805 species, 46 varieties, 10 subspecies, 12 forma belonging to 185 genera and 61 families have been recorded based on previous published literatures. Host lichen specificity and relationship between species richness and environmental variables have not much focused yet. These types of studies are important to explore.

Author Contributions

Both the authors have contributed in giving final shape of this article. Dr. C. B. Baniya is a corresponding author as well as guarantor for this article.

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Table 1: List of taxa of Lichens of Nepal based on Olley and Sharma (2013), Rai et al. (2016), Devkota et al. (2017a) and Karmacharya et al. (2018)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
1	*Acroscyphus sphaerophoroides* Lév.		Caliciaceae	Olley and Sharma (2013)
2	*Acarospora fusca* B. de Lesd		Acarosporaceae	Rai et al. (2016)
3	*Agonimia tristicula* (Nyl.) Zahlbr.		Verrucariaceae	Olley and Sharma (2013)
4	*Alectoria himalayana* Motyka		Parmeliaceae	Olley and Sharma (2013)
5	*Alectoria jubata* Ach.		Parmeliaceae	Olley and Sharma (2013)
6	*Alectoria ochroleuca* (Hoffm.) A.Massal.		Parmeliaceae	Olley and Sharma (2013)
7	*Alectoria sarmentosa* (Ach.) Ach.		Parmeliaceae	Olley and Sharma (2013)
8	*Allocetraria ambigua* (C.Bab.) Kurok. & M.J.Lai		Parmeliaceae	Olley and Sharma (2013)
9	*Allocetraria flavonigrescens* Thell. & Randlane	*Cetraria flavonigrescens* (A.Thell & Randlane) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
10	*Allocetraria globulans* (Nyl.) Thell. & Randlane		Parmeliaceae	Olley and Sharma (2013)
11	*Allocetraria oakesiana* (Tuck.) Randlane & Thell.	*Usnocetraria oakesiana* (Tuck.) M.J.Lai & J.C.Wei	Parmeliaceae	Olley and Sharma (2013)
12	*Allocetraria sinensis* X.Q.Gao	*Cetraria sinensis* (X.Q.Gao) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
13	*Allocetraria stracheyi* (Bab.) Kurok. & M.J. Lai	*Nephromopsis stracheyi* (C.Bab.) Müll.Arg.	Parmeliaceae	Olley and Sharma (2013)
14	*Amandinea punctata* (Hoffm.) Coppins & Schied.		Caliciaceae	Olley and Sharma (2013)
15	*Amygdalaria aeolotera* (Vain.) Hertel & Brodo		Lecideaceae	Olley and Sharma (2013)
16	*Anamylopsora pulcherrima* (Vain.) Timdal		Baeomycetaceae	Olley and Sharma (2013)
17	*Anaptychia boryi* (Fée) A.Massal.	*Leucodermia boryi* (Fée) Kalb	Physciaceae	Olley and Sharma (2013)
18	*Anaptychia bryorum* Poelt		Physciaceae	Olley and Sharma (2013)
19	*Anaptychia chondroidea* (W.A.Weber & D.D.Awasthi) Kurok.	*Heterodermia chondroidea* W.Weber & Awasthi	Physciaceae	Olley and Sharma (2013)
20	*Anaptychia dectyliza* forma serpens (Vain.) Kurok.		Physciaceae	Olley and Sharma (2013)
21	*Anaptychia esorediata* (Vain.) Du Rietz & Lynge		Physciaceae	Olley and Sharma (2013)
22	*Anaptychia firmula* (Nyl.) C.W.Dodge & D.D. Awasthi		Physciaceae	Olley and Sharma (2013)
23	*Anaptychia hypoleuca* var. diademata (Tayl.) Zahlbr.		Physciaceae	Olley and Sharma (2013)
24	*Anaptychia isidiophora* (Nyl.) Vain.	*Heterodermia isidiophora* (Nyl.) D.D.Awasthi	Physciaceae	Olley and Sharma (2013)
25	*Anaptychia leucomelaena* var. angustifolia (Meyen & Flot.) Müll. Arg.		Physciaceae	Olley and Sharma (2013)
26	*Anaptychia neoleucomelaena* forma squarrosa (Vain.) Kurok.		Physciaceae	Olley and Sharma (2013)
27	*Anaptychia pseudospeciosa* var. tremulans (Müll. Arg.) Kurok.		Physciaceae	Olley and Sharma (2013)
28	*Anaptychia speciosa* forma compactior Zahlbr.		Physciaceae	Olley and Sharma (2013)
29	*Anisomeridium* sp.		Monoblastiaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
30	*Anthracothecium himalayense* (Räsänen) D.D.Awasthi		Pyrenulaceae	Olley and Sharma (2013)
31	*Anthracothecium leucostomum* Ach.		Pyrenulaceae	Olley and Sharma (2013)
32	*Arctocetraria nigricascens* (Nyl.) Karnefelt & Thell.	*Nephromopsis nigricascens* (Nyl.) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
33	*Arctoparmelia subcentrifuga* (Oxner) Hale		Parmeliaceae	Olley and Sharma (2013)
34	*Arthonia destruens* var. *nana* Grube & Hafellner		Arthoniaceae	Olley and Sharma (2013)
35	*Arthonia recedens* Stirt.		Arthoniaceae	Rai et al. (2016)
36	*Arthrorhaphis alpina* (Schaer.) R.Sant.		Arthrorhaphidaceae	Olley and Sharma (2013)
37	*Arthrorhaphis citrinella* (Ach.) Poelt		Arthrorhaphidaceae	Olley and Sharma (2013)
38	*Arthrorhaphis vacillans* Th.Fr. & Almq. ex Th.Fr.		Arthrorhaphidaceae	Olley and Sharma (2013)
39	*Aspicilia cinerea* (L.) Körb.		Megasporaceae	Olley and Sharma (2013)
40	*Awasthia melanotricha* (D.D.Awasthi) Essl.		Physciaceae	Olley and Sharma (2013)
41	*Bacidia millegrana* var. *millegrana* (Taylor) Zahlbr.		Ramalinaceae	Olley and Sharma (2013)
42	*Bacidia nigrofusca* (Müll.Arg.) Zahlbr.		Ramalinaceae	Olley and Sharma (2013)
43	*Bacidia personata* Malme		Ramalinaceae	Olley and Sharma (2013)
44	*Bacidia rubella* (Hoffm.) A.Massal.		Ramalinaceae	Olley and Sharma (2013)
45	*Bacidia subannexa* (Nyl.) Zahlbr		Ramalinaceae	Rai et al. (2016)
46	*Bacidia spadicea* (Ach.) Zahlbr.		Ramalinaceae	Olley and Sharma (2013)
47	*Bacidia subincompta* (Nyl.) Arnold	*Toniniopsis subincompta* (Nyl.) Kistenich, Timdal, Bendiksby & S.Ekman	Ramalinaceae	Olley and Sharma (2013)
48	*Bacidia vermifera* (Nyl.) Th.Fr.	*Bibbya vermifera* (Nyl.) Kistenich, Timdal, Bendiksby & S.Ekman	Ramalinaceae	Olley and Sharma (2013)
49	*Baeomyces pachypus* Nyl.		Baeomycetaceae	Olley and Sharma (2013)
50	*Baeomyces placophyllus* (Lam.) Ach.		Baeomycetaceae	Olley and Sharma (2013)
51	*Baeomyces roseus* Pers.	*Dibaeis rosea* (Pers.) Clem.	Icmadophilaceae	Olley and Sharma (2013)
52	*Bellemerea cinereorufescens* (Ach.) Clauzade & Cl.Roux		Lecideaceae	Olley and Sharma (2013)
53	*Biatora carneoalbida* (Müll.Arg.) Coppins		Ramalinaceae	Olley and Sharma (2013)
54	*Bryonora castanea* var. *castanea* (E. Hepp) Poelt		Lecanoraceae	Olley and Sharma (2013)
55	*Bryonora castanea* var. *euryspora* Poelt & Obermayer		Lecanoraceae	Olley and Sharma (2013)
56	*Bryonora curvescens* (Mudd) Poelt		Lecanoraceae	Olley and Sharma (2013)
57	*Bryonora pulvinar* var. *microspora* Poelt & Obermayer		Lecanoraceae	Olley and Sharma (2013)
58	*Bryonora pulvinar* var. *pulvinar* Poelt & Obermayer		Lecanoraceae	Olley and Sharma (2013)
59	*Bryonora reducta* Poelt & H. Mayrhofer		Lecanoraceae	Olley and Sharma (2013)
60	*Bryonora rhypariza* var. *cyanotropha* Poelt & H. Mayrhofer		Lecanoraceae	Olley and Sharma (2013)
61	*Bryonora rhypariza* var. *lamaina* Poelt		Lecanoraceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
62	Bryonora rhyparizа var. rhyparizа (Nyl.) Poelt		Lecanoraceae	Olley and Sharma (2013)
63	*Bryonora selenospora* Poelt & H. Mayrhofer	*Bryodina selenospora* (Poelt & H. Mayrhofer) Hafellner	Lecanoraceae	Olley and Sharma (2013)
64	*Bryonora stipitata* Poelt		Lecanoraceae	Olley and Sharma (2013)
65	*Bryonora yeti* Poelt		Lecanoraceae	Olley and Sharma (2013)
66	*Bryoria acanthodes* (Hue) Bystrek	Alectoria acanthodes Hue	Parmeliaceae	Olley and Sharma (2013)
67	*Bryoria bicolor* (Ehrh.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
68	*Bryoria confusa* (D.D.Awasthi) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
69	*Bryoria furcellata* (Fr.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
70	*Bryoria himalayana* (Motyka) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
71	*Bryoria implexa* (Hoffm.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
72	*Bryoria lactinea* (Nyl.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
73	*Bryoria lanestris* (Ach.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
74	*Bryoria levis* Awas.		Parmeliaceae	Olley and Sharma (2013)
75	*Bryoria nadvornikiana* (Gyeln.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
76	*Bryoria nepalensis* Awas.		Parmeliaceae	Olley and Sharma (2013)
77	*Bryoria nitidula* (Th.Fr.) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
78	*Bryoria perspinosa* (Bystrek) Brodo & D. Hawksw.		Parmeliaceae	Olley and Sharma (2013)
79	*Bryoria poeltii* (Bystrek) Brodo & D.Hawksw.		Parmeliaceae	Olley and Sharma (2013)
80	*Bryoria smithii* (Du Rietz) Brodo & D.Hawksw.		Parmeliaceae	Olley and Sharma (2013)
81	*Bryoria tenuis* (Å.E.Dahl) Brodo & D.Hawksw.		Parmeliaceae	Olley and Sharma (2013)
82	*Bryoria variabilis* (Bystrek) Bystrek		Parmeliaceae	Olley and Sharma (2013)
83	*Buellia aethalea* (Ach.) Th. Fr		Caliciaceae	Rai et al. (2016)
84	*Buellia disciformis* (Fr.) Mudd		Caliciaceae	Rai et al. (2016)
85	*Buellia disjecta* Zahlbr		Caliciaceae	Rai et al. (2016)
86	*Buellia elegans* Poelt & Sulzer		Caliciaceae	Olley and Sharma (2013)
87	*Buellia geophila* (Flörke) Lynge		Caliciaceae	Olley and Sharma (2013)
88	*Buellia granularis* Müll.Arg.		Caliciaceae	Olley and Sharma (2013)
89	*Buellia inornata* (Stirt.) Zahlbr.		Caliciaceae	Olley and Sharma (2013)
90	*Buellia papillata* (Sommerf.) Tuck.	*Tetramelas papillatus* (Sommerf.) Kalb	Caliciaceae	Olley and Sharma (2013)
91	*Buellia schaereri* De Not.		Caliciaceae	Olley and Sharma (2013)
92	*Bulbothrix isidiza* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
93	*Bulbothrix meizospora* ((Nyl.) Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
94	*Bulbothrix setschwanensis* (Zahlbr.) Hale		Parmeliaceae	Olley and Sharma (2013)
95	*Bulbothrix tabacina* (Mont. & Bosch) Hale		Parmeliaceae	Olley and Sharma (2013)
96	*Calicium abietinum* Pers.		Caliciaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
97	*Calicium chlorosporum* F.Wilson		Caliciaceae	Olley and Sharma (2013)
98	*Calicium lenticulare* Ach.		Caliciaceae	Olley and Sharma (2013)
99	*Calicium nobile* Tibell		Caliciaceae	Olley and Sharma (2013)
100	*Calicium parvum* Tibell		Caliciaceae	Olley and Sharma (2013)
101	*Calicium quercinum* Pers.		Caliciaceae	Olley and Sharma (2013)
102	*Calicium salicinum* Pers.		Caliciaceae	Olley and Sharma (2013)
103	*Calicium verrucosum* Tibell		Caliciaceae	Olley and Sharma (2013)
104	*Calicium viride* Pers.		Caliciaceae	Olley and Sharma (2013)
105	*Caloplaca arnoldii* (Wedd.) Zahlbr. ex Ginzb.		Teloschistaceae	Olley and Sharma (2013)
106	*Caloplaca aureosora* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
107	*Caloplaca borealis* var. *borealis* Poelt		Teloschistaceae	Olley and Sharma (2013)
108	*Caloplaca borealis* var. *oligosperma* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
109	*Caloplaca castellana* (Räsänen) Poelt	*Pachypeltis castellana* (Räsänen) Søchting, Frödén & Arup	Teloschistaceae	Olley and Sharma (2013)
110	*Caloplaca cerina* var. *cerina* (Ehrh. ex Hedw.) Th.Fr.		Teloschistaceae	Olley and Sharma (2013)
111	*Caloplaca cerina* var. *chloroleuca* (Sm.) Th.Fr.		Teloschistaceae	Olley and Sharma (2013)
112	*Caloplaca cerinopsis* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
113	*Caloplaca cirrochroa* (Ach.) Th.Fr.		Teloschistaceae	Olley and Sharma (2013)
114	*Caloplaca cirrochroopsis* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
115	*Caloplaca citrina* (Hoffm.) Th.Fr.	*Flavoplaca citrina* (Hoffm.) Arup, Frödén & Søchting	Teloschistaceae	Olley and Sharma (2013)
116	*Caloplaca cupreobrunnea* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
117	*Caloplaca cupulata* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
118	*Caloplaca epiphyta* Lynge	*Gyalolechia epiphyta* (Lynge) Vondrák	Teloschistaceae	Olley and Sharma (2013)
119	*Caloplaca epithallina* Lynge		Teloschistaceae	Olley and Sharma (2013)
120	*Caloplaca exsecuta* var. *aphanes* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
121	*Caloplaca farinosa* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
122	*Caloplaca flavorubescens* (Huds.) J.R. Laundon	*Gyalolechia flavorubescens* (Huds.) Søchting, Frödén & Arup	Teloschistaceae	Olley and Sharma (2013)
123	*Caloplaca frigida* (Paulson) Zahlbr.		Teloschistaceae	Olley and Sharma (2013)
124	*Caloplaca grimmiae* (Nyl.) H.Olivier		Teloschistaceae	Olley and Sharma (2013)
125	*Caloplaca holocarpa* A.E.Wade	*Athallia holocarpa* (Hoffm.) Arup, Frödén & Søchting	Teloschistaceae	Olley and Sharma (2013)
126	*Caloplaca holochracea* (Nyl.) Zahlbr.		Teloschistaceae	Olley and Sharma (2013)
127	*Caloplaca insularis* Poelt		Teloschistaceae	Olley and Sharma (2013)
128	*Caloplaca isabellina* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
129	*Caloplaca leptocheila* H. Magn		Teloschistaceae	Olley and Sharma (2013)
130	*Caloplaca lithophila* H. Magn		Teloschistaceae	Olley and Sharma (2013)
131	*Caloplaca lobulascens* Poelt & E.		Teloschistaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	Hinteregger			
132	*Caloplaca lypera* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
133	*Caloplaca maura* Poelt & E.Hinteregger		Teloschistaceae	Olley and Sharma (2013)
134	*Caloplaca obliterans* (Nyl.) Blomb. & Forssell	*Leproplaca obliterans* (Nyl.) Arup, Frödén & Søchting	Teloschistaceae	Olley and Sharma (2013)
135	*Caloplaca ochroplaca* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
136	*Caloplaca phoenicopt*a Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
137	*Caloplaca praeruptorum* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
138	*Caloplaca procerispora* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
139	*Caloplaca rinodinopsis* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
140	*Caloplaca sancta* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
141	*Caloplaca saxicola* var. *chamaeleon* Poelt & E. Hinteregger		Teloschistaceae	Olley and Sharma (2013)
142	*Caloplaca saxicola* var. *saxicola* Nordin		Teloschistaceae	Olley and Sharma (2013)
143	*Caloplaca saxifragarum* Poelt	*Athallia saxifragarum* (Poelt) Arup, Frödén & Søchting	Teloschistaceae	Olley and Sharma (2013)
144	*Caloplaca tetraspora* (Nyl.) H.Olivier	*Bryoplaca tetraspora* (Nyl.) Søchting, Frödén & Arup	Teloschistaceae	Olley and Sharma (2013)
145	*Caloplaca ulcerata* de Lesd.		Teloschistaceae	Olley and Sharma (2013)
146	*Caloplaca variabilis* (Pers.) Müll.Arg.	*Pyrenodesmia variabilis* (Pers.) A.Massal.	Teloschistaceae	Olley and Sharma (2013)
147	*Calvitimela aglaea* (Sommerf.) Hafellner		Tephromelataceae	Olley and Sharma (2013)
148	*Calvitimela armeniaca* (DC.) Hafellner		Tephromelataceae	Olley and Sharma (2013)
149	*Candelaria crawfordii* P.M. Jørg. & Galloway		Candelariaceae	Olley and Sharma (2013)
150	*Candelaria sphaerobola* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
151	*Candelariella aurella* forma *aurella* (Hoffm.) Zahlbr.		Candelariaceae	Olley and Sharma (2013)
152	*Candelariella coralliza* (Nyl.) H.Magn		Candelariaceae	Olley and Sharma (2013)
153	*Candelariella grimmiae* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
154	*Candelariella himalayana* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
155	*Candelariella nepalensis* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
156	*Candelariella sorediosa* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
157	*Candelariella vitellina* forma *vitellina* (Ehrh.) Müll. Arg.		Candelariaceae	Olley and Sharma (2013)
158	*Candelariella vitellina* var. *glacialis* Poelt & Reddi		Candelariaceae	Olley and Sharma (2013)
159	*Candelariella xanthostigma* (Pers. ex		Candelariaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	Ach.) Lettau			
160	*Canomaculina subsumpta* (Nyl.) Elix	*Parmotrema subsumptum* (Nyl.) Hale	Parmeliaceae	Olley and Sharma (2013)
161	*Canomaculina subtinctoria* (Zahlbr.) Elix	*Parmotrema subtinctorium* (Zahlbr.) Hale	Parmeliaceae	Olley and Sharma (2013)
162	*Canoparmelia aptata* (Kremp.) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
163	*Canoparmelia ecaperata* (Müll.Arg.) Elix & Hale	*Pseudoparmelia ecaperata* (Müll.Arg.) Hale	Parmeliaceae	Olley and Sharma (2013)
164	*Canoparmelia eruptens* (Kurok.) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
165	*Canoparmelia pustulescens* (Kurok.) Elix		Parmeliaceae	Rai et al. (2016)
166	*Carbonea assimilis* ((Körb.) Th.Fr.) Hafellner & Hertel		Lecanoraceae	Olley and Sharma (2013)
167	*Carbonea vitellinaria* (Nyl.) Hertel		Lecanoraceae	Olley and Sharma (2013)
168	*Carbonea vorticosa* (Flörke) Hertel		Lecanoraceae	Olley and Sharma (2013)
169	*Catapyrenium cinereum* (Pers.) Körb.		Verrucariaceae	Olley and Sharma (2013)
170	*Catapyrenium daedalium* (Kremp.) Stein		Verrucariaceae	Olley and Sharma (2013)
171	*Catapyrenium squamulosum* (Ach.) Breuss		Verrucariaceae	Olley and Sharma (2013)
172	*Catillaria leptocheiloides* (Nyl.) Zahlbr.		Catillariaceae	Olley and Sharma (2013)
173	*Catillaria sikkimensis* (Müll.Arg.) Zahlbr.		Catillariaceae	Olley and Sharma (2013)
174	*Catolechia wahlenbergii* (Flot. ex Ach.) Körb.		Rhizocarpaceae	Olley and Sharma (2013)
175	*Cetraria aculeata* (Schreb.) Fr.		Parmeliaceae	Olley and Sharma (2013)
176	*Cetraria collata* forma *isidiata* Asahina		Parmeliaceae	Olley and Sharma (2013)
177	*Cetraria crispa* var. *japonica* Asahina ex M.Satô		Parmeliaceae	Olley and Sharma (2013)
178	*Cetraria delavayi* (Hue) M.Satô	*Nephromopsis delavayi* Hue	Parmeliaceae	Olley and Sharma (2013)
179	*Cetraria ericetorum* Opiz		Parmeliaceae	Olley and Sharma (2013)
180	*Cetraria everniella* forma *subteres* Asahina		Parmeliaceae	Olley and Sharma (2013)
181	*Cetraria islandica* (L.) Ach.		Parmeliaceae	Olley and Sharma (2013)
182	*Cetraria laevigata* Rass.		Parmeliaceae	Olley and Sharma (2013)
183	*Cetraria nepalensis* Awas.		Parmeliaceae	Olley and Sharma (2013)
184	*Cetraria nephromoides* (Nyl.) D.D.Awasthi	*Nephromopsis nephromoides* (Nyl.) Ahti & Randlane	Parmeliaceae	Olley and Sharma (2013)
185	*Cetraria nigricans* var. *himalayana* Asahina		Parmeliaceae	Olley and Sharma (2013)
186	*Cetrariopsis pallescens* (Schaer.) Thell. & Randlane		Parmeliaceae	Olley and Sharma (2013)
187	*Cetrariopsis wallichiana* (Tayl.) Kurok.		Parmeliaceae	Olley and Sharma (2013)
188	*Cetrelia braunsiana* (Müll.Arg.) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
189	*Cetrelia cetrarioides* (Delise) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
190	*Cetrelia collata* (Nyl.) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
191	*Cetrelia isidiata* (Asahina) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
192	*Cetrelia nuda* (Hue) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
193	*Cetrelia olivetorum* (Nyl.) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
194	*Cetrelia pseudolivetorum* (Asahina) W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
195	*Cetrelia sanguinea* (W.L.Culb. & C.F.Culb.) Schaer.		Parmeliaceae	Olley and Sharma (2013)
196	*Cetrelia sinensis* W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
197	*Cetreliopsis endoxanthoides* (D.D.Awasthi) Randlane & Saag		Parmeliaceae	Olley and Sharma (2013)
198	*Cetreliopsis laeteflava* (Zahlbr.) Randlane & Saag	*Nephromopsis laeteflava* (Zahlbr.) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
199	*Cetreliopsis rhytidocarpa* (Mont. & Bosch) M.J.Lai		Parmeliaceae	Olley and Sharma (2013)
200	*Cetreliopsis rhytidocarpa* subsp. *langtanii* Randlane & Saag		Parmeliaceae	Olley and Sharma (2013)
201	*Chaenotheca brunneola* (Ach.) Müll.Arg.		Coniocybaceae	Olley and Sharma (2013)
202	*Chaenotheca chlorella* (Ach.) Müll.Arg.		Coniocybaceae	Olley and Sharma (2013)
203	*Chaenotheca chrysocephala* (Turner ex Ach.) Th.Fr.		Coniocybaceae	Olley and Sharma (2013)
204	*Chaenotheca furfuracea* (L.) Tibell		Coniocybaceae	Olley and Sharma (2013)
205	*Chaenotheca hispidula* (Ach.) Zahlbr.		Coniocybaceae	Olley and Sharma (2013)
206	*Chaenotheca phaeocephala* (Turner) Th.Fr.		Coniocybaceae	Olley and Sharma (2013)
207	*Chaenotheca phaeocephala* subsp. *alpina* (Nádv.) Alb.Schmidt		Coniocybaceae	Olley and Sharma (2013)
208	*Chaenotheca stemonea* (Ach.) Müll.Arg.		Coniocybaceae	Olley and Sharma (2013)
209	*Chaenotheca trichialis* (Ach.) Th.Fr.		Coniocybaceae	Olley and Sharma (2013)
210	*Chaenothecopsis consociata* (Nádv.) Alb.Schmidt		Mycocaliciaceae	Olley and Sharma (2013)
211	*Chaenothecopsis nana* Tibell		Mycocaliciaceae	Olley and Sharma (2013)
212	*Chaenothecopsis nigra* Tibell		Mycocaliciaceae	Olley and Sharma (2013)
213	*Chaenothecopsis pusilla* (Ach.) A.F.W.Schmidt		Mycocaliciaceae	Olley and Sharma (2013)
214	*Chaenothecopsis savonica* (Räsänen) Tibell		Mycocaliciaceae	Olley and Sharma (2013)
215	*Chaenothecopsis viridialba* (Kremp.) A.F.W.Schmidt		Mycocaliciaceae	Olley and Sharma (2013)
216	*Chrysothrix chlorina* (Ach.) J.R. Laundon		Chrysotrichaceae	Olley and Sharma (2013)
217	*Chrysothrix candelaris* (L.) J.R. Laundon		Chrysothrichaceae	Rai et al. (2016)
218	Cladia aggregata (Sw.) Nyl.		Cladoniaceae	Olley and Sharma (2013)
219	*Cladina arbuscula* subsp. *beringiana* (Ahti) N.S.Golubk.		Cladoniaceae	Olley and Sharma (2013)
220	*Cladonia amaurocraea* (Flörke)		Cladoniaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	Schaer.			
221	*Cladonia arbuscula* (Wallr.) Hale & W.L.Culb.		Cladoniaceae	Olley and Sharma (2013)
222	*Cladonia awasthiana* Ahti & Upreti		Cladoniaceae	Olley and Sharma (2013)
223	*Cladonia calyciformis* Nuno		Cladoniaceae	Olley and Sharma (2013)
224	*Cladonia cariosa* (Ach.) Spreng.		Cladoniaceae	Olley and Sharma (2013)
225	*Cladonia carneola* (Fr.) Fr.		Cladoniaceae	Olley and Sharma (2013)
226	*Cladonia cartilaginea* Müll.Arg.		Cladoniaceae	Olley and Sharma (2013)
227	*Cladonia ceratophyllina* (Nyl.) Vain.		Cladoniaceae	Olley and Sharma (2013)
228	*Cladonia chlorophaea* (Flörke ex Sommerf.) Spreng.		Cladoniaceae	Olley and Sharma (2013)
229	*Cladonia ciliata* var. *tenuis* (Flörke) Nimis		Cladoniaceae	Olley and Sharma (2013)
230	*Cladonia coccifera* (L.) Willd.		Cladoniaceae	Olley and Sharma (2013)
231	*Cladonia coniocraea* (Flo¨rke) Spreng.		Cladoniaceae	Rai et al. (2016)
232	*Cladonia corniculata* Ahti & Kashiw.		Cladoniaceae	Olley and Sharma (2013)
233	*Cladonia corymbescens* Nyl. ex F.M.Leight.		Cladoniaceae	Olley and Sharma (2013)
234	*Cladonia delavayi* Abbayes		Cladoniaceae	Olley and Sharma (2013)
235	*Cladonia didyma* (Fée) Vain.		Cladoniaceae	Olley and Sharma (2013)
236	*Cladonia fenestralis* Nuno		Cladoniaceae	Olley and Sharma (2013)
237	*Cladonia fimbriata* var. *ambigua* Asahina		Cladoniaceae	Olley and Sharma (2013)
238	*Cladonia fruticulosa* Kremp.		Cladoniaceae	Olley and Sharma (2013)
239	*Cladonia furcata* (Huds.) Schrad.		Cladoniaceae	Olley and Sharma (2013)
240	*Cladonia laii* S.Stenroos		Cladoniaceae	Olley and Sharma (2013)
241	*Cladonia luteoalba* Wheldon & A.Wilson		Cladoniaceae	Olley and Sharma (2013)
242	*Cladonia macilenta* (Hoffm.) Nyl.		Cladoniaceae	Olley and Sharma (2013)
243	*Cladonia macilenta* var. *bacillaris* (Genth) Schaer.		Cladoniaceae	Olley and Sharma (2013)
244	*Cladonia macroptera* Räsänen		Cladoniaceae	Olley and Sharma (2013)
245	*Cladonia mongolica* Ahti		Cladoniaceae	Olley and Sharma (2013)
246	*Cladonia nitens* Ahti		Cladoniaceae	Olley and Sharma (2013)
247	*Cladonia ochrochlora* Flörke		Cladoniaceae	Olley and Sharma (2013)
248	*Cladonia pocillum* (Ach.) Grognot		Cladoniaceae	Olley and Sharma (2013)
249	*Cladonia pyxidata* (L.) Hoffm.		Cladoniaceae	Olley and Sharma (2013)
250	*Cladonia ramulosa* (With.) J.R. Laundon		Cladoniaceae	Olley and Sharma (2013)
251	*Cladonia rangiferina* (L.) Weber ex F.H.Wigg.		Cladoniaceae	Olley and Sharma (2013)
252	*Cladonia scabriuscula* (Delise) Nyl.		Cladoniaceae	Olley and Sharma (2013)
253	*Cladonia singhii* Ahti & R.D.Dixit		Cladoniaceae	Olley and Sharma (2013)
254	*Cladonia squamosa* Rabenh.		Cladoniaceae	Olley and Sharma (2013)
255	*Cladonia squamosa* var. *subsquamosa* (Nyl.) Th.Fr.		Cladoniaceae	Olley and Sharma (2013)
256	*Cladonia stellaris* (Opiz) Pouzar & Vezda		Cladoniaceae	Olley and Sharma (2013)
257	*Cladonia subconistea* Asahina		Cladoniaceae	Olley and Sharma (2013)
258	*Cladonia yunnana* (Vainio) des Abb.		Cladoniaceae	Olley and Sharma (2013)
259	*Cliostomum leprosum* (Räsänen) Holien & Tønsberg		Ramalinaceae	Olley and Sharma (2013)
260	*Coccocarpia erythroxyli* (Spreng.)		Ramalinaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	Swinscow & Krog			
261	*Coccocarpia palmicola* (Spreng.) Arv. & Galloway		Coccocarpiaceae	Olley and Sharma (2013)
262	*Coccocarpia pellita* (Ach.) Müll.Arg.		Coccocarpiaceae	Olley and Sharma (2013)
263	*Coenogonium moniliforme* Tuck.		Coenogoniaceae	Olley and Sharma (2013)
264	*Coenogonium subluteum* (Rehm) Kalb & Lücking		Coenogoniaceae	Olley and Sharma (2013)
265	*Collema callibotrys* var. callibotrys Tuck.		Collemataceae	Olley and Sharma (2013)
266	*Collema callibotrys* var. coccophyllizum (Zahlbr.) Degel.		Collemataceae	Olley and Sharma (2013)
267	*Collema cristatum* (L.) Weber ex F.H. Wigg.		Collemataceae	Rai et al. (2016)
268	*Collema japonicum* (Müll.Arg.) Hue		Collemataceae	Olley and Sharma (2013)
269	*Collema leptaleum* var. biliosum (Mont.) Degel.		Collemataceae	Olley and Sharma (2013)
270	*Collema leptaleum* var. leptaleum Tuck.		Collemataceae	Olley and Sharma (2013)
271	*Collema nepalense* Degel.		Collemataceae	Olley and Sharma (2013)
272	*Collema poeltii* Degel.	*Lathagrium poeltii* (Degel.) Otálora, P.M.Jørg. & Wedin	Collemataceae	Olley and Sharma (2013)
273	*Collema pulcellum* Ach.		Collemataceae	Olley and Sharma (2013)
274	*Collema pulcellum* var. *subnigrescens* (Müll.Arg.) Degel.		Collemataceae	Olley and Sharma (2013)
275	*Collema rugosum* Kremp.		Collemataceae	Olley and Sharma (2013)
276	*Collema subconveniens* Nyl.		Collemataceae	Olley and Sharma (2013)
277	*Collema subflaccidum* Degel.		Collemataceae	Olley and Sharma (2013)
278	*Collema substipitatum* Zahlbr.		Collemataceae	Olley and Sharma (2013)
279	*Dermatocarpon miniatum* (L.)		Verrucariaceae	Olley and Sharma (2013)
280	*Dermatocarpon vellereum* Zschacke		Verrucariaceae	Olley and Sharma (2013)
281	*Dimelaena oreina* (Ach.) Norman		Caliciaceae	Olley and Sharma (2013)
282	*Dimerella isidiata* G.Thor & Vezda	*Coenogonium isidiatum* (G.Thor & Vězda) Lücking, Aptroot & Sipman	Coenogoniaceae	Olley and Sharma (2013)
283	*Dimerella lutea* (Dicks.) Trevis.	*Coenogonium luteum* (Dicks.) Kalb & Luking	Coenogoniaceae	Olley and Sharma (2013)
284	*Dimerella nepalensis* G.Thor & Vezda	*Coenogonium nepalense* (G.Thor & Vězda) Lücking, Aptroot & Sipman	Coenogoniaceae	Olley and Sharma (2013)
285	*Dimerella pineti* (Ach.) Vezda	*Coenogonium pineti* (Ach.) Lucking & Lumbsch	Coenogoniaceae	Olley and Sharma (2013)
286	*Diorygma hieroglyphicum* (Pers.) Staiger & Kalb		Graphidaceae	Karmacharya et al., (2018)
287	*Diorygma junghuhnii* (Mont. & Bosch) Kalb, Staiger & Elix		Graphidaceae	Karmacharya et al., (2018)
288	*Diploicia wahlenbergii* (Ach.) S. Singh		Caliciaceae	Olley and Sharma (2013)
289	*Diploschistes gypsaceus* (Ach.) Zahlbr.		Graphidaceae	Olley and Sharma (2013)
290	*Diploschistes muscorum* (Scop.) R.Sant.		Graphidaceae	Olley and Sharma (2013)
291	*Diploschistes muscorum* subsp. *bartlettii* Lumbsch		Graphidaceae	Olley and Sharma (2013)
292	*Diploschistes muscorum* subsp.		Graphidaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	muscorum (Scop.) R.Sant.			
293	*Diploschistes nepalensis* Pant & Upreti		Graphidaceae	Olley and Sharma (2013)
294	*Diploschistes scruposus* (Schreb.) Norman		Graphidaceae	Olley and Sharma (2013)
295	*Diploschistes scruposus* var. *bryophilus* (Schreb.) Ehrh.		Graphidaceae	Olley and Sharma (2013)
296	*Diplotomma epipolium* forma *epopolium* (Ach.) Arnold		Caliciaceae	Olley and Sharma (2013)
297	*Diplotomma megasporum* S.R.Singh & D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
298	*Dirinaria aegialita* (Afzel. ex Ach.) B.J.Moore		Caliciaceae	Olley and Sharma (2013)
299	*Dirinaria applanata* (Fée) D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
300	*Dirinaria applanta* var. *endochroma* (H.Magn & Awas.) D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
301	*Dirinaria confluens* (Fr.) D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
302	*Dirinaria consimilis* (Stirt.) D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
303	*Endocarpon* sp.		Verrucariaceae	Olley and Sharma (2013)
304	*Endocarpon subrosettum* Ajay Singh and Upreti		Verrucariaceae	Rai et al. (2016)
305	*Erioderma meiocarpum* Nyl.		Pannariaceae	Olley and Sharma (2013)
306	*Everniastrum cirrhatum* (Fr.) Hale ex Shipman	*Hypotrachyna cirrhata* (Fr.) Divakar, A.Crespo, Sipman, Elix & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
307	*Everniastrum nepalense* (Taylor) Hale ex Shipman	*Hypotrachyna nepalensis* (Taylor) Divakar, A.Crespo, Sipman, Elix & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
308	*Everniastrum rhizodendroideum* (Y.J. Yao & C.L.Jiang) Sipman	*Hypotrachyna rhizodendroidea* (J.C.Wei & Y.M.Jiang) Divakar, A.Crespo, Sipman, Elix & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
309	*Everniastrum sorocheilum* (Vain.) Hale ex Sipman	*Hypotrachyna sorocheila* (Vain.) Divakar, A.Crespo, Sipman, Elix & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
310	*Fellhanera* sp.		Pilocarpaceae	Olley and Sharma (2013)
311	*Flavocetraria cucullata* (Bellardi) Karnefelt & Thell.	*Nephromopsis cucullata* (Bellardi) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
312	*Flavocetraria nivalis* (L.) Karnefelt & Thell.	*Nephromopsis nivalis* (L.) Divakar, A.Crespo & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
313	*Flavocetrariella leucostigma* (Lév.) D.D.Awasthi		Parmeliaceae	Olley and Sharma (2013)
314	*Flavocetrariella melaloma* (Nyl.) D.D.Awasthi	Nephromopsis melaloma (Nyl.) A.Thell & Randlane	Parmeliaceae	Olley and Sharma (2013)
315	*Flavoparmelia caperata* (L.) Hale		Parmeliaceae	Olley and Sharma (2013)
316	*Flavopunctelia flaventior* (Stirt.) Hale		Parmeliaceae	Olley and Sharma (2013)
317	*Flavopunctelia soredica* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
318	*Frutidella caesioatra* (Schaer.) Kalb		Ramalinaceae	Olley and Sharma (2013)
319	*Fuscopannaria coerulescens* P.M. Jørg.		Pannariaceae	Olley and Sharma (2013)
320	*Fuscopannaria poeltii* (P.M. Jørg.)		Pannariaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	P.M. Jørg.			
321	*Fuscopannaria praetermissa* (Nyl.) P.M. Jørg.		Pannariaceae	Olley and Sharma (2013)
322	*Fuscopannaria subgemmascens* Upreti & P.K.Divakar		Pannariaceae	Olley and Sharma (2013)
323	*Glyphis cicatricosa* Ach.		Graphidaceae	Olley and Sharma (2013)
324	*Graphis antillarum* Vain.		Graphidaceae	Karmacharya et al., (2018)
325	*Graphis breussii G. Neuwirth & Lucking*		Graphidaceae	Karmacharya et al., (2018)
326	*Graphis cincta* (Pers.) Aptroot		Graphidaceae	Karmacharya et al., (2018)
327	*Graphis cleistoblephara* Nyl.	*Allographa cleistoblephara* (Nyl.) Lücking & Kalb	Graphidaceae	Karmacharya et al., (2018)
328	*Graphis galactoderma* (Zahlbr.) Lücking		Graphidaceae	Karmacharya et al., (2018)
329	*Graphis chlorotica* A. Massal		Graphidaceae	Rai et al. (2016)
330	*Graphis leprographa* Nyl.	*Allographa leprographa* (Nyl.) Lücking & Kalb	Graphidaceae	Karmacharya et al., (2018)
331	*Graphis lineola* Ach.		Graphidaceae	Karmacharya et al., (2018)
332	*Graphis paradisserpens* Sipman & Lücking		Graphidaceae	Karmacharya et al., (2018)
333	*Graphis paraserpens* Lizano & Lücking		Graphidaceae	Karmacharya et al., (2018)
334	*Graphis pertricosa (*Kremp.) A.W.Archer		Graphidaceae	Karmacharya et al., (2018)
335	*Graphis pinicola* Zahlbr.		Graphidaceae	Karmacharya et al., (2018)
336	*Graphis proserpens* Vain.		Graphidaceae	Rai et al. (2016)
337	*Graphis scripta* (L.) Ach.		Graphidaceae	Olley and Sharma (2013)
338	*Graphis stenotera* Vain.		Graphidaceae	Karmacharya et al., (2018)
339	Graphis subglauconigra Nagarkar & Patw.		Graphidaceae	Olley and Sharma (2013)
340	Graphis subvelata Stirt.	*Thalloloma subvelata* (Stirt.) D.J.Galloway	Graphidaceae	Karmacharya et al., (2018)
341	*Gyalectidium caucasicum* (Elenkin & Woron.) Vezda		Graphidaceae	Olley and Sharma (2013)
342	*Gyalidea lecideopsis* (A.Massal.) Lettau & Vezda		Graphidaceae	Olley and Sharma (2013)
343	*Gyalidea scutellaris* (Bagl. & Carestia) Lettau		Graphidaceae	Olley and Sharma (2013)
344	*Gyalidea testacea* Vezda & Poelt		Graphidaceae	Olley and Sharma (2013)
345	*Gyalideopsis lithophila* G.Thor & Vezda	*Diploschistella lithophila* (G.Thor & Vězda) Lücking, Sérus. & Vězda	Gomphillaceae	Olley and Sharma (2013)
346	*Gyalideopsis megalospora* Vezda & Poelt		Gomphillaceae	Olley and Sharma (2013)
347	*Gyalideopsis nepalensis* Vezda & Poelt		Gomphillaceae	Olley and Sharma (2013)
348	*Gyrophora polyrhiza* (L.) Körb.	*Umbilicaria polyrrhiza* (L.) Fr.	Umbilicariaceae	Olley and Sharma (2013)
349	*Haematomma puniceum* (Sw.) A.Massal.		Haematommataceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
350	*Haematomma wattii* (Stirt.) Zahlbr.		Haematommataceae	Olley and Sharma (2013)
351	*Hafellia tetrapla* (Nyl.) Pusswald		Caliciaceae	Rai et al. (2016)
352	*Herpothallon* sp.		Arthoniaceae	Olley and Sharma (2013)
353	*Herpothallon isidiatum* Jagadeesh and G.P. Sinha		Arthoniaceae	Rai et al. (2016)
354	*Heterodermia albidiflava* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013), Rai et al. (2016)
355	*Heterodermia angustiloba* (Müll.Arg.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
356	*Heterodermia awasthii* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
357	*Heterodermia boryi* (Fée) Hale	*Leucodermia boryi* (Fée) Kalb	Physciaceae	Olley and Sharma (2013)
358	*Heterodermia comosa* (Eschw.) Follmann & Redón		Physciaceae	Olley and Sharma (2013)
359	*Heterodermia coronata* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
360	*Heterodermia dactyliza* (Nyl.) Swinscow & Krog		Physciaceae	Olley and Sharma (2013)
361	*Heterodermia dactyliza* forma *serpens* (Vain.) Ajay Singh		Physciaceae	Olley and Sharma (2013)
362	*Heterodermia dendritica* (Pers.) Poelt	*Polyblastidium dendriticum* (Pers.) Kalb	Physciaceae	Olley and Sharma (2013)
363	*Heterodermia diademata* (Taylor) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
364	*Heterodermia dissecta* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
365	*Heterodermia firmula* (Nyl.) Trevis.		Physciaceae	Olley and Sharma (2013)
366	*Heterodermia flabellata* (Fée) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
367	*Heterodermia himalayensis* (D.D.Awasthi) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
368	*Heterodermia hypocaesia* (Yasuda ex Räsänen) D.D.Awasthi	*Polyblastidium hypocaesium* (Yasuda ex Räsänen) Kalb	Physciaceae	Olley and Sharma (2013)
369	*Heterodermia hypochraea* (Vain.) Swinscow and Krog		Physciaceae	Rai et al. (2016)
370	*Heterodermia hypoleuca* (Ach.) Trevis.	*Polyblastidium hypoleucum* (Ach.) Kalb	Physciaceae	Olley and Sharma (2013)
371	*Heterodermia incana* (Stirt.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
372	*Heterodermia isidiophora* (Nyl.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
373	*Heterodermia japonica* (M.Satô) Swinscow & Krog	*Polyblastidium japonicum* (M.Satô) Kalb	Physciaceae	Olley and Sharma (2013)
374	*Heterodermia leucomela* (L.) Poelt	*Leucodermia leucomelos* (L.) Kalb	Physciaceae	Olley and Sharma (2013)
375	*Heterodermia neoleucomelaena* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
376	*Heterodermia obscurata* (Nyl.) Trevis.		Physciaceae	Olley and Sharma (2013)
377	*Heterodermia pelludica* (D.D.Awasthi) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
378	*Heterodermia podocarpa* (Bél.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
379	*Heterodermia pseudospeciosa*		Physciaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	(Kurok.) W.L.Culb.			
380	*Heterodermia punctifera* (Kurok.) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
381	*Heterodermia rubescens* (Räsänen) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
382	*Heterodermia speciosa* (Wulfen) Trevis.		Physciaceae	Olley and Sharma (2013)
383	*Heterodermia togashii* (Kurok.) D.D.Awasthi	*Polyblastidium togashii* (Kurok.) Kalb	Physciaceae	Olley and Sharma (2013)
384	*Heterodermia tremulans* (Müll.Arg.) W.L.Culb.		Physciaceae	Olley and Sharma (2013)
385	*Huilia elegantior* (H.Magn) Hertel	*Amygdalaria elegantior* (H.Magn.) Hertel & Brodo	Lecideaceae	Olley and Sharma (2013)
386	*Hyperphyscia adglutinata* (Flörke) H.Mayrhofer & Poelt		Physciaceae	Olley and Sharma (2013), Rai et al. (2016)
387	*Hyperphyscia granulata* (Poelt) Moberg		Physciaceae	Olley and Sharma (2013)
388	*Hyperphyscia minor* (Fée) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
389	*Hyperphyscia syncolla* (Tuck. ex Nyl.) Kalb		Physciaceae	Olley and Sharma (2013)
390	*Hypogymnia alpina* D.D.Awasthi		Parmeliaceae	Olley and Sharma (2013)
391	*Hypogymnia delavayi* (Hue) Rass.		Parmeliaceae	Olley and Sharma (2013)
392	*Hypogymnia flavida* McCune & Obermayer		Parmeliaceae	Olley and Sharma (2013)
393	*Hypogymnia hypotrypa* (Nyl.) Rass.		Parmeliaceae	Olley and Sharma (2013)
394	*Hypogymnia hypotrypella* (Asahina) Rass.		Parmeliaceae	Olley and Sharma (2013)
395	*Hypogymnia magnifica* X.L. Wei & McCune in litt.		Parmeliaceae	Olley and Sharma (2013)
396	*Hypogymnia subarticulata* (J.D. Zhao, L.W. Hsu & Z.M. Sun) J.C.Wei & Y.M. Jiang		Parmeliaceae	Olley and Sharma (2013)
397	*Hypogymnia vittata* (Ach.) Parrique		Parmeliaceae	Olley and Sharma (2013)
398	*Hypotrachyna crenata* (Kurok. in Hale & S.Kurokawa) Hale		Parmeliaceae	Olley and Sharma (2013)
399	*Hypotrachyna exsecta* (Taylor) Hale		Parmeliaceae	Olley and Sharma (2013)
400	*Hypotrachyna flexilis* (Kurok.) Hale	*Remototrachyna flexilis* (Kurok.) Divakar & A. Crespo	Parmeliaceae	Olley and Sharma (2013)
401	*Hypotrachyna imbricatula* (Zahlbr.) Hale		Parmeliaceae	Olley and Sharma (2013)
402	*Hypotrachyna incognita* (Kurok.) Hale		Parmeliaceae	Olley and Sharma (2013)
403	*Hypotrachyna infirma* (Kurok.) Hale		Parmeliaceae	Olley and Sharma (2013)
404	*Hypotrachyna koyaensis* (Asahina) Hale		Parmeliaceae	Olley and Sharma (2013)
405	*Hypotrachyna laevigata* (Sm.) Hale		Parmeliaceae	Olley and Sharma (2013)
406	*Hypotrachyna majoris* (Vain.) Hale		Parmeliaceae	Olley and Sharma (2013)
407	*Hypotrachyna neodissecta* (Hale) Hale		Parmeliaceae	Olley and Sharma (2013)
408	*Hypotrachyna osseoalba* (Vain.) Y.S. Park & Hale		Parmeliaceae	Olley and Sharma (2013)
409	*Hypotrachyna physcioides* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
410	*Hypotrachyna revoluta* (Flörke) Hale		Parmeliaceae	Olley and Sharma (2013)
411	*Hypotrachyna sinuosa* (Sm.) Hale		Parmeliaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
412	*Hypotrachyna sublaevigata* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
413	*Icmadophila ericetorum* (L.) Zahlbr.		Icmadophilaceae	Olley and Sharma (2013)
414	*Immersaria athroocarpa* (Ach.) Rambold & Pietschm.		Lecideaceae	Olley and Sharma (2013)
415	*Ingvariella bispora* (Bagl.) Guderley & Lumbsch		Stictidaceae	Olley and Sharma (2013)
416	*Ioplaca pindarensis* (Räsänen) Poelt & Hinter.		Teloschistaceae	Olley and Sharma (2013)
417	*Japewia* sp.		Ramalinaceae	Olley and Sharma (2013)
418	*Lasallia freyana* D.D.Awasthi		Umbilicariaceae	Olley and Sharma (2013)
419	*Lasallia pertusa* (Rass.) Llano		Umbilicariaceae	Olley and Sharma (2013)
420	*Lasallia pertusa* forma pertusa (Rass.) Llano		Umbilicariaceae	Olley and Sharma (2013)
421	*Lasallia pustulata* (L.) Mérat		Umbilicariaceae	Olley and Sharma (2013)
422	*Lasallia sinensis* (Wei) Wei		Umbilicariaceae	Olley and Sharma (2013)
423	*Lecania erysibe* (Ach.) Mudd		Ramalinaceae	Olley and Sharma (2013)
424	*Lecanora adolfii* Wei		Lecanoraceae	Olley and Sharma (2013)
425	*Lecanora albella* (Pers.) Ach.		Lecanoraceae	Olley and Sharma (2013)
426	*Lecanora amorpha* Poelt		Lecanoraceae	Olley and Sharma (2013)
427	*Lecanora chlarotera* Nyl.		Lecanoraceae	Olley and Sharma (2013)
428	*Lecanora chondroderma* Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
429	*Lecanora demissa* (Flot.) Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
430	*Lecanora garovaglii* (Korb) Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
431	*Lecanora flavidofusca* Müll.Arg.		Lecanoraceae	Olley and Sharma (2013)
432	*Lecanora garovaglii* (Korb.) Zahlbr.	*Protoparmeliopsis garovaglii* (Körb.) Arup, Zhao Xin & Lumbsch	Lecanoraceae	Olley and Sharma (2013)
433	*Lecanora hellmichiana* Poelt		Lecanoraceae	Olley and Sharma (2013)
434	*Lecanora himalayae* Poelt		Lecanoraceae	Olley and Sharma (2013)
435	*Lecanora indica* Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
436	*Lecanora kirra* Poelt & Grube		Lecanoraceae	Olley and Sharma (2013)
437	*Lecanora lesleyana* (Darb.) Paulson	*Aspicilia lesleyana* Darbish.	Lecanoraceae	Olley and Sharma (2013)
438	*Lecanora luteomarginata* Nayaka, Upreti and Lumbsch		Lecanoraceae	Rai et al. (2016)
439	*Lecanora melanophthalma* (DC.) Ramond	*Rhizoplaca melanophthalma* (DC.) Leuckert	Lecanoraceae	Olley and Sharma (2013)
440	*Lecanora meridionalis* H.Magn		Lecanoraceae	Olley and Sharma (2013)
441	*Lecanora muralis* (Schreb.) Rabenh.	*Protoparmeliopsis muralis* (Schreb.) M.Choisy	Lecanoraceae	Olley and Sharma (2013)
442	*Lecanora muralis* var. dubyi (Müll.Arg.) Poelt		Lecanoraceae	Olley and Sharma (2013)
443	*Lecanora phaedrophthalma* Poelt	*Omphalodina phaedrophthalma* (Poelt) S.Y.Kondr., L.Lőkös & Farkas	Lecanoraceae	Olley and Sharma (2013)
444	*Lecanora rubina* (Hoffm.) Ach.		Lecanoraceae	Olley and Sharma (2013)
445	*Lecanora rubina* var. australis Poelt		Lecanoraceae	Olley and Sharma (2013)
446	*Lecanora rugosella* Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
447	*Lecanora sherparum* Poelt		Lecanoraceae	Olley and Sharma (2013)
448	*Lecanora sommervellii* Paulson		Lecanoraceae	Olley and Sharma (2013)
449	*Lecanora subfusca* Schaer.		Lecanoraceae	Olley and Sharma (2013)
450	*Lecanora sulphurea* (Hoffm.) Ach.	*Glaucomaria sulphurea* (Hoffm.) S.Y.Kondr., L.Lokos & Farkas	Lecanoraceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
451	*Lecanora teretiuscula* Zahlbr.		Lecanoraceae	Olley and Sharma (2013)
452	*Lecanora tschomolongmae* Poelt		Lecanoraceae	Olley and Sharma (2013)
453	*Lecanora xylophila* Hue		Lecanoraceae	Olley and Sharma (2013)
454	*Lecidea advena* Nyl.		Lecideaceae	Olley and Sharma (2013)
455	*Lecidea auriculata* Th.Fr.		Lecideaceae	Olley and Sharma (2013)
456	*Lecidea bella* Hertel		Lecideaceae	Olley and Sharma (2013)
457	*Lecidea brachyspora* (Th.Fr.) Nyl.		Lecideaceae	Olley and Sharma (2013)
458	*Lecidea bucculenta* Hertel		Lecideaceae	Olley and Sharma (2013)
459	*Lecidea bullosa* Zahlbr.		Lecideaceae	Olley and Sharma (2013)
460	*Lecidea cerviniicola* B.de Lesd.		Lecideaceae	Olley and Sharma (2013)
461	*Lecidea diducens* Nyl.		Lecideaceae	Olley and Sharma (2013)
462	*Lecidea epiiodiza* Nyl.		Lecideaceae	Olley and Sharma (2013)
463	*Lecidea fuscoatra* var. *indecora* Hertel		Lecideaceae	Olley and Sharma (2013)
464	*Lecidea haerjedalica* var. *gyrodisca* Hertel		Lecideaceae	Olley and Sharma (2013)
465	*Lecidea himalaica* Hertel		Lecideaceae	Olley and Sharma (2013)
466	*Lecidea khumbuensis* Hertel		Lecanoraceae	Olley and Sharma (2013)
467	*Lecidea lactea* Florke & Schaer.		Lecideaceae	Olley and Sharma (2013)
468	*Lecidea leotoboloides* Nyl.		Lecideaceae	Olley and Sharma (2013)
469	*Lecidea molybdochroa* Hertel	*Miriquidica molybdochroa* (Hertel) Hertel & Rambold	Lecanoraceae	Olley and Sharma (2013)
470	*Lecidea peoltii* Hertel		Lecideaceae	Olley and Sharma (2013)
471	*Lecidea russula* Ach.	*Ramboldia russula* (Ach.) Kalb, Lumbsch & Elix	Ramboldiaceae	Olley and Sharma (2013)
472	*Lecidea sanguineoatra* (Wulfen) Ach.	*Bryobilimbia sanguineoatra* (Wulfen) Fryday, Printzen & S.Ekman	Lecideaceae	Olley and Sharma (2013)
473	*Lecidea secernens* H.Magn		Lecanoraceae	Olley and Sharma (2013)
474	*Lecidea silacea* (Hoffm.) Ach.		Lecanoraceae	Olley and Sharma (2013)
475	*Lecidea steineri* Hertel		Lecanoraceae	Olley and Sharma (2013)
476	*Lecidea sulphurea* (Hoffm.) Wahlenb.	*Glaucomaria sulphurea* (Hoffm.) S.Y.Kondr., L.Lokos & Farkas	Lecanoraceae	Olley and Sharma (2013)
477	*Lecidea tessellata* Florke		Lecanoraceae	Olley and Sharma (2013)
478	*Lecidella bullata* Korb.		Lecanoraceae	Olley and Sharma (2013)
479	*Lecidella carpathica* Korb.		Lecanoraceae	Olley and Sharma (2013)
480	*Lecidella dimelaenophila* Hertel		Lecanoraceae	Olley and Sharma (2013)
481	*Lecidella inamoena* (Müll.Arg.) Hertel		Lecanoraceae	Olley and Sharma (2013)
482	*Lecidella stigmatea* (Ach.) Hertel & Leuckert		Lecanoraceae	Olley and Sharma (2013)
483	*Lecidella wulfenii* (Ach.) Korb.		Lecanoraceae	Olley and Sharma (2013)
484	*Lecidoma demissum* (Rutstr.) Gotth.Schneid. & Hertel		Lecideaceae	Olley and Sharma (2013)
485	*Lepraria lobificans* Nyl.		Stereocaulaceae	Olley and Sharma (2013)
486	*Lepraria squamatica* Elix		Stereocaulaceae	Olley and Sharma (2013)
487	*Lepraria usnica* Sipman	*Septotrapelia usnica* (Sipman) Kalb & Bungartz	Pilocarpaceae	Olley and Sharma (2013)
488	*Lepraria yunnaniana* (Hue) Zahlbr.		Stereocaulaceae	Olley and Sharma (2013)
489	*Leprocaulon arbuscula* (Nyl.) Nyl.	*Lepraria arbuscula* (Nyl.) Lendemer & B.P.Hodk.	Stereocaulaceae	Olley and Sharma (2013)
490	*Leprocaulon microscopicum* (Vill.) Gams		Leprocaulaceae	Olley and Sharma (2013)
491	*Leprocaulon pseudoarbuscula* (Asahina) I.M.Lamb & A.Ward	*Lepraria pseudoarbuscula* (Asahina) Lendemer &	Stereocaulaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
		B.P.Hodk.		
492	*Leproplaca chrysodeta* (Vain.) J.R.Laundon & Ahti		Teloschistaceae	Olley and Sharma (2013)
493	*Leptogium arisanense* Asahina		Collemataceae	Olley and Sharma (2013)
494	*Leptogium asiaticum* P.M. Jorg.		Collemataceae	Olley and Sharma (2013)
495	*Leptogium askotense* D.D.Awasthi		Collemataceae	Olley and Sharma (2013)
496	*Leptogium austroamericanum* (Malme) C.W.Dodge		Collemataceae	Olley and Sharma (2013)
497	*Leptogium azureum* (Sw.) Mont.		Collemataceae	Olley and Sharma (2013)
498	*Leptogium brebissonii* Mont.		Collemataceae	Olley and Sharma (2013)
499	*Leptogium burnetiae* Dodge		Collemataceae	Olley and Sharma (2013)
500	*Leptogium cochleatum* (Dicks.) P.M.Jørg. & P.James		Collemataceae	Olley and Sharma (2013)
501	*Leptogium cyanescens* (Ach.) Korb.		Collemataceae	Olley and Sharma (2013)
502	*Leptogium delavayi* forma *fuliginosulum* Zahlbr.		Collemataceae	Olley and Sharma (2013)
503	*Leptogium delavayi* Hue		Collemataceae	Olley and Sharma (2013)
504	*Leptogium indicum* D.D.Awasthi & Akhatar		Collemataceae	Olley and Sharma (2013)
505	*Leptogium isidiosellum* (Riddle) Sierk		Collemataceae	Olley and Sharma (2013)
506	*Leptogium javanicum* (Mont. & Bosch) Mont.		Collemataceae	Olley and Sharma (2013)
507	*Leptogium papillosum* (de Lesd.) C.W.Dodge		Collemataceae	Olley and Sharma (2013)
508	*Leptogium pedicellatum* P.M.Jorg.		Collemataceae	Olley and Sharma (2013)
509	*Leptogium phyllocarpum* (Pers.) Mont.		Collemataceae	Olley and Sharma (2013)
510	*Leptogium platynum* (Tuck.) Herre	*Scytinium platynum* (Tuck.) Otalora, P.M.Jorg. & Wedin	Collemataceae	Rai et al. (2016)
511	*Leptogium resupinans* Nyl.		Collemataceae	Olley and Sharma (2013)
512	*Leptogium saturninum* (Dicks.) Nyl.		Collemataceae	Olley and Sharma (2013)
513	*Leptogium sphaerosporum* P.M. Jørg. & L. Olley		Collemataceae	Olley and Sharma (2013)
514	*Leptogium tremelloides* (Ach) Gray		Collemataceae	Olley and Sharma (2013)
515	Leptogium trichophorum forma fuliginosum Müll.Arg.		Collemataceae	Olley and Sharma (2013)
516	*Leptogium trichophorum* Müll.Arg.		Collemataceae	Olley and Sharma (2013)
517	Letharia mesomorpha (Nyl.) Du Rietz	*Evernia mesomorpha* Nyl.	Parmeliaceae	Olley and Sharma (2013)
518	*Letharia vulpina* (L.) Hue		Parmeliaceae	Olley and Sharma (2013)
519	*Lethariella cladonioides* (Nyl.) Krog		Parmeliaceae	Olley and Sharma (2013)
520	*Letrouitia domingensis* (Pers.) Hafellner & Bellem.		Letrouitiaceae	Olley and Sharma (2013)
521	*Letrouitia leprolyta* (Nyl.) Hafellner		Letrouitiaceae	Olley and Sharma (2013)
522	*Letrouitia transgressa* (Malme) Hafellner & Bellem.		Letrouitiaceae	Olley and Sharma (2013)
523	*Lichenomphalia hudsoniana* (H.S.Jenn.) Redhead		Hygrophoraceae	Olley and Sharma (2013)
524	*Llimoniella neglecta* (Vain.) Triebel & Rambold		Rhymbocarpus	Olley and Sharma (2013)
525	*Lobaria adscriptens* (Nyl.) Hue		Lobariaceae	Olley and Sharma (2013)
526	*Lobaria adscripturiens* (Nyl.) Hue		Lobariaceae	Devkota et al. (2017a)
527	*Lobaria discolor* (Bory) Hue		Lobariaceae	Olley and Sharma (2013)
528	*Lobaria fuscotomentosa* Yoshim.		Lobariaceae	Olley and Sharma (2013)
529	*Lobaria isidiosa* (Mull.Arg.) Vain.		Lobariaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
530	*Lobaria kurokawae* Yoshim.		Lobariaceae	Olley and Sharma (2013)
531	*Lobaria meridionalis* Vain.		Lobariaceae	Olley and Sharma (2013)
532	*Lobaria pindarensis* Rasanen		Lobariaceae	Olley and Sharma (2013)
533	*Lobaria pseudopulmonaria* Gyeln.		Lobariaceae	Olley and Sharma (2013)
534	*Lobaria retigera* (Bory) Trev.		Lobariaceae	Olley and Sharma (2013)
535	*Lobaria subretigera* Inumaru		Lobariaceae	Olley and Sharma (2013)
536	*Lobothallia alphoplaca* (Wahlenb.) Hafellner		Megasporaceae	Olley and Sharma (2013)
537	*Lobothallia praeradiosa* (Nyl.) Hafellner		Megasporaceae	Olley and Sharma (2013)
538	*Maronea* sp.		Fuscideaceae	Olley and Sharma (2013)
539	*Megaspora verrucosa* (Ach.) Hafellner & V.Wirth		Megasporaceae	Olley and Sharma (2013)
540	*Melanelia glabra* (Schaer.) Essl.	*Melanelixia glabra* (Schaer.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch	Parmeliaceae	Olley and Sharma (2013)
541	*Melanelia hepatizon* (Ach.) Thell.		Parmeliaceae	Olley and Sharma (2013)
542	*Melanelia tominii* (Oxner) Essl.	*Montanelia tominii* (Oxner) Divakar, A.Crespo, Wedin & Essl.	Parmeliaceae	Olley and Sharma (2013)
543	*Melanohalea elegantula* (Zahlbr.) O.Blanco, A.Crespo, Divakar, Essl., D.Hawksw. & Lumbsch		Parmeliaceae	Olley and Sharma (2013)
544	*Melanohalea poeltii* (Essl.) O.Blanco, A.Crespo, P.K.Divakar, Essl., D.Hawksw. & Lumbsch		Parmeliaceae	Olley and Sharma (2013)
545	*Menegazzia terebrata* Hoffm. ex A.Massal.		Parmeliaceae	Olley and Sharma (2013)
546	*Micarea* sp.		Pilocarpaceae	Olley and Sharma (2013)
547	*Microcalicium disseminatum* (Ach.) Vain.		Microcaliciaceae	Olley and Sharma (2013)
548	*Microglaena thelostomoides* (Nyl.) Zahlbr.		Thelenellaceae	Olley and Sharma (2013)
549	*Mycobilimbia hunana* (Zahlbr.) D.D.Awasthi		Ramalinaceae	Olley and Sharma (2013)
550	*Mycoblastus sanguinarius* (L.) Norman		Tephromelataceae	Olley and Sharma (2013)
551	*Myelochroa aurulenta* (Tuck.) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
552	*Myelochroa entotheiochra* (Hue) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
553	*Myelochroa galbina* (Ach.) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
554	*Myelochroa indica* (Hale) Elix and Hale		Parmeliaceae	Rai et al. (2016)
555	*Myelochroa irrugans* (Nyl.) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
556	*Myelochroa metarevoluta* (Asahina) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
557	*Myelochroa xantholepis* (Mont. & Bosch) Elix & Hale	*Parmelina xantholepis* (Mont. & v.d.Bosch) Hale	Parmeliaceae	Olley and Sharma (2013)
558	*Nephroma helveticum* Ach.		Nephromataceae	Olley and Sharma (2013)
559	*Nephroma isidiosum* (Nyl.) Gyeln.		Nephromataceae	Olley and Sharma (2013)
560	*Nephroma nakaoi* Asahina		Nephromataceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
561	*Nephromopsis ahtii* (Randlane & Saag) Randlane & Saag		Parmeliaceae	Olley and Sharma (2013)
562	*Nephromopsis ectocarpisma* (Hue) Gyeln.		Parmeliaceae	Olley and Sharma (2013)
563	*Nephromopsis isidioidea* (Rasanen) Randlane & Saag		Parmeliaceae	Olley and Sharma (2013)
564	*Nephromopsis laureri* (Kremp.) Kurok.	*Tuckneraria laureri* (Kremp.) Randlane & A.Thell	Parmeliaceae	Olley and Sharma (2013)
565	*Nephromopsis leucostigma* (Lev.) Thell. & Randlane	*Flavocetrariella leucostigma* (Lév.) D.D.Awasthi	Parmeliaceae	Olley and Sharma (2013)
566	*Nephromopsis melaloma* (Nyl.) Thell. & Randlane		Parmeliaceae	Olley and Sharma (2013)
567	*Nephromopsis nephromoides* (Nyl.) Ahti & Randlane		Parmeliaceae	Olley and Sharma (2013)
568	*Nephromopsis pallescens* (Schaer.) Park	*Cetrariopsis pallescens* (Schaerer) Randl. & Thell	Parmeliaceae	Olley and Sharma (2013)
569	*Nephromopsis stracheyi* (Bab.) Mull.Arg.		Parmeliaceae	Olley and Sharma (2013)
570	*Normandina pulchella* (Borrer) Nyl.		Verrucariaceae	Olley and Sharma (2013)
571	*Ochrolechia bryophaga* (Erichsen) K.Schmitz & Lumbsch		Ochrolechiaceae	Olley and Sharma (2013)
572	*Ochrolechia glacialis* Poelt		Ochrolechiaceae	Olley and Sharma (2013)
573	*Ochrolechia margarita* Poelt		Ochrolechiaceae	Olley and Sharma (2013)
574	*Ochrolechia rosella forma sorediascens* Poelt		Ochrolechiaceae	Olley and Sharma (2013)
575	*Ochrolechia trochophora* (Vain.) Oshio		Ochrolechiaceae	Olley and Sharma (2013)
576	*Ochrolechia yasudae* Vain.		Ochrolechiaceae	Olley and Sharma (2013)
577	*Ochrolechia yasudae* var. *corallina* Poelt		Ochrolechiaceae	Olley and Sharma (2013)
578	*Ophioparma ventosa* (L.) Norman		Ophioparmaceae	Olley and Sharma (2013)
579	*Oropogon formosanus* Asah.		Parmeliaceae	Olley and Sharma (2013)
580	*Pachyphiale himalayensis* Vezda & Poelt	*Gyalecta himalayensis* (Vězda & Poelt) Baloch & Lücking	Gyalectaceae	Olley and Sharma (2013)
581	*Pallidogramme chrysenteron* (Mont.) Staiger, Kalb & Lücking		Graphidaceae	Karmacharya et al., (2018)
582	*Pallidogramme divaricoides* (Rasanen) Pushpi Singh & Kr.P.Singh		Graphidaceae	Karmacharya et al., (2018)
583	*Pannaria conoplea* (Ach.) Bory		Pannariaceae	Olley and Sharma (2013)
584	*Pannaria emodi* P.M. Jørg.		Pannariaceae	Olley and Sharma (2013)
585	*Parmelaria subthomsonii* D.D.Awasthi	*Parmotrema subthomsonii* (D.D.Awasthi) A.Crespo, Divakar & Elix	Parmeliaceae	Olley and Sharma (2013)
586	*Parmelaria thomsonii* (Stirt.) D.D.Awasthi	*Parmotrema thomsonii* (Stirt.) A.Crespo, Divakar & Elix	Parmeliaceae	Olley and Sharma (2013)
587	*Parmelia adaugescens* Nyl.		Parmeliaceae	Olley and Sharma (2013)
588	*Parmelia dodapetta* (Hale & Patw.) D.D.Awasthi	*Remototrachyna dodapetta* (Hale & Patw.) Divakar & A.Crespo	Parmeliaceae	Olley and Sharma (2013)
589	*Parmelia erumpens* Kurok.	*Notoparmelia erumpens* (Kurok.) A.Crespo, Ferencová & Divakar	Parmeliaceae	Olley and Sharma (2013)
590	*Parmelia latissima* var. *marmariza* (Nyl.) G.L.Chopra		Parmeliaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
591	*Parmelia masonii* Essl. & Poelt	*Emodomelanelia masonii* (Essl. & Poelt) Divakar & A.Crespo	Parmeliaceae	Olley and Sharma (2013)
592	*Parmelia meiophora* Nyl.		Parmeliaceae	Olley and Sharma (2013)
593	*Parmelia melanothrix* Vain.		Parmeliaceae	Olley and Sharma (2013)
594	*Parmelia nimandairana* Zahlbr.	*Parmelinella nimandairana* (Zahlbr.) Benatti & Marcelli	Parmeliaceae	Olley and Sharma (2013)
595	*Parmelia omphalodes* (L.) Ach.		Parmeliaceae	Olley and Sharma (2013)
596	*Parmelia pseudohyporysalea* Asahina		Parmeliaceae	Olley and Sharma (2013)
597	*Parmelia rhytidodes* (Hale) Ajay Singh		Parmeliaceae	Olley and Sharma (2013)
598	*Parmelia ricasolioides* Nyl.	*Nipponoparmelia ricasolioides* (Nyl.) A.Crespo & Divakar	Parmeliaceae	Olley and Sharma (2013)
599	*Parmelia squarrosa* Hale		Parmeliaceae	Olley and Sharma (2013)
600	*Parmelia stenophylla* J.D.Zhao		Parmeliaceae	Olley and Sharma (2013)
601	*Parmelia sublaevigata* (Nyl.) Nyl.	*Hypotrachyna sublaevigata* (Nyl.) Hale	Parmeliaceae	Olley and Sharma (2013)
602	*Parmelia submutata* Hue		Parmeliaceae	Olley and Sharma (2013)
603	*Parmelia sulcata* Taylor		Parmeliaceae	Olley and Sharma (2013)
604	*Parmeliella* sp.		Pannariaceae	Olley and Sharma (2013)
605	*Parmelina quercina* (Willd.) Hale		Parmeliaceae	Olley and Sharma (2013)
606	*Parmelina tiliacea* (Hoffm.) Hale		Parmeliaceae	Olley and Sharma (2013)
607	*Parmelinella simplicior* (Hale) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
608	*Parmelinella wallichiana* (Taylor) Elix & Hale		Parmeliaceae	Olley and Sharma (2013)
609	*Parmelinopsis expallida* (Kurok.) Elix & Hale	*Hypotrachyna expallida* (Kurok.) Elix & Hale	Parmeliaceae	Olley and Sharma (2013)
610	*Parmelinopsis minarum* (Vain.) Elix & Hale	*Parmelinopsis minarum* (Vain.) Elix & Hale	Parmeliaceae	Olley and Sharma (2013)
611	*Parmotrema andinum* (Müll.Arg.) Hale		Parmeliaceae	Olley and Sharma (2013)
612	*Parmotrema austrosinense* (Zahlbr.) Hale		Parmeliaceae	Olley and Sharma (2013)
613	*Parmotrema cetratum* (Ach.) Hale		Parmeliaceae	Olley and Sharma (2013)
614	*Parmotrema chinense* (Osbeck) Hale & Ahti		Parmeliaceae	Olley and Sharma (2013)
615	*Parmotrema cooperi* (Stein & Zahlbr.) Sérus.		Parmeliaceae	Olley and Sharma (2013)
616	*Parmotrema dilatatum* (Vain.) Hale		Parmeliaceae	Olley and Sharma (2013)
617	*Parmotrema eunetum* (Stirt.) Hale		Parmeliaceae	Olley and Sharma (2013)
618	*Parmotrema grayanum* (Hue) Hale		Parmeliaceae	Olley and Sharma (2013)
619	*Parmotrema hababianum* (Gyeln.) Hale		Parmeliaceae	Olley and Sharma (2013)
620	*Parmotrema indicum* Hale		Parmeliaceae	Olley and Sharma (2013)
621	*Parmotrema lobulascens* (Stein) Hale		Parmeliaceae	Olley and Sharma (2013)
622	*Parmotrema maclayanum* (Müll.Arg.) Hale		Parmeliaceae	Olley and Sharma (2013)
623	*Parmotrema melanothrix* (Mont.) Hale		Parmeliaceae	Olley and Sharma (2013)
624	Parmotrema mellissii (Dodge) Hale		Parmeliaceae	Olley and Sharma (2013)
625	*Parmotrema nilgherrensis* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
626	*Parmotrema praesorediosum* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
627	*Parmotrema pseudonilgherrense*		Parmeliaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	(Asahina) Hale			
628	*Parmotrema rampoddense* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
629	*Parmotrema reticulatum* (Taylor) Choisy		Parmeliaceae	Olley and Sharma (2013)
630	*Parmotrema sancti-angelii* (Lynge) Hale		Parmeliaceae	Olley and Sharma (2013)
631	*Parmotrema stuppeum* (Taylor) Hale		Parmeliaceae	Olley and Sharma (2013)
632	*Parmotrema tinctorum* (Nyl.) Hale		Parmeliaceae	Olley and Sharma (2013)
633	*Parmotrema ultralucens* (Krog) Hale		Parmeliaceae	Olley and Sharma (2013)
634	*Parmotrema yodae* (Kurok.) Hale		Parmeliaceae	Olley and Sharma (2013)
635	*Peltigera canina* (L.) Willd.		Peltigeraceae	Olley and Sharma (2013)
636	*Peltigera diactyla* (With.) J.R. Laundon		Peltigeraceae	Olley and Sharma (2013)
637	*Peltigera dolichorrhiza* (Nyl.) Nyl.		Peltigeraceae	Olley and Sharma (2013)
638	*Peltigera dolichospora* (D.A.Lu) Vitik.		Peltigeraceae	Olley and Sharma (2013)
639	*Peltigera elisabethae* Gyeln.		Peltigeraceae	Olley and Sharma (2013)
640	*Peltigera lepidophora* (Nyl.) Bitter		Peltigeraceae	Olley and Sharma (2013)
641	*Peltigera leucophlebia* (Nyl.) Gyeln.		Peltigeraceae	Olley and Sharma (2013)
642	*Peltigera malacea* (Ach.) Funk.		Peltigeraceae	Olley and Sharma (2013)
643	*Peltigera membranacea* (Ach.) Nyl.		Peltigeraceae	Olley and Sharma (2013)
644	*Peltigera microphylla* (Anders) Gyeln.		Peltigeraceae	Olley and Sharma (2013)
645	*Peltigera neopolydactyla* (Gyeln.) Gyeln.		Peltigeraceae	Olley and Sharma (2013)
646	*Peltigera polydactylon* (Neck.) Hoffm.		Peltigeraceae	Olley and Sharma (2013)
647	*Peltigera praetextata* (Florke ex Sommerf.) Zopf		Peltigeraceae	Olley and Sharma (2013)
648	*Peltigera pruinosa* (Inumaru) Gyeln.		Peltigeraceae	Olley and Sharma (2013)
649	*Peltigera rufescens* (Weis.) Humb.		Peltigeraceae	Olley and Sharma (2013)
650	*Peltigera scabrosa* Th.Fr.		Peltigeraceae	Olley and Sharma (2013)
651	*Pertusaria bryontha* (Ach.) Nyl.		Pertusariaceae	Olley and Sharma (2013)
652	*Pertusaria composita* Zahlbr.		Pertusariaceae	Olley and Sharma (2013)
653	*Pertusaria hemisphaerica* (Flörke) Erichsen	*Varicellaria hemisphaerica* (Flörke) I.Schmitt & Lumbsch	Ochrolechiaceae	Olley and Sharma (2013)
654	*Pertusaria leioplaca* DC.		Pertusariaceae	Olley and Sharma (2013)
655	*Pertusaria leucosorodes* Nyl.	*Lepra leucosorodes* (Nyl.) I.Schmitt, B.G.Hodk. & Lumbsch	Pertusariaceae	Olley and Sharma (2013)
656	*Pertusaria multipuncta* (Turner) Nyl.	*Lepra multipuncta* (Turner) Hafellner	Pertusariaceae	Olley and Sharma (2013)
657	*Pertusaria pertusa* (L.) Tuck.		Pertusariaceae	Olley and Sharma (2013)
658	*Pertusaria pertusella* Müll.Arg.		Pertusariaceae	Olley and Sharma (2013)
659	*Pertusaria quassiae* (Fée) Nyl.		Pertusariaceae	Olley and Sharma (2013)
660	*Pertusaria submultipuncta* Nyl.		Pertusariaceae	Olley and Sharma (2013)
661	*Pertusaria variolosa* (Kremp.) Vain.		Pertusariaceae	Olley and Sharma (2013)
662	*Phaeographina nepalensis* D.D.Awasthi & Kr.P.Singh		Graphidaceae	Olley and Sharma (2013)
663	*Phaeographina pyrrhochroa* (Mont. & Bosch) Zahlbr.	*Platythecium pyrrhochroum* (Mont. & Bosch) Z.F.Jia & Lücking	Graphidaceae	Olley and Sharma (2013)
664	*Phaeographis leiogrammodes* (Kremp.) Müll.Arg.		Graphidaceae	Karmacharya et al., (2018)
665	*Phaeophyscia endococcina* (Körb.) Moberg		Physciaceae	Olley and Sharma (2013)

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666	*Phaeophyscia endococcina* var. *khumbuensis* (Poelt) Ajay Singh		Physciaceae	Olley and Sharma (2013)
667	*Phaeophyscia endococcinodes* (Poelt) Essl.		Physciaceae	Olley and Sharma (2013)
668	*Phaeophyscia endococcinodes* var. *megalospora* Poelt		Physciaceae	Olley and Sharma (2013)
669	P*haeophyscia hispidula* (Ach.) Essl.		Physciaceae	Olley and Sharma (2013)
670	*Phaeophyscia hispidula* subsp. *hispidula* (Ach.) Moberg		Physciaceae	Olley and Sharma (2013)
671	*Phaeophyscia hispidula* subsp. l*imbata* (Poelt)		Physciaceae	Olley and Sharma (2013)
672	*Phaeophyscia hispidula* var. *exornatula* (Zahlbr.) Moberg		Physciaceae	Olley and Sharma (2013)
673	*Phaeophyscia hispidula* var. *hispidula* (Ach.) Essl.		Physciaceae	Olley and Sharma (2013)
674	*Phaeophyscia limbata* (Poelt) Kashiw.		Physciaceae	Olley and Sharma (2013)
675	*Phaeophyscia lygaea* (Poelt) D.D.Awasthi		Physciaceae	Olley and Sharma (2013)
676	*Phaeophyscia primaria* (Poelt) Trass		Physciaceae	Olley and Sharma (2013)
677	*Phaeophyscia pyrrhophora* (Poelt) D.D.Awasthi & M.Joshi		Physciaceae	Olley and Sharma (2013)
678	*Phaeophyscia sciastra* (Ach.) Moberg		Physciaceae	Olley and Sharma (2013)
679	*Phaeorrhiza nimbosa* (Fr.) Mayrh. & Poelt		Physciaceae	Olley and Sharma (2013)
680	*Phlyctella indica* Awasthi		Roccellaceae	Olley and Sharma (2013)
681	*Phlyctis nepalensis* Räsänen		Phlyctidaceae	Olley and Sharma (2013)
682	*Phyllopsora* sp		Ramalinaceae	Olley and Sharma (2013)
683	*Physcia aipolia* (Ehrh. ex Humb.) Fürnr.		Physciaceae	Olley and Sharma (2013)
684	*Physcia albonigra* (Schl.) Dalla Torre & Sarnth.		Physciaceae	Olley and Sharma (2013)
685	*Physcia aspera* var. *alutacea* H.Magn		Caliciaceae	Olley and Sharma (2013)
686	*Physcia caesia* (Hoffm.) Fürnr.		Physciaceae	Olley and Sharma (2013)
687	*Physcia clementii* (Sm.) Lynge		Physciaceae	Olley and Sharma (2013)
688	*Physcia dilatata* Nyl.		Physciaceae	Olley and Sharma (2013)
689	*Physcia dubia* (Hoffm.) Lettau		Physciaceae	Olley and Sharma (2013)
690	*Physcia intermedia* Vain.		Physciaceae	Olley and Sharma (2013)
691	*Physcia phaea* (Tuck.) J.W.Thomson		Physciaceae	Olley and Sharma (2013)
692	*Physcia pulverulenta* Nyl.		Physciaceae	Olley and Sharma (2013)
693	*Physcia stellaris* (L.) Nyl.		Physciaceae	Olley and Sharma (2013)
694	*Physcia stellaris* subsp. i*ntesiniformis* (Frey) Poelt		Physciaceae	Olley and Sharma (2013)
695	*Physcia tribacia* (Ach.) Nyl.		Physciaceae	Olley and Sharma (2013)
696	*Physcia tribacioides* Nyl.		Physciaceae	Olley and Sharma (2013)
697	*Physciella nepalensis* (Poelt) Essl.		Physciaceae	Olley and Sharma (2013)
698	*Physciopsis minor* (Fée) Moore		Physciaceae	Olley and Sharma (2013)
699	*Physconia detersa* (Nyl.) Poelt		Physciaceae	Olley and Sharma (2013)
700	*Physconia enteroxantha* (Nyl.) Poelt		Physciaceae	Olley and Sharma (2013)
701	*Physconia farrea* (Ach.) Poelt		Physciaceae	Olley and Sharma (2013)
702	*Physconia muscigena* (Ach.) Poelt		Physciaceae	Olley and Sharma (2013)
703	*Physconia pulverulenta* (Schreb.) Poelt		Physciaceae	Olley and Sharma (2013)
704	*Physma byrsaeum* (Afzel. ex Ach.) Tuck.		Pannariaceae	Olley and Sharma (2013)

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705	*Physma byrsinum* (Ach.) Müll.Arg.		Pannariaceae	Olley and Sharma (2013)
706	*Placidiopsis pseudocinerea* Breuss		Verrucariaceae	Olley and Sharma (2013)
707	*Placynthiella icmalea* (Ach.) Coppins & P. James		Trapeliaceae	Olley and Sharma (2013)
708	Pl*atismatia erosa* W.L.Culb. & C.F.Culb.		Parmeliaceae	Olley and Sharma (2013)
709	*Pleopsidium flavum* (Bellardi) Körb.		Acarosporaceae	Olley and Sharma (2013)
710	*Polysporina simplex* (Davies) Vezda		Acarosporaceae	Olley and Sharma (2013)
711	*Porina corruscans* (Rehm) R.Sant.		Porinaceae	Olley and Sharma (2013)
712	*Porina hoehneliana* (Jaap) R.Sant.		Porinaceae	Olley and Sharma (2013)
713	*Porina pallescens* R.Sant.		Porinaceae	Olley and Sharma (2013)
714	*Porpidia crustulata* (Ach.) Hertel & Knoph		Lecideaceae	Olley and Sharma (2013)
715	*Porpidia hydrophila* (Fr.) Hertel & A.J.Schwab		Lecideaceae	Olley and Sharma (2013)
716	*Porpidia macrocarpa* (DC.) Hertel & Knoph		Lecideaceae	Olley and Sharma (2013)
717	*Protoblastenia russula* (Ach.) Räsänen	*Ramboldia russula* (Ach.) Kalb, Lumbsch & Elix	Ramboldiaceae	Olley and Sharma (2013)
718	*Protoparmelia badia* (Hoffm.) Hafellner		Parmeliaceae	Olley and Sharma (2013)
719	*Protoparmelia effigurans* Grube & Poelt		Parmeliaceae	Olley and Sharma (2013)
720	*Psora decipiens* (Hedw.) Hoffm.		Psoraceae	Olley and Sharma (2013)
721	*Psoroma hypnorum* (Vahl) Gray		Pannariaceae	Olley and Sharma (2013)
722	*Punctelia borreri* (Turner) Krog		Parmeliaceae	Olley and Sharma (2013)
723	*Punctelia rudecta* (Ach.) Krog		Parmeliaceae	Olley and Sharma (2013)
724	*Punctelia subrudecta* (Nyl.) Krog		Parmeliaceae	Olley and Sharma (2013)
725	*Pycnothelia papillaria* (Ehrh.) L.M.Dufour		Cladoniaceae	Olley and Sharma (2013)
726	*Pyrenula cayennensis* Müll.Arg.		Pyrenulaceae	Olley and Sharma (2013)
727	*Pyrenula complanata* (Mont.) Trevis.		Pyrenulaceae	Rai et al. (2016)
728	*Pyrenula immersa* Müll.Arg.		Pyrenulaceae	Olley and Sharma (2013)
729	*Pyxine berteriana* (Fée) Imshaug		Caliciaceae	Olley and Sharma (2013), Rai et al. (2016)
730	*Pyxine berteriana* var. *himalaica* D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
731	*Pyxine coccifera* (Fée) Nyl.		Caliciaceae	Olley and Sharma (2013)
732	*Pyxine farinosa* Kashiw.		Caliciaceae	Rai et al. (2016)
733	*Pyxine messnerina* Nyl.		Caliciaceae	Olley and Sharma (2013)
734	*Pyxine nilgiriensis* D.D.Awasthi		Caliciaceae	Olley and Sharma (2013)
735	*Pyxine philippina* Vain.		Caliciaceae	Olley and Sharma (2013)
736	*Pyxine retirugella* Nyl.		Caliciaceae	Olley and Sharma (2013)
737	*Pyxine sorediata* (Ach.) Mont.		Caliciaceae	Olley and Sharma (2013)
738	*Ramalina australiensis* Nyl.		Ramalinaceae	Olley and Sharma (2013)
739	*Ramalina calicaris* (L.) Röhl.		Ramalinaceae	Olley and Sharma (2013)
740	*Ramalina conduplicans* Vain.		Ramalinaceae	Olley and Sharma (2013)
741	*Ramalina farinacea* Ach.		Ramalinaceae	Olley and Sharma (2013)
742	*Ramalina flabelliformis* Asahina		Ramalinaceae	Olley and Sharma (2013)
743	*Ramalina hossei* Vain.		Ramalinaceae	Olley and Sharma (2013)
744	*Ramalina roesleri* (Hochst. ex Schaer.) Hue		Ramalinaceae	Olley and Sharma (2013)
745	*Ramalina sinensis* Jatta		Ramalinaceae	Olley and Sharma (2013)
746	*Ramalina subampliata* (Nyl.) Fink		Ramalinaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
747	*Ramalina subcomplanata* Nyl. Kashiw.		Ramalinaceae	Olley and Sharma (2013)
748	*Ramalina subfarinacea* (Nyl. ex Cromb.) Nyl.		Ramalinaceae	Olley and Sharma (2013)
749	Remototrachyna adducta (Nyl.) P.K.Divakar & A.Crespo		Parmeliaceae	Olley and Sharma (2013)
750	Remototrachyna rhabdiformis (Kurok.) P.K.Divakar & A.Crespo		Parmeliaceae	Olley and Sharma (2013)
751	*Remototrachyna scytophylla* (Kurok.) P.K.Divakar & A.Crespo		Parmeliaceae	Olley and Sharma (2013)
752	*Rhizocarpon badioatrum* (Flörke & Spreng.) Th.Fr.		Rhizocarpaceae	Olley and Sharma (2013)
753	*Rhizocarpon geographicum* (L.) DC.		Rhizocarpaceae	Olley and Sharma (2013)
754	*Rhizocarpon geographicum* var. *macrosporum* (Räsänen) Clauzade & Rondon		Rhizocarpaceae	Olley and Sharma (2013)
755	*Rhizocarpon kansuense* H.Magn		Rhizocarpaceae	Olley and Sharma (2013)
756	*Rhizocarpon superficiale* (Schaer.) Vain.		Rhizocarpaceae	Olley and Sharma (2013)
757	*Rhizoplaca chrysoleuca* (Sm.) Zopf	*Omphalodina chrysoleuca* (Sm.) S.Y.Kondr., L.Lőkös & Farkas	Lecanoraceae	Olley and Sharma (2013)
758	*Rhizoplaca melanopthalma* var. *obscura* (J.Steiner) Leuckert & Poelt		Lecanoraceae	Olley and Sharma (2013)
759	*Rhizoplaca peltata* (Ramond) Leuckert & Poelt	*Protoparmeliopsis peltata* (Ramond) Arup, Zhao Xin & Lumbsch	Lecanoraceae	Olley and Sharma (2013)
760	*Rimelia clavulifera* (Räsänen) Kurok.	*Parmotrema clavuliferum* (Räsänen) Streimann	Parmeliaceae	Olley and Sharma (2013)
761	*Rinodina arnoldii* Mayrh. & Poelt		Physciaceae	Olley and Sharma (2013)
762	*Rinodina badiella* (Nyl.) Th.Fr.		Physciaceae	Olley and Sharma (2013)
763	*Rinodina cinnamomea* (Th.Fr.) Räsänen		Physciaceae	Olley and Sharma (2013)
764	*Rinodina conradii* Körb.		Physciaceae	Olley and Sharma (2013)
765	*Rinodina mniaraea* var. *mniaraea* (Ach.) Körb.		Physciaceae	Olley and Sharma (2013)
766	*Rinodina sophodes* (Ach.) A. Massal.		Physciaceae	Rai et al. (2016)
767	*Rinodina turfacea* (Wahlenb.) Körb.		Physciaceae	Olley and Sharma (2013)
768	*Sagema potentillae* Poelt & Grube		Lecanoraceae	Olley and Sharma (2013)
769	*Sclerophora amabilis* (Tibell) Tibell		Coniocybaceae	Olley and Sharma (2013)
770	*Sclerophora coniophaea* (Norman) Mattson & Middleb.		Icmadophilaceae	Olley and Sharma (2013)
771	*Siphula ceratites* (Wahlenb.) Fr.		Icmadophilaceae	Olley and Sharma (2013)
772	*Solorina bispora* Nyl.		Peltigeraceae	Olley and Sharma (2013)
773	*Solorina crocea* (L.) Ach.		Peltigeraceae	Olley and Sharma (2013)
774	*Solorina saccata* (L.) Ach.		Peltigeraceae	Olley and Sharma (2013)
775	*Solorina simensis* Flotow		Peltigeraceae	Olley and Sharma (2013)
776	*Sphaerophorus fragilis* (L.) Pers.		Sphaerophoraceae	Olley and Sharma (2013)
777	*Sphaerophorus* sp		Sphaerophoraceae	Olley and Sharma (2013)
778	*Sporastatia testudinea* (Ach.) A.Massal.		Sporastatiaceae	Olley and Sharma (2013)
779	*Stereocaulon claviceps* Th.Fr.		Stereocaulaceae	Olley and Sharma (2013)
780	*Stereocaulon coniophyllum* Lamb.		Stereocaulaceae	Olley and Sharma (2013)
781	*Stereocaulon foliolosum* Nyl.		Stereocaulaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
782	*Stereocaulon foliolosum* var. *botryophorum* (Müll.Arg.) I.M.Lamb		Stereocaulaceae	Olley and Sharma (2013)
783	*Stereocaulon foliolosum* var. *strictum* (Bab.) Lamb.		Stereocaulaceae	Olley and Sharma (2013)
784	*Stereocaulon glareosum* (Savicz) H.Magn		Stereocaulaceae	Olley and Sharma (2013)
785	*Stereocaulon himalayense* D.D.Awasthi & I.M.Lamb		Stereocaulaceae	Olley and Sharma (2013)
786	*Stereocaulon leprocauloides* I.M.Lamb		Stereocaulaceae	Olley and Sharma (2013)
787	*Stereocaulon myriocarpum* Th.Fr.		Stereocaulaceae	Olley and Sharma (2013)
788	*Stereocaulon piluliferum* Th.Fr.		Stereocaulaceae	Olley and Sharma (2013)
789	*Stereocaulon pomiferum* P.A.Duvign.		Stereocaulaceae	Olley and Sharma (2013)
790	*Stereocaulon sasakii* Zahlbr.		Stereocaulaceae	Olley and Sharma (2013)
791	*Stereocaulon togashii* Lamb.		Stereocaulaceae	Olley and Sharma (2013)
792	*Stereocaulon tomentosum* subsp. *myriocarpum* (Th.Fr.) Nyl.		Stereocaulaceae	Olley and Sharma (2013)
793	*Stereocaulon tomentosum* subsp. *myriocarpum* var. orizabae (Th.Fr.) Lamb. ex Asahina		Stereocaulaceae	Olley and Sharma (2013)
794	*Sticta limbata* (Sm.) Ach.		Lobariaceae	Devkota et al. (2017a)
795	*Sticta henryana* Müll.Arg.		Lobariaceae	Olley and Sharma (2013)
796	*Sticta nylanderiana* Zahlbr.		Lobariaceae	Olley and Sharma (2013)
797	*Sticta platyphylloides* Nyl.	*Dendriscosticta platyphylla* (Trevis.) Moncada & Lücking	Lobariaceae	Olley and Sharma (2013)
798	*Sticta praetextata* (Räsänen) D.D.Awasthi	*Dendriscosticta praetextata* (Räsänen) Moncada & Lücking	Lobariaceae	Olley and Sharma (2013)
799	*Sticta weigelii* (Ach.) Vainio		Lobariaceae	Olley and Sharma (2013)
800	*Strigula smaragdula* Fr.		Strigulaceae	Olley and Sharma (2013)
801	*Sulcaria sulcata* (Lév.) Bystrek ex Brodo & D.Hawksw.		Parmeliaceae	Olley and Sharma (2013)
802	*Sulcaria virens* (Taylor) Bystrek ex Brodo & D.Hawksw.			Olley and Sharma (2013)
803	*Tapellaria saxicola* Vezda & Poelt		Pilocarpaceae	Olley and Sharma (2013)
804	*Tephromela glacialis* Grube & Poelt		Mycoblastaceae	Olley and Sharma (2013)
805	*Tephromela siphulodes* Poelt & Grube		Mycoblastaceae	Olley and Sharma (2013)
806	*Thamnolia vermicularis* (L.) Schaer.		Icmadophilaceae	Olley and Sharma (2013)
807	*Thamnolia vermicularis* subsp. *subuliformis* (Ehrh.) Schaer.		Icmadophilaceae	Olley and Sharma (2013)
808	*Thyrea* sp.		Lichinaceae	Olley and Sharma (2013)
809	*Toninia* sp.		Ramalinaceae	Olley and Sharma (2013)
810	*Trapelia subconcolor* (Anzi) Hertel	*Parainoa subconcolor* (Anzi) Resl & T.Sprib.	Baeomycetaceae	Olley and Sharma (2013)
811	*Trapeliopsis flexuosa* (Fr.) Coppins & P. James		Trapeliaceae	Olley and Sharma (2013)
812	*Tremolecia atrata* (Ach.) Hertel		Hymeneliaceae	Olley and Sharma (2013)
813	*Tylophoron moderatum* Nyl.		Arthoniaceae	Olley and Sharma (2013)
814	*Tylophoron protrudens* Nyl.		Arthoniaceae	Olley and Sharma (2013)
815	*Umbilicaria badia* Frey		Umbilicariaceae	Olley and Sharma (2013)
816	*Umbilicaria cinereorufescens* (Schaer.) Frey		Umbilicariaceae	Olley and Sharma (2013)
817	*Umbilicaria decussata* (Vill.) Zahlbr.		Umbilicariaceae	Olley and Sharma (2013)
818	*Umbilicaria indica* Frey		Umbilicariaceae	Olley and Sharma (2013)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
819	*Umbilicaria indica* var. *nana* Frey & Poelt		Umbilicariaceae	Olley and Sharma (2013)
820	*Umbilicaria krascheninnikovii* (Sav.) Zahlbr.		Umbilicariaceae	Olley and Sharma (2013)
821	*Umbilicaria leiocarpa* DC.		Umbilicariaceae	Olley and Sharma (2013)
822	*Umbilicaria nanella* Frey & Poelt		Umbilicariaceae	Olley and Sharma (2013)
823	*Umbilicaria nepalensis* Poelt		Umbilicariaceae	Olley and Sharma (2013)
824	*Umbilicaria rhizinata* (Frey & Poelt) Krzewicka		Umbilicariaceae	Olley and Sharma (2013)
825	*Umbilicaria thamnodes* Hue		Umbilicariaceae	Olley and Sharma (2013)
826	*Umbilicaria trabeculata* Frey & Poelt		Umbilicariaceae	Olley and Sharma (2013)
827	*Umbilicaria vellea* (L.) Ach. & Frey		Umbilicariaceae	Olley and Sharma (2013)
828	*Umbilicaria verginis* Schaer.		Umbilicariaceae	Olley and Sharma (2013)
829	*Umbilicaria yunnana* (Nyl.) Hue		Umbilicariaceae	Olley and Sharma (2013)
830	*Usnea aciculifera* Vain.		Parmeliaceae	Olley and Sharma (2013)
831	*Usnea baileyi* (Stirt.) Zahlbr.	*Eumitria baileyi* Stirt.	Parmeliaceae	Olley and Sharma (2013)
832	*Usnea compressa* Tayl.		Parmeliaceae	Olley and Sharma (2013)
833	*Usnea dendritica* Stirt.		Parmeliaceae	Olley and Sharma (2013)
834	*Usnea filipendula* Stirt.		Parmeliaceae	Olley and Sharma (2013)
835	*Usnea galbinifera* var. s*ubfibrillos*a Asahina		Parmeliaceae	Olley and Sharma (2013)
836	*Usnea himalayana* Bab.		Parmeliaceae	Olley and Sharma (2013)
837	*Usnea implicata* forma *subcreberrima* (Vain.) Asahina		Parmeliaceae	Olley and Sharma (2013)
838	*Usnea longissima* (Hepp) Overeem		Parmeliaceae	Olley and Sharma (2013)
839	*Usnea luridorufa* Stirt.		Parmeliaceae	Olley and Sharma (2013)
840	*Usnea montis-fuji* Motyka		Parmeliaceae	Olley and Sharma (2013)
841	*Usnea nepalensis* G.Awasthi		Parmeliaceae	Olley and Sharma (2013)
842	*Usnea nipparensis* Asahina		Parmeliaceae	Olley and Sharma (2013)
843	*Usnea norkettii* G.Awasthi		Parmeliaceae	Olley and Sharma (2013)
844	*Usnea orientalis* Motyka		Parmeliaceae	Olley and Sharma (2013)
845	*Usnea pangiana* Stirt.		Parmeliaceae	Olley and Sharma (2013)
846	*Usnea perplexans* Stirt.		Parmeliaceae	Olley and Sharma (2013)
847	*Usnea pseudojaponica* G.Awasthi		Parmeliaceae	Olley and Sharma (2013)
848	*Usnea pseudomontis-fuji* Asahina		Parmeliaceae	Olley and Sharma (2013)
849	*Usnea pseudosinensis* Asahina		Parmeliaceae	Olley and Sharma (2013)
850	*Usnea robusta* Stirt.		Parmeliaceae	Olley and Sharma (2013)
851	*Usnea roseola* Vain.		Parmeliaceae	Olley and Sharma (2013)
852	*Usnea rubescens* Stirt.		Parmeliaceae	Olley and Sharma (2013)
853	*Usnea rubicunda* Stirt.		Parmeliaceae	Olley and Sharma (2013)
854	*Usnea splendens* Stirt.		Parmeliaceae	Olley and Sharma (2013)
855	*Usnea subsordida* Stirt.		Parmeliaceae	Olley and Sharma (2013)
856	*Usnea thomso*nii Stirt.		Parmeliaceae	Olley and Sharma (2013)
857	*Usnea trichodea* Vain.		Parmeliaceae	Olley and Sharma (2013)
858	*Usnea trichodeoides* Vain. ex Motyka	*Dolichousnea trichodeoides* (Vain. ex Motyka) Articus	Parmeliaceae	Olley and Sharma (2013)
859	*Verrucaria acrotella* Ach.		Verrucariaceae	Rai et al. (2016)
860	*Verrucaria margacea* (Wahlenb.) Wahlenb.		Verrucariaceae	Rai et al. (2016)
861	*Xanthomendoza ulophyllodes* (Räsänen) Soøchting, Karnefelt & S. Kondr.	*Xanthoria ulophyllodes* Räsänen	Teloschistaceae	Olley and Sharma (2013)
862	*Xanthoparmelia australasica* D.J.		Parmeliaceae	Rai et al. (2016)

S.N.	Lichen Taxa	Modified Names (www.gbif.org)	Family	References
	Galloway			
863	*Xanthoparmelia coreana* (Gyeln.) Hale		Parmeliaceae	Olley and Sharma (2013)
864	*Xanthoparmelia isidiosa* (Jatta) Elix & J.Johnst.		Parmeliaceae	Olley and Sharma (2013)
865	*Xanthoparmelia mexicana* (Gyeln.) Hale		Parmeliaceae	Olley and Sharma (2013)
866	*Xanthoparmelia nepalensis* L.R.Sharma & Kurok.		Parmeliaceae	Olley and Sharma (2013)
867	*Xanthoparmelia tuberculiformis* Kurok.		Parmeliaceae	Olley and Sharma (2013)
868	*Xanthoria borealis* R.Sant. & Poelt	*Gallowayella borealis* (R.Sant. & Poelt) S.Y.Kondr., Fedorenko, S.Stenroos, Kärnefelt, Elix, Hur & A.Thell	Teloschistaceae	Olley and Sharma (2013)
869	*Xanthoria candelaria* (L.) Arn.	*Polycauliona candelaria* (L.) Frödén, Arup & Søchting	Teloschistaceae	Olley and Sharma (2013)
870	*Xanthoria elegans* (Link) Th.Fr.		Teloschistaceae	Olley and Sharma (2013)
871	*Xanthoria fallax* Arnold	*Oxneria fallax* (Arnold) S.Y.Kondr. & Kärnefelt	Teloschistaceae	Olley and Sharma (2013)
872	*Xanthoria fulva* (Hoffm.) Poelt & Petut.	*Gallowayella fulva* (Hoffm.) S.Y.Kondr., Fedorenko, S.Stenroos, Kärnefelt, Elix, Hur & A.Thell	Teloschistaceae	Olley and Sharma (2013)
873	*Xanthoria sorediata* (Vain.) Poelt	*Rusavskia sorediata* (Vain.) S.Y.Kondr. & Kärnefelt	Teloschistaceae	Olley and Sharma (2013)

Inventory of Ferns and Fern Allies of Raja-Rani Wetland and Adjoining Forest, Eastern Nepal

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Abstract

Pteridophytic flora of Raja-Rani wetland area occurring in the churia range was studied in pre monsoon 2019 to post monsoon 2020. A total of 50 species of ferns and fern allies belonging to 19 families and 32 genera were recorded. Pteridaceae was the largest family with 13 species and *Thelypteris* was the largest genus with five species. Occurrence of the fern species inareawas in the order: terrestrial (60%) > lithophytic (18%) > epiphytic (10%) > aquatic (6%) and climbers (6%). Nine species were threatened and *Huperzia phlegmaria* (L.) Rothm. & *Lindsaea ensifolia* Sw. were rare species new to Eastern, Nepal.

Keywords: *Angiopteris helferiana*, Endangered, Epiphytes, Letang, *Oeosporangium belangeri*

Introduction

Ferns along with fern allies are an integral part of the world vegetation. They are non-flowering leafy or leafless vascular plants generally found in moist and shady places of tropical to alpine climate. Ferns are considered as the oldest vascular plant to become dominant on the earth about 299-369 million years ago (Carboniferous Period), now they are replaced by Angiosperms and Gymnosperms (Rothwell & Stockey, 2008). They have varied habits like terrestrial, epiphytic, aquatic, lithophytic (Gurung, 1991). They are also being used as an important source of vegetable, medicine, fodder, ornamental plants in different parts of the world including Nepal (Dangol, 2002; Rout et al., 2009). There are about 12000 species of pteridophytes in the world (Christenhusz & Byng, 2016). In Nepal, 582 taxa (550 species and 32 subspecies) of ferns and fern allies are found (Kandel & Fraser-Jenkins, 2020).

In National Herbarium and Plant Laboratories, Nepal (KATH) about 18,000 specimens of the Pteridophytes have been preserved and greatest number of collection is confined to central Nepal (Kandel, 2020). Three ferns *viz., Asplenium pseudofugax*, *Bolbitis andreisii* and *Polystichum annapurnicola* are endemic to Nepal (Fraser-Jenkins et al., 2015; Fraser-Jenkins & Kandel, 2019; Kandel & Fraser-Jenkins, 2020). The maximum species richness of pteridophytes is found in central Nepal at an altitude of 2000m (Bhattrai et al., 2004).

Eastern region of Nepal being rich in plant diversity also lacks major studies in the pteridophytes. Some of the literature regarding pteridophytes of eastern Nepal are: Siwakoti & Sharma, (1998); Jha, (2000); Thapa, (2001); Bhagat & Shrestha, (2010); Pathak et al., (2012) etc. Present work is preliminary exploration of fern and fern allies along with their ecology and status from the Raja-Rani wetland and adjoining forest located in Letang Municipality of Morang District Eastern Nepal.

Materials and Methods

Study Area

Raja-Rani wetland (26°45'21" N, 87°29'10"E, Altitude 470 m) is situated in the Letang Municipality-1, Morang District in chure range of Province-1, Nepal (Figure 1). It is protected under Raja-Rani community forest (17 sq. km.), which harbors three ponds *viz.,* Raja, Rani, and Rajkumari altogether covering 0.2 sq. km (Basnet et al., 2005). The wetland area is an important religious and historic place for Dhimal tribes surrounded by *Shorea robusta* dominated dense mixed forest associated with *Adina cordifolia*, *Cassia fistula*, *Semecarpus anacardium, Anthocephalus cadamba* etc (Chettry, 2017).

The climate of the study area is hot and humid during the summer, having rich monsoon rain and cold dry winters. The average annual maximum and minimum temperature ranges from 12°C-19°C and 22°C-30°C respectively. The annual rainfall of the region varies from 1,138mm to 2,671mm (Godar & Rai, 2018). The area is passing through socioeconomic changes like infrastructural development, tourism andrecreations.

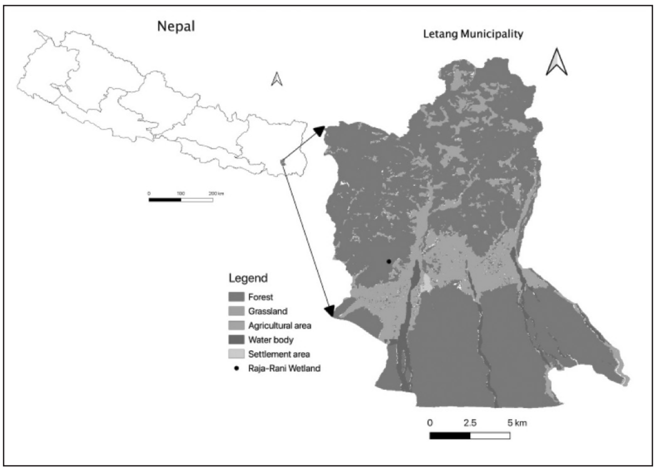

Figure1: Raja-Rani wetland in the map of Letang Municipality, Nepal.

Plant collection and Identification

The present work is based on regular field visits, herbarium collection, field notes, photography, and identification. Several field visits were conducted during the pre-monsoon of 2019 to post-monsoon of 2020. Mature fronds of the plants along with sori were gently cut and in the case of small plants, whole plants were collected from around 50m of the bank of the pond area. The photographs of the plants in natural habitat and after collection were taken. A boat was also used to collect the plants of wetland area. The collected plants were placed in between newspaper, pressed for several days with frequently changing paper usedand after got dried mounted on herbarium sheets with labeling. Identification and notes on status (Distribution status and Threaten status) of the collected specimens were done using Fraser-Jenkins et al., (2015), Fraser-Jenkins & Kandel, (2019), Kandel & Fraser-Jenkins, (2020) etc. Herbarium specimens were deposited in the Tribhuvan University Regional Herbarium, Department Botany, Post Graduate Campus, T.U., Biratnagar. Most of the specimens were identified in National Herbarium and Plant Laboratories, Godawari (KATH).

Results and Discussion

In the present study, 50 species of ferns and fern allies belonging to 19 families and 32 genera were reported from the study area (Appendix 1). Two species *Huperzia phlegmaria* and *Lindsaea ensifolia* were new to Eastern Nepal. Six species were fern allies and the rest were ferns. Among 19 families, Pteridaceae was the largest family (13 species) followed by Polypodiaceae (6 species), Thelypteridaceae (5 species). Lomariopsidaceae, Lycopodiaceae & Lygodiaceaehad (3 species) in each and Dryopteridaceae, Lindaeceae, Selaginellaceae & Woodsiaceaehad (2 species) in each. Aspleniaceae, Blechnaceae, Cyatheaceae, Dennstaedtiaceae, Equisetaceae, Gleicheniaceae, Marattiaceae, Salvinaceae and Vittariacaeaehad single species in each (Figure 2).

The largest genus was *Thelypteris* (5 species) followed by *Pteris* and *Pyrrosia* (4 species) in each. Most of the species were terrestrial (60%) followed by lithophytic (18%), epiphytic (10%), aquatic (6%) and climbers (6%) respectively (figure 3). No species were found in more than one habit.

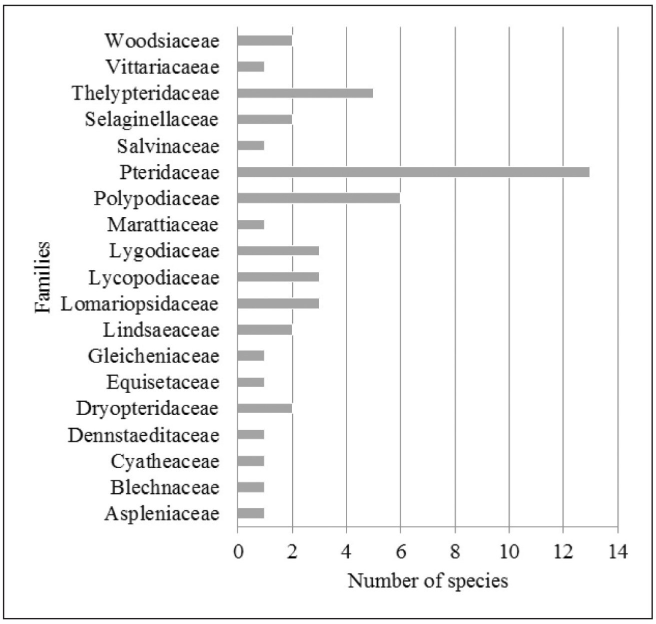

Figure 2: Number of species among the families in Raja-Rani, Letang.

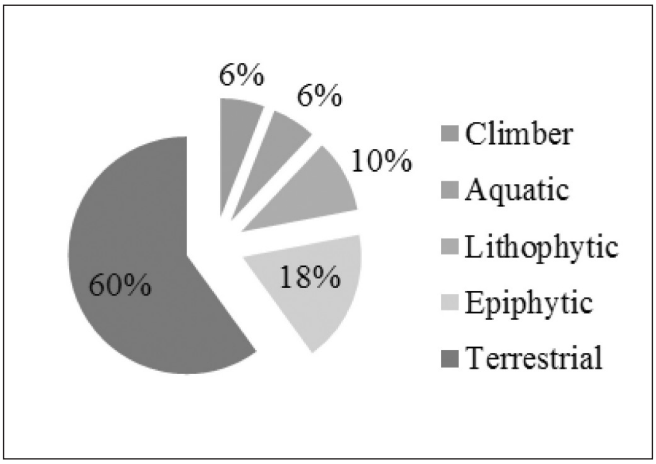

Figure 3: Habit of Ferns and Fern Allies in Raja-Rani, Letang.

Nine threatened ferns and fern allieswere reported from the area. One species *Lygodium microphyllum* is critically endangered, three species (*Huperzia phlegmaria, Lindsaea ensifolia* and *Oeosporangium belangeri*) are endangered, two species (*Pteris semipinnata* and *Thelypteris interrupta*) are vulnerable, two species (*Angiopteris helferiana* and *Cyathea spinulosa*) are least concerned and one species *Huperzia squarrosa* is nearly threatened. *Cyathea spinulosa* is a CITES appendix II listed fern and *Oeosporangium belangeri* is one of the rarest fern of Nepal (Joshi et al., 2017; Kandel, 2020).

Diplazium esculentum and *Dryopteris cochleata* were locally used as vegetable. *Aleuritopteris bicolor, Angiopteris helferiana, Blechnum orientale, Cyathea spinulosa*, *Dynaria quercifolia, Lygodium japonicum, Lygodium flexuosum, Pteris biaurita, Pityrogramma calomelanos* and *Tectaria coadunata* were medicinal ferns (Gurung, 1979; Pathak et al., 2012).

Sharma et al., (2020) reported 10 species of ferns from Raja-Rani wetland Letang, among them two species *Azolla pinnata* subsp. *asiatiica* and *Thelypteris interrupta* (Synonym *Cyclosorus interruptus*) were aquatic. Beside these species, present study reported one morecommon aquatic fern *Ceratopteris thalictroides* from the area.Two species of ferns *Microlepis setosa* (Sharma et al., 2020) and *Drynaria coronans* (Kandel & Fraser-Jenkins, 2020) were not reported from the area.

Conclusions

In about 0.3 sq. km., 50 species of ferns and fern allies were reported and two of them were new to the eastern Nepal. The area has a high diversity of ferns and fern allies with number of threatened species requiring urgent need for conservation strategies. Further studies are also inevitable for biodiversity management strategies in the Raja-Rani wetland and adjoining forest area of Letang municipality, Morang.

Author Contributions

The first author conducted field visits, prepared herbariums, identified specimens, and prepared manuscript. Second author designed the study, helped in identification & manuscript preparation and supervised the work.

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Table 1 : Distribution and occurrence of Pteridophytes from Raja-Rani Morang.

S.N.	Name	Family	Habitat	Threaten Status	Distribution Status
1	*Asplenium obscurum* Blume	Aspleniaceae	Lithophytic	-	C; E: Sunsari, Panchthar.
2	*Blechnum orientale* L.	Blechnaceae	Terrestrial	-	C;E: Solukhumbu, Sankhuwasabha, Morang, Jhapa, Ilam.
3	*Cyathea spinulosa* Wall. ex Hook.	Cyatheaceae	Terrestrial	LC	C; E: Solukhumbu, Sankhuwasbha, Bhojpur, Ilam, Taplejung.
4	*Microlepia speluncae* (L.) T. Moore	Dennstaedtiaceae	Terrestrial	-	C;E: Morang, Jhapa.
5	*Dryopteris cochleata* (D.Don) C.Chr.	Dryopteridaceae	Terrestrial	-	W;C;E: Okhaldhunga, Bhojpur, Sankhuwasabha, Sunsari, Dhankuta, Jhapa, Ilam, Taplejung.
6	*Tectaria coadunata* (Wall. ex Hook. & Grev.) C.Chr.	Dryopteridaceae	Terrestrial	-	W;C;E: Udaypur, Sankhuwasabha, Sunsari, Dhankuta, Ilam, Panchthar, Taplejung.
7	*Equisetum ramosissimum* Desf.	Equisetaceae	Terrestrial	-	W;C;E: Sankhuwasabha, Sunsari, Saptari, Morang, Dhankuta, Taplejung
8	*Dicranopteris lanigera* (D.Don) Fraser-Jenk.	Gleicheniaceae	Terrestrial	-	W;C;E: Okhaldhunga, Khotang, Solukhumbu, Sankhuwasabha
9	*Lindsaea ensifolia* Sw.*	Lindsaeaceae	Terrestrial	EN	C
10	*Odontosoria chinensis* (L.) J.Sm.	Lindsaeaceae	Terrestrial	-	C;E: Bhojpur, Sankhuwasabha, Jhapa, Ilam, Taplejung.
11	*Bolbitis costata* (C.Presl) Ching	Lomariopsidaceae	Lithophytic	-	C;E: Solukhumbu, Jhapa.
12	*Bolbitis heteroclita* (C.Presl) Ching	Lomariopsidaceae	Terrestrial	-	C;E: Jhapa, Sankhuwasabha, Ilam.
13	*Elaphoglossum stelligerm* (Wall. ex Baker) T. Moore ex Salpmon	Lomariopsidaceae	Lithophytic	-	W;C;E: Okhaldhunga, Sankhuwasabha, Dhankuta, Taplejung.
14	*Huperzia phlegmaria* (L.) Rothm.*	Lycopodiaceae	Epiphytic	EN	C
15	*Huperzia squarrosa* (G.Forst.) Trevis.	Lycopodiaceae	Epiphytic	NT	C;E: Sankhuwasabha, Ilam.
16	*Palhinhaea cernua* (L.) Vasc. & Franco.	Lycopodiaceae	Terrestrial	-	C;E: Jhapa, Ilam, Taplejung.
17	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Climber	-	W;C;E: Udayapur, Sunsari, Morang, Dhankuta, Sankhuwasabha, Terathum, Jhapa, Ilam, Taplejung.
18	*Lygodium japonicum* (Thunb.) Sw.	Lygodiaceae	Climber	-	W;C;E: Udayapur, Khotang, Bhojpur, Sankhuwasabha, Sunsari, Morang, Dhankuta, Ilam, Taplejung.
19	*Lygodium microphyllum* (Cav.) R.Br.	Lygodiaceae	Climber	CR	E: Morang.
20	*Angiopteris helferiana* C.Presl	Marattiaceae	Terrestrial	LC	C;E: Morang, Jhapa, Ilam.
21	*Drynaria quercifolia* (L.) J. Sm	Polypodiaceae	Epiphytic	-	C;E: Sankhuwasabha, Morang, Jhapa, Ilam.

S.N.	Name	Family	Habitat	Threaten Status	Distribution Status
22	*Microsorum punctatum* (L.) Copel.	Polypodiaceae	Epiphytic	-	C;E: Morang, Jhapa, Ilam.
23	*Pyrrosia costata* (Wall. ex C.Presl) Tagawa & K.I wast	Polypodiaceae	Epiphytic	-	W;C;E: Bhojpur, Sankhuwasabha, Sunsari,Dhankuta, Taplejung.
24	*Pyrrosia lanceolata* (L.) Farw.	Polypodiaceae	Epiphytic	-	W;C;E: Sankhuwasabha, Sunsari, Morang, Jhapa, Ilam, Taplejung.
25	*Pyrrosia nuda* (Giesenh.) Ching	Polypodiaceae	Epiphytic	-	C;E: Bhojpur, Sankhuwasabha, Morang, Dhankuta, Taplejung.
26	*Pyrrosia porosa* (Presl) Hovenkamp	Polypodiaceae	Epiphytic	-	W;C;E: Bhojpur, Sankhuwasabha, Sunsari, Dhankuta, Ilam, Taplejung
27	*Adiantum incisum* Forssk. subsp. *incisum*	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Okhaldhunga, Bhgojpur, Sunsari, Morang, Dhankuta, Sankhuwasabha, Taplejung.
28	*Adiantum philippense* L.	Pteridaceae	Terrestrial	-	W;C;E: Sankhuwasabha, Sunsari, Morang, Dhankuta, Jhapa, Ilam.
29	*Aleuritopteris bicolor* (Roxb.)	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Bhojpur, Sankhuwasabha, Sunsari, Morang, Dhankuta, Jhapa, Ilam, Panchthar, Taplejung.
30	*Ceratopteris thalictroides* (L.) Brongn.	Pteridaceae	Aquatic	-	W;C;E: Sankhuwasabha, Jhapa, Taplejung.
31	*Oeosporangium belangeri* (Bory) Fraser-Jenk.	Pteridaceae	Terrestrial	EN	C;E: Sunsari, Jhapa
32	*Oeosporangium tenuifolim* (Burm.fil.) Fraser-Jenk. & Pariyar	Pteridaceae	Terrestrial	-	W;C;E: Khotang, Sankhuwasabha, Solukhumbu, Bhojpur, Jhapa, Ilam
33	*Onychium lucidum* (D.Don) Spreng.	Pteridaceae	Epiphytic	-	W;C;E: Sankhuwasabha, Taplejung
34	*Onychium siliculosum* (Desv.) C.Chr.	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Okhaldhunga, Bhojpur, Sunsari, Sankhuwasabha, Morang, Dhankuta, Tewrathum, Jhapa, Ilam, Panchthar, Taplejung.
35	*Pityrogramma calomelans* (L.) Link.	Pteridaceae	Terrestrial	-	W;C;E: Sankhuwasabha, Sunsari, Morang, Dhankuta, Jhapa, Ilam, Taplejung.
36	*Pteris biaurita* L.	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Solukhumbu, Morang, dhankuta, Ilam, Taplejung.
37	*Pteris semipinnata*L.	Pteridaceae	Terrestrial	VU	C;E: Morang, Jhapa.
38	*Pteris venusta* Kunze subsp. *matsudae* (Masam.) Fraser-Jenk. & Kandel	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Sunsari, Jhapa, Ilam.
39	*Pteris vittata* L.	Pteridaceae	Terrestrial	-	W;C;E: Udayapur, Khotang, Sunsari, Morang, Dhankuta, Sankhuwasabha, Jhapa, Ilam.
40	*Azolla pinnata* R. Br. subsp. *asiatica* R.M.K. Saunders & K. Fowler.	Salvinaceae	Aquatic	-	W;C;E: Bhojpur, Sankhuwasabha, Sunsari, Morang, Taplejung.
41	*Selaginella cillaris* (Retz.) Spring	Selaginellaceae	Lithophytic	-	W;C;E: Siraha, Morang, Taplejung.
42	*Selaginella subdiaphana* (Wall. ex Hook. & Grew) Spring	Selaginellaceae	Lithophytic	-	W;C;E: Sankhuwasabha, Bhojpur, Dhankuta, Siraha, Sunsari, Ilam, Taplejung.

S.N.	Name	Family	Habitat	Threaten Status	Distribution Status
43	*Thelypteris interrupta* (Willd.) K.Iwats	Thelypteridaceae	Aquatic	VU	W;E: Morang.
44	*Thelypteris lakhimpurensis* (Rosenst.) K.Iwats.	Thelypteridaceae	Terrestrial	-	C;E: Ilam.
45	*Thelypteris nudata* (Roxb.) C.V.Morrton	Thelypteridaceae	Terrestrial	-	W;C;E: Sunsari, Sankhuwasabha, Jhapa, Ilam.
46	*Thelypterisornata* (J.Sm) Ching	Thelypteridaceae	Terrestrial	-	W;C;E: Sankhuwasabha, Ilam.
47	*Thelypteris procera* (D.Don) Fraser-Jenk	Thelypteridaceae	Terrestrial	-	W;C;E: Udayapur, Okhaldhunga, Sankhuwasabha, Sunsari, Dhankuta, Morang, Jhapa,Ilam, Panchthar, Taplejung.
48	*Vittaria flexuosa* Fée	Vittariacaeae	Epiphytic	-	W;C;E: Bhojpur, Sankhuwasabha, Solukhumbu, Jhapa, Sunsari, Ilam, Panchthar, Taplejung.
49	*Deparia japonica* (Thunb.) M.Kato subsp. *japonica*	Woodsiaceae	Terrestrial	-	W; C; E: Sankhuwasabha, Ilam, Taplejung.
50	*Diplazium esculentum* (Retz.) Sw.	Woodsiaceae	Terrestrial	-	W;C;E: Sankhuwasabha, Sunsari, Morang, Dhankuta, Panchthar, Taplejung.

Note:* = New report for Eastern Nepal CR= Critically Endangered, EN= Endangered, LC= Least Concerned, NT= Nearly Threatened, VU= Vulnerable, W= Western Nepal, C= Central Nepal, E= Eastern Nepal

An Assessment of Floristic Diversity and Uses of Plant Resources in Madane Protected Forest Gulmi, Western Nepal

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Abstract

Madane Protected Forest (MPF) located in western Nepal is enriched with diverse biodiversity. MPF is pristine in terms of scientific research featuring floristic diversity and documenting traditional knowledge of locals. In this study, we aimed to document floristic diversity and usage of plant resources among locals of MPF. Altogether 50 plots were established along an elevational gradient of Bhedikhor–Banjhkateri cluster to document the floristic diversity. Plant-use data were obtained through 30 key informant interviews and five group discussions. Total of 185 species belonging to 154 genera from 74 families were recorded. Asteraceae was the dominant family followed by Poaceae, Rosaceae, and Lamiaceae. Several highly prioritized plants such as *Paris polyphylla, Dioscorea deltoidea, Tinospora sinensis, Swertia chirayita* were documented. *Hypericum cordifolium* (Hyperiaceae), an endemic species was also recorded for the first time from the MPF. Locals of MPF were directly or indirectly dependent on forest resources for meeting their daily requirements. Findings showed, locals gave more priority to those species that provide them with multitude of benefits. Habitat destruction, overharvesting of natural resources, wildfire, unmanaged road constructions are the major threats to the natural forest in MPF. We recommend that the forest officials of MPF should realize the urgency of conservation of this unique hub of biodiversity. Besides, a large area of this forest remained untouched in terms of scientific research so, a detailed survey or inventory should be done immediately to document the unique biodiversity.

Keywords: Biodiversity, Conservation, Disturbance, Exploration, Traditional knowledge

Introduction

The floristic study refers to the documentation of all plant species present in a given geographical region (Simpson, 2006). Study of the floristic diversity of the local or regional area is inevitable, because such studies help in botanical enumeration, updating nomenclature, documenting changes in ecological conditions, adding herbarium specimens in the existing herbaria and determining the nature and distribution of flora resources to be managed (Raghubanshi & Singh, 2003; Chalise et al., 2018). Knowledge of floral diversity of a particular area can reflect the total resources, their traditional uses, and conservation status which are very helpful for making conservation strategies and policies (Chaudhary et al., 2002; Bhanadari et al., 2018).

Plants are regarded as the most important component of natural resources upon which peoples and animals are highly dependent. Natural forest resources are an important component for maintaining the ecological balance of nature, stabilizing the water cycle, and serve as a source of income by attracting tourists, serve as recreational facilities, serve as carbon sequestration and regulate water resources (Tsegaye, 2006). Hence, to maintain ecological equilibrium and to meet the forest requirement, systematic floristic inventory and ecological exploration are important to judge the success of the conservation efforts of the natural forest (Dangol & Shivakoti, 2001). No such study was previously done in Madane Protected Forest (MPF) excluding the general survey of MPF conducted by Department of Forest during declaration of Protected Forest (DoF, 2011).

Major people of the rural area directly depend on forest resources for meeting their daily requirements as well as economic well-being (Gubhaju & Ghimire, 2009; Aryal et al., 2018).

The plant world provides society with a wide array of goods and services and plan-use practice is found to vary according to location, tradition, climatic condition, vegetation type and, rooted belief system of locals (Kunwar & Bussman, 2008). The components of biodiversity are the source of all our food and nutrition and many of our medicines, vegetables, fibers, fuels, timbers, condiments, dye, fruit, meat, and building materials and industrial products (Ghimire, 2008; Rana et al., 2015). Hence plant resources can be the major source of rural income and an important source of revenue to the government (Ghimire, 2008). Humankind derives considerable benefits not only from the products of biodiversity but also from the services of ecological systems, such as water purification, erosion control, and pollination (NRC, 1999).

Realizing the importance of biodiversity cum watershed conservation, the ecological significance of biological corridor connecting to the Dhorpatan Hunting Reserve, the cultural importance of forest and, the surrounding area, the Government of Nepal has declared Madane Forest area as Madane Protected Forest (MPF) in 2013 AD. The MPF is known for its typical middle mountain forest ecosystem that holds 38.62% dense forest at a higher elevation (Thakuri et al., 2018; Kandel, 2018). The forest is an important watershed, providing drinking water to thousands of households and also serve as a major source of rivers of Gulmi, Arghakhachi, Baglung, and Pyuthan. Most of the traditional knowledge and information about plant resources of rural areas of Nepal are still unknown (Primack et al., 2013). Therefore, it is quite important to explore more and document floral diversity and traditional knowledge about forest resources of different communities of MPF before it is completely lost. Several studies have been conducted on floristic exploration in different parts of Nepal but no any in-depth research has been conducted in MPF till now. This small step, therefore, helps to conceptualized and assess the floristic composition along with multiple uses of key plant resources of the MPF. This type of study is essential to make proper conservation plans and sustainable utilization of plant resources (Uprety et al., 2016).

Materials and Methods

Study Area

Madane Protected Forest (MPF) is located in Gulmi district, Lumbini province of west Nepal. MPF lies in a distance of 30 km (west) from the district headquarter, Tamghas. It covers an area of 13,761 ha and ranges in elevation from 975 m (basin of Ghamir) to 2690 m (peak of Hawangdii). Climatically, the area lies between subtropical and temperate zone with minimum annual precipitation of 2021 millimeter (mm) (DoF, 2016). The area is enriched with unique biodiversity and beautiful landscape with a mild climate (Thakuri et al. 2018). MPF falls on two rural municipalities Madane and Malika. MPF consists of 56 community forest (CF) and 8 leasehold forest (LF). Our study area was Bhedikhor-Banjhkateri cluster in which the elevation ranges from 1700 m asl. (Bhedikhor) to 2500 m asl (Malika Mandir). Forest types found in MPF are classified as Schima-Castanopsis forest, Lower temperate Oak forest, Temperate mountain Oak forest, Chir pine forest, and Alder forest (DoF, 2011). Major ethnicities are Brahmin, Kshetri, Magar, Thakuri, Sanyashi, and Dalit.

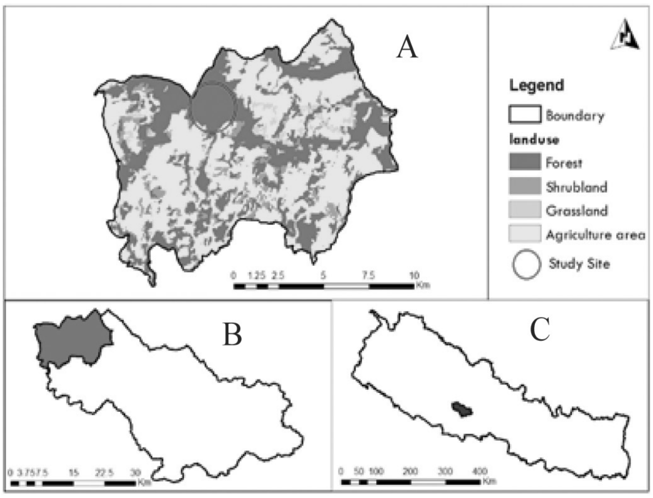

Figure 1: Map showing: A: study area inside Madane Protected Forest (MPF); B: MPF location inside Gulmi district and C: location of Gulmi district in Nepal map

Sampling and Data Collection

Permissions to carry out this research were obtained from the Ministry of Forest and Soil Conservation, Department of Forest, Government of Nepal, and from Division Forest Office Gulmi. The field sampling was done in January and September of 2018. Study site was stratified into five horizontal transects roughly in an interval of 200 m from 1700-2500 m asl to cover the whole study area. A systematic random sampling approach was used to document floral diversity. On each transects 10 plots (10 m x 10 m) were sampled by maintaining an inter-plot distance of at least 20 m. All forms of plant species present in the plot were recorded and categorized based on their habit.

Altogether 50 plots were sampled in study the area. Plant species were collected from the study site with at least a local name with the help of an experienced local guide. Taxonomically important characters were noted in the field and samples for voucher specimens of each species on the state of either flowering or fruiting or both were collected. Identification of those specimens was done by following standard literature (Polunin & Stainton 1984; Stainton 1988; Press et al. 2000; Shrestha 2018), expert consultation, and comparing with specimen housed at TUCH and KATH. Herbarium specimens prepared were deposited at TUCH. Nomenclature and author citation of plant species followed the International Plant Name Index (https://www.ipni.org/). Information regarding plant-use was collected from the local communities by implying thirty key informant (senior citizens, local healer, school teacher, farmers) interviews and five group discussions with their prior verbal consent. Informants mainly include senior citizens, traditional healers, farmers, and local teachers. Respondents were within the age group of 20-70 years (male and female). Semi-structured questionnaires were used to obtain detailed information regarding knowledge on plant resources, use-value, harvesting methods, and conservation practices. Plant specimens and field photographs were shown during interviews and group discussions. The information collected included the local name of plants and different uses.

Results and Discussion

We recorded 185 species belonging to 154 genera under 74 families from the study area. Dominant families were Asteraceae with 14 genera followed by Poaceae (10 genera), Rosaceae (9 genera), Lamiaceae (8 genera), Fabaceae (7 genera) and Moraceae (6 genera) (Figure 1, Table 1). So far, the previous works are concerned, DoF (2011) has given a list of only 118 plant species from entire MPF (13671 ha.). It doesn't seem DoF conducted in-depth floristic assessment. Most of the recorded plant species in the study sites were angiosperms. A total of 148 species of dicotyledonous plants, 22 monocotyledonous plants, 14 pteridophytes, and one species of gymnosperm were documented in our study (Table 1).

Based on life form (habit) highest number belongs to herbs, followed by shrubs, trees, ferns grasses, and climbers whereas, the lowest number was recorded for epiphytes (Figure 2). The study area housed many plant species, which were categorized as rare, commercially threatened, endemic, vulnerable, and highly prioritized medicinal plants by different organizations. *Asparagaus racemosus*, *Cinnamomum glaucescens*, *Phyllanthus emblica*, and *Zanthoxylum armatum* found in the study area are the medicinal plants which fall under the prioritized list of plant resources (DPR, 2011) (Table 2). *Dioscorea deltoidea* found in the study area is included in CITES Appendix II and its trade is regulated by export permit (Joshi et al., 2017). Similarly, *Paris polyphylla, Rubia manjith* and *Swertia chirayita* fall under the vulnerable category of Conservation Assessment and Management Plan (CAMP) (Bhattarai et al., 2002) (Table 2). One endemic species, *Hypericum cordifolium* (Rajbhandari et al., 2016; Tiwari et al., 2019) was also recorded from MPF for the first time. To preserve these valuable natural resources, the exact information about their population status is needed to be documented before they are completely lost (Acharya, 2012). Unfortunately, little knowledge of important plant resources, unscientific harvesting practices, lack of conservation awareness amongst the local communities are the main factors that may threaten valuable plant assets present in the area.

The information collected showed that the locals of MPF depend upon the forest for their primary healthcare, fodder, food, fuelwood, timber, and other miscellaneous purposes. Out of 185 species recorded in Bhedikhor – Banjhkateri cluster, 130 species (70 %) were utilized by locals for different purposes. The highest number of plants were used as fodder followed by medicine, fruit and food, fuelwood, and timber. (Figure 4). The majority of the households of MPF were involved in the traditional agriculture system hence, forest areas at lower elevations were in the high pressure of uncontrol fodder, timber and, fuelwood collection, which was shifting towards upper core forest area. Oak was one of the most overexploited species found in the study area due to its multiple uses (fodder, timber, leaf litter and, fuelwood). Poisonous plant species recorded in the study area were *Buddleja paniculata* and *Sapium insigne*, which were used for fishing in local rivers (Joshi & Joshi 2006). *Desmostachys bipinnata* and *Artemesia indica* were among the few plants used in religious and traditional rituals. Some plants were of multiple uses, such as *Mahonia napaulensis, Phyllanthus emblica* used as fruit and medicine, *Asparagus racemosus* as medicinal and religious, *Urtica dioca* as vegetable and medicine, *Daphne bholua* as fiber and medicine. Few species of plants were used for making fiber such as *Daphne bholua*, *Girardiana diversifolia* (Table 1). People preferred to collect species with multiple uses and the population of those plants was more disturbed due to overharvesting and developmental activities (Chaudhary et al., 2002; Thapa & Chapman, 2010). We documented Nepali paper plant i.e., *Daphne bholua*, which is regarded as commercially threatened non-timber forest product (NTFP) of west Nepal (Adhikari et al., 2017). Although this plant was not yet used commercially for paper making, locals used it frequently for making cordage and medicinal purposes. There was very good population of *Daphne bholua* in MPF, which possesses a great possibility to be an alternative source of income for locals if it is used sustainably. Hence, concerned authorities; (Ministry of Forest, Division Forest Office, and local government) along with the stakeholders (locals of MPF and traders) should initiate an immediate research plan which can be very helpful for conserving the vast resource of this forest.

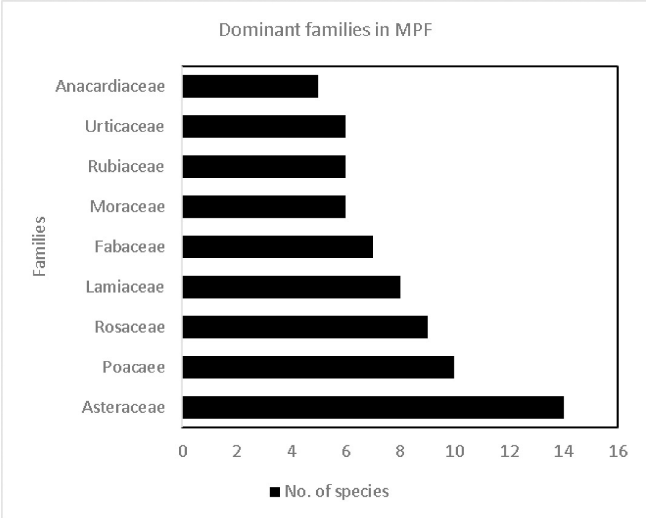

Figure 2: Highest number of family in MPF

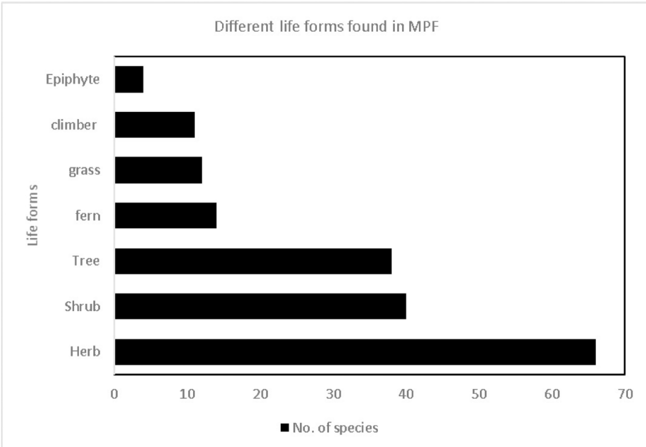

Figure 3: Different life forms of plant found in MPF

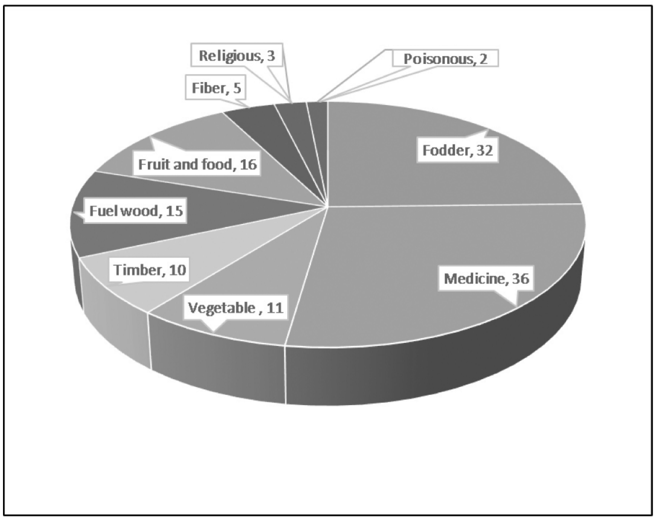

Figure 4: Different uses of plants in MPF

Table 1: List of plant species found in MPF and their uses

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
1	*Aconogonum molle* (D. Don) H. Hara	Halhale	Polygonaceae	Hb	Di	Vg	BG 23
2	*Adiantum philippense* L.		Pteridaceae	Fr	Fr	-	BG 01
3	*Ageratina adenophora* (Spreng.) King & H. Rob.	Kalo banmaraa	Asteraceae	Hb	Di	-	BG 85
4	*Albizia chinensis* (Osbeck) Merr.	Kalo siris	Fabaceae	Tr	Di	Tb	BG 07
5	*Albizia julibrissin* Durazz.	Rato siris	Fabaceae	Tr	Di	Tb	BG 19
6	*Albizia procera* (Roxb.) Benth.	Seto siris	Fabaceae	Tr	Di	Tb	BG 424
7	*Alnus nepalensis* D. Don	Uttis	Betulaceae	Tr	Di	Tb	BG 71
8	*Amaranthus spinosus* L.	Kade lunde	Amaranthaceae	Hb	Di	Vg	BG 76
9	*Amaranthus viridis* L.	Lunde	Amaranthaceae	Hb	Di	Vg	BG 02
10	*Anaphilis controta* (D. Don) Hook. F.	Buki	Asteraceae	Hb	Di		BG 34
11	*Anaphilis triplinervis* (Sims) C.B. Clarke	Buki	Asteraceae	Hb	Di		BG 37
12	*Androsace primuloides* D. Don		Primulaceae	Hb	Di		BG 38
13	*Argemone mexicana* L.	Thakal	Papaveraceae	Hb	Di		BG 18
14	*Artemisia indica* Willd.	Titepati	Asteraceae	Hb	Di	Md, Fdd,Rg	BG 05
15	*Artocarpus lacucha* Buch. - Ham	Badahar	Moraceae	Tr	Di	Frt	BG 11
16	*Arundinaria nepalensis* Trin., Gram. Pan	Ghas	Poaceae	Gr	Mo	Fw	BG 22
17	*Asparagus racemosus* Willd.	Kurilo	Asparagaceae	Hb	Mo	Md/Rg	BG 89
18	*Astragalus donianus* DC.		Fabaceae	Hb	Di	Fdd	BG 16
19	*Bauhinia purpurea* L.	Tanki	Fabaceae	Tr	Di	Fdd	BG 466
20	*Berberis asiatica* Roxb. ex. DC.	Chutro	Berberidaceae	Sh	Di	Frt	BG 30
21	*Berberis glaucocarpa* Stapf	Chutro	Berberidaceae	Sh	Di	Md	BG 41
22	*Berginia ciliata* (Haw) Sternb.	Pakhanbed	Saxifragaceae	Hb	Di	Md	BG 453
23	*Boehmeria platyphylla* Buch. - Ham ex. D. Don		Urticaceae	Sh	Di	Fdd	BG 101
24	*Brassaiopsis hainla* (Buch. - Ham) Seem.	Chuletro	Araliaceae	Tr	Di	Fdd	BG 04
25	*Brassiopsis polycantha* (wall.) Banerjee	Kalo chuletro	Araliaceae	Tr	Di	Frt, Md	BG 40
26	*Buddleja asiatica* Lour.	Bhimsen pati	Scrophulariaceae	Sh	Di	Ps	BG 51
27	*Calanthe sylvatica* (Thoura) Lindl.		Orchidaceae	Ep	Mo	Md	BG 53
28	*Carduus edelbergii* L.	Kazmi	Asteraceae	Hb	Di		BG 106
29	*Carex condensata* Nees		Cyperaceae	Gr	Mo		BG 109
30	*Castanopsis indica* (Roxb.) Miq.	Katush	Fagaceae	Tr	Di	Tb	BG 209
31	*Castanopsis tribuloides* (Sm.) A. DC.	Masure katush	Fagaceae	Tr	Di	Fw	BG 224

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
32	*Centella asiatica* (L.) Urb.	Ghodtapre/ bramhi	Apiaceae	Hb	Di	Md	BG 12
33	*Cersium* sp.		Asteraceae	Hb	Di	Md	BG 103
34	*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill	Lapsi	Anacardiaceae	Tr	Di	Frt, Tb	BG 81
35	*Cinnamomum glauscens* (Nees.) Nand. Mazz	Sugandha kokila	Lauraceae	Tr	Di	Md	BG 62
36	*Cinnamomum tamala* (Buch.-Ham.) Ness & Eberm	Sunkaulii	Lauraceae	Tr	Di	Md	BG 67
37	*Cissampelos pareira* L.	Batulopate	Menispermaceae	Cb	Di	Fdd	BG 97
38	*Clematis acuminata* DC.	Bagh laharo	Ranunculaceae	Cb	Di	Md	BG 107
39	*Clematis buchaniana* Wall.	Bagh lahara	Ranunculaceae	Cb	Di	Md	BG 426
40	*Coelogyne cristata* Lindl.	Orchid	Orchidaceae	Ep	Mo	Md	BG 24
41	*Colebrookea oppositifolia* Sm.	Bhogate	Lamiacea	Sh	Di	Fw	BG 44
42	*Colocasia fallax* Schott.	Ban karkalo / Ban Pindalu	Areaceae	Hb	Mo		BG 125
43	*Colquhounia coccinea* Wall.	Fulchiso/ syal kainchi	Lamiacae	Sh	Di	Fdd	BG 76
44	*Cotoneaster* sp.	Jarbuta /thate	Rosaceae	Sh	Di	Fdd	BG 225
45	*Crassocephalum crepidioides* (Benth.) S. Moore	Anikale jhar	Asteraceae	Hb	Di		BG 77
46	*Crateva unilocularis* Buch.-Ham	Sibligan	Capparaceae	Tr	Di	Vg, Md	BG 284
47	*Cuscuta reflexa* Roxb.	Akash beli	Convolvulacaea	Ep	Di	Md	BG 116
48	*Cyanotis vaga* (Lour.) Schult. & Schult.f.		Commelinaceae	Hb	Mo		BG 153
49	*Cynodon dactylon* (L.) Pers.	Dubo	Poaceae	Gr	Mo	Md, Fdd	BG 140
50	*Cyperus rotundus* L.	Mothe	Cyperaceae	Gr	Mo		BG 64
51	*Daphne bholua* Buch.-Ham. ex D.Don	Nilo baruwa	Thymalaceae	Sh	Di	Fbr, Md	BG 20
52	*Daphne papyreceae* Wall. ex Steud.	Seto baruwa	Thymalaceae	Sh	Di	Fbr, Md	BG 21
53	*Daphniphyllum himalayense* (K. Rosenthal)	Nepali chandan	Daphniphyllaceae	Tr	Di	Fdd	BG 203
54	*Datura suaveolens* Humb. & Bonpl. ex Willd	Dhature phul	Solanaceae	Sh	Di		BG 185
55	*Desmodium microphyllum* (Thunb.) DC.		Fabaceae	Hb	Di		BG 187
56	*Desmostachys bipinnata* (L.) Stapf	Kush	Poaceae	Gr	Mo	Rg, Fdd	BG 186
57	*Dichroa fabrifuga* Lour.	Ganaune pat	Hydragenaceae	Hb	Di		BG 29
58	*Didymocarpus pedicellatus* R.Br.	Ghyu dadu	Gesneriaceae	Hb	Di		BG 257
59	*Digitaria cilliaris* (Retz.) Koeler	Banso	Poaceae	Gr	Mo	Fdd	BG 191
60	*Digitaria longiflora* (Retz.) Pers.	Banso	Poaceae	Gr	Mo	Fdd	BG 163
61	*Dioscorea bulbifera* L.	Ban tarul/teme	Dioscoreaceae	Cb	Mo	Fd and	BG 59

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
						Vg	
62	*Dioscorea deltoidea* Wall. ex Griseb.	Griseb bhyakur/teme	Dioscoreaceae	Cb	Mo	Fd and Vg	BG 153
63	*Dipsacus inermis* Wall.	Mula pate	Dipsacaceae	Hb	Di		BG 78
64	*Dobinea vulgaris* Buch.-Ham. ex D.Don	Sangale	Anacardiaceae	Sh	Di	Fdd	BG 69
65	*Drepanostachym flacatum* (Ness) Keng F.	Nigalo	Poaceae	Hb	Mo	Fw	BG 132
66	*Drymaria cordata* (L.) Willd. ex Roem & Scolt	Abijalo	Caryophyllaceae	Hb	Di	Md	BG 58
67	*Elaeagnus parvifolia* Wall. ex Royale	Guelo	Elagnaceae	Tr	Di	Fd	BG 201
68	*Elsholtzia blanda* (Benth.) Benth.	Bansilam	Lamiaceae	Hb	Di		BG 307
69	*Engelhardia spicata* Lesch. ex Bl.	Mahuwa/plee	Juglandaceae	Tr	Di	Tb	BG 47
70	*Eregeron multiradiatus* (Lindl. Ex DC.) Benth. ex CB Clarke		Asteraceae	Hb	Di		BG 71
71	*Eurya acuminata* DC.	Jhyano	Theaceae	Tr	Di	Fdd	BG 283
72	*Eurya cerasifolia* (D.Don)	Kobuski pate/kalo jhya	Moraceae	Sh	Di	Fdd	BG 307
73	*Ficus auriculata* Lour.	Nimaro/tamala	Moraceae	Sh	Di	Fdd	BG 152
74	*Ficus lacor* Buch.- Ham.	Kabro/tangu	Moraceae	Tr	Di	Fd and Fdd	BG 144
75	*Ficus neriifolia* Sm.	Dudhilo/ nara/ nata	Moraceae	Tr	Di	Fd and Fdd	BG 231
76	*Flemingia strobilifera* (L.) W. T. Aiton	Bhatmase	Fabaceae	Hb	Di	Fdd	BG 147
77	*Fragaria nubicola* Lindl. ex Lacaita	Bhuin kafal	Rosaceae	Hb	Di	Frt	BG 159
78	*Fraxinus floribunda* Wall.	Lankuri	Oleaceae	Tr	Di	Tb	BG 357
79	*Galium aparine* L.		Rubiaceae	Hb	Di		BG 251
80	*Gaultheria fragrantissima* Wall.	Dhasingare	Ericaceae	Sh	Di	Md	BG 167
81	*Gentiana depressa* L.		Gentianaceae	Hb	Di		BG 95
82	*Geranium wallichianum* (D.Don) ex Sweet		Geraniaceae	Hb	Di		BG 97
83	*Girardinia diversifolia* (Link) Friis	Allo	Urticaceae	Sh	Di	Fbr, Md	BG 99
84	*Gnaphalium affine* D. Don	Buki ful	Asteraceae	Hb	Di		BG 133
85	*Gonatanthus pumilus* (D. Don) Engler & Krause	Patarkanch	Areaceae	Hb	Mo		BG 136
86	*Gonostegia hirta* (Blume) Miq		Urticaceae	Hb	Mo		BG 131
87	*Hedyotis scandens* Roxb.		Rubiaceae	Cb	Di		BG 298
88	*Hemiphragma heterophyllum* wall.		Scrophulariaceae	Hb	Di		BG 130
89	*Hydrocotyle* sp.	Ghodtapre	Apiaceae	Hb	Di	Md	BG 120

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
90	*Hypericum cordifolium* DC.		Clusiaceae	Hb	Di	Fdd	BG 331
91	*Ilex dipreyana* Wall.	Seto khasru	Aquifoliaceae	Tr	Di		BG 71
92	*Imperata cylindrica* (L.) P. Beauv	Siru	Poaceae	Gr	Mo	Fdd	BG 79
93	*Ixeris gracilis* (DC.) Stebb		Asteraceae	Hb	Di		BG 180
94	*Juncus articulatus* L.	Jwanee	Juncaceae	Gr	Mo		BG 101
95	*Justicia adhatoda* L.	Asuro	Acanthaceae	Sh	Di	Ps	BG 239
96	*Lepisorous bicolor* (Takeda) Ching, Bull		Polypodiaceae	Fr	Fr		BG 300
97	*Leucosceptrum canum* Sm		Lamiacea	Sh	Di	Fw	BG 29
98	*Lindera pulcherrima* (Ness) Hook.f.	Phosre	Lauraceae	Tr	Di	Fw	BG 09
99	*Litsea cubeba* (Lour.) Press.	Siltimur	Lauraceae	Sh	Di	Md	BG 211
100	*Lyonia ovalifolia* (Wall.) Drude	Angero	Ericaceae	Sh	Di		BG 46
101	*Macaranga indica* Wight	Malata/malato/ kalan	Euphorbiaceae	Tr	Di	Tb	BG 211
102	*Maesa chisia* Buch. -Ham ex D. Don	Bilaunii	Primulaceae	Sh	Di	Md	BG 132
103	*Mahonia napaulensis* DC.	Jamanemanro	Berberidaceae	Sh	Di	Frt,Md	BG 297
104	*Mussaenda roxburghii* Hook. f.		Rubiaceae	Sh	Di	Fdd	BG 119
105	*Myrica esculenta* Buch.-Ham. ex D. Don	Kaphal	Myricaceae	Tr	Di	Frt, Tb	BG 73
106	*Myrsine semiserrata* Wall.	Kalikath	Myrsinaceae	Tr	Di	Fw	BG 178
107	*Nepeta ciliaris* Benth.		Lamiaceae	Hb	Di		BG 294
108	*Nephrolepis cordifolia* (L.) C. Presl	Pani saro	Nephrolepidaceae	Fr	Fr	Md	BG 28
109	*Onychium japonicum* (Thunberg) Kunze		Pteridaceae	Fr	Fr		BG 47
110	*Onychium lucidum* (D. Don) Spreng.		Pteridaceae	Fr	Fr		BG 210
111	*Oplismenus compositus* (L.) P. Beauv.		Poaceae	Gr	Mo	Fdd	BG 129
112	*Osbekia stellata* Buch.-Ham.ex D. Don	Angeri	Melastomataceae	Sh	Di	Fdd	BG 38
113	*Osyris wightiana* Wall. ex Wight	Nundhiki	Santalaceae	Sh	Di	Fw	BG 70
114	*Paris polyphylla* Sm.	Satuwa	Liliaceae	Hb	Di	Md	BG 213
115	*Paspalum* sp	Likhebanso	Poaceae	Gr	Mo	Fdd	BG 301
116	*Persea odoratissima* (Nees.) Kosterm.	Kaulo	Moraceae	Tr	Di	Fdd	BG 255
117	*Persicaria capitata* (Buch.-Ham. ex D. Don)	Raktanyaule jhar	Polygonaceae	Hb	Di	Md	BG 298
118	*Persicaria nepalensis* (Meisn.) Miyabe		Polygonaceae	Hb	Di	Vg	BG 309
119	*Phyllanthus emblica* L.		Phyllanthaceae	Hb	Di	Frt, Md	BG 86
120	*Phyllanthus niruri* L.		Phyllanthaceae	Sh	Di		BG 389
121	*Pieris formosa* (Wall.) D. Don	Pore	Ericaceae	Tr	Di	Fw	BG 107

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
122	*Pilea scripta* (Buch.-Ham. ex D. Don) Wedd.	Gaulato / gablato	Urticaceae	Hb	Di	Fdd	BG 19
123	*Pinus wallichiana* A.B. Jacks	Gobre salla	Pinaceae	Tr	Gm	Tb	BG 74
124	*Plantago depressa* Willd.		Plantaginaceae	Hb	Di	Md	BG 37
125	*Pogostemon benghalensis* (Brum. f.) Kuntze		Lamiaceae	Hb	Di		BG 127
126	*Polygonatum griffithii* Baker		Asparagaceae	Hb	Di	Fdd	BG 134
127	*Polystichum aculeatum* (L) Schott.		Dryopteridaceae	Fr	Fr		BG 152
128	*Potentilla fulgens* Hook. F.	Bajradanti	Rosaceae	Hb	Di		BG 213
129	*Potentilla lineata* Trevir.	Bajradanti	Rosaceae	Hb	Di		BG 321
130	*Prunus cerasoides* D.Don	Paiyu	Rosaceae	Tr	Di	Rg	BG 92
131	*Pteris vittata* L.		Pteridaceae	Fr	Fr	Vg	BG 14
132	*Pteris wallichiana* J. Agardh		Pteridaceae	Fr	Fr		BG 303
133	*Pyracantha crenulata* (D. Don) M. Roem.	Ghangaru	Rosaceae	Sh	Di	Frt	BG 325
134	*Quercus glauca* Thunb.	Phalant	Fagaceae	Tr	Di	Fdd	BG 204
135	*Quercus lanata* Sm.	Banjh	Fagacea	Tr	Di	Fdd	BG 219
136	*Quercus semicarpifolia* Sm.	Khasru	Fagacea	Tr	Di	Fw	BG 27
137	*Randia tetrasperma* (Wall. ex Roxb.) Benth. & Hook.f. ex BranDis	Ghorikath/basantikath	Rubiaceae	Sh	Di		BG 74
138	*Ranunculus sceleratus* L.	Nakkore	Ranunculaceae	Hb	Di	Md	BG 117
139	*Reinwardtia indica* Dumort	Pyauli	Linaceae	Hb	Di	Fdd	BG 452
140	*Rhododendron arboreum* Sm.	Lali guransh	Ericaceae	Tr	Di	Fw	BG 401
141	*Rhus javanica* L.	Bhakimlo/ tipru	Anacardiaceae	Sh	Di	Fd	BG 395
142	*Rhus succedanea* L.	Rani bhalayio	Anacardiaceae	Sh	Di		BG 322
143	*Rosa laevigata* Michx.	Bangulab	Rosaceae	Sh	Di		BG 411
144	*Roscoea alpina* Royle		Araceae	Hb	Mo	Fdd	BG 320
145	*Rubia manjith* Roxb. ex Fleming	Majitho	Rubiaceae	Cb	Di	Md	BG 402
146	*Rubus ellipticus* Sm.	Ainshalu	Rosaceae	Sh	Di	Frt	BG 419
147	*Rubus rosifolius* Smith	Kalo ainselu	Rosaceae	Sh	Di	Frt	BG 498
148	*Rumex hastatus* D. Don	Iimili	Polygonaceae	Hb	Di	Md	BG 358
149	*Rumex nepalensis* Spreng.	Halhale	Polygonaceae	Hb	Di	Vg	BG 37
150	*Sapium insigne* (Royle) Benth. ex Hook. F	Khirro	Euphorbiaceae	Tr	Di	Ps	BG 222
151	*Sarcococca coriaceae* (Hook.) Sweet		Buxaceae	Sh	Di	Md	BG 159
152	*Saurauia napaulensis* DC.	Gogan	Saurauiaceae	Tr	Di	Fw	BG 403
153	*Schefflera* sp.	Kutsimal	Araliaceae	Sh	Di		BG 444
154	*Schima wallichii* Choisy	Chilaune	Theaceae	Tr	Di	Tb	BG 447
155	*Scurulla parasitica* L.	Ainjeru	Loranthaceae	Ep	Di		BG 156
156	*Selaginella vaginata* Spring		Selaginellaceae	Fr	Fr	Md	BG 31
157	*Semecarpus anacardium* L.f.	Bhalayo	Anacardiaceae	Sh	Di	Md	BG 459
158	*Senecio cappa* Buch-Ham. ex D. Don	Bhakre kane	Asteraceae	Hb	Di	Fdd	BG 261

S.N.	Scientific name	Nepali name	Family	Habit	Life-form	Uses	Herbarium number
159	*Sigesbeckia orientalis* L.		Asteracae	Hb	Di		BG 333
160	*Smilax ovalifolia* Roxb.	Kukur daino	Smilaceae	Cb	Di	Vg	BG 459
161	*Solanum erianthum* D. Don	Dursul	Solanaceae	Sh	Di		BG 234
162	*Solanum virginianum* L.	Kantakari	Solanaceae	Hb	Di	Md	BG 95
163	*Stellaria media* (L.) Vill.		Caryophyllaceae	Hb	Di		BG 325
164	*Swertia chirayita* (Roxb. ex Fleming) Karsten	Tite	Gentianaceae	Hb	Di	Md	BG 405
165	*Symplocos theifolia* D. Don	Dabdabe	Symplocaceae	Tr	Di	Fw	BG 461
166	*Taraxacum officinale* F. H. Camus		Asteraceae	Hb	Di		BG 163
167	*Tectaria gemmifera* (Fée) Alston		Tectariaceae	Fr	Fr	Vg	BG 357
168	*Tetrastigma serrulatum* (Roxb.) planch.	Pani lahara	Vitaceae	Cb	Di	Fbr	BG 181
169	*Thalictrum punduanum* wall		Ranunculaceae	Hb	Di	Fdd	BG 411
170	*Thelypteris dentata* (Forssk.) E.P. St. John		Thelypteridaceae	Fr	Fr		BG 497
171	*Themeda villosa* (Lam.) A. Camus	Camus khar/ kee	Poacaee	Gr	Mo	Fdd	BG 455
172	*Thunbergia coccinea* Wall.	Singarne lahera	Acanthaceae	Cb	Di		BG 318
173	*Thymas linearis* Benth		Lamiaceae	Hb	Di		BG 465
174	*Trichilia connaroides* (Wight & Arn.) Bentv	Ankha taruwa	Meliaceae	Tr	Di	Fw	BG 493
175	*Tinospora sinensis* (Lour.) Merr.	Gurjo	Menispermaceae	Cb	Cb	Md	BG 455
176	*Tridax procumbens* L.		Asteraceae	Hb	Di		BG 463
177	*Urtica ardens* Link.	Sisnu/ pulu	Urticaceae	Hb	Di	Vg, Md	BG 245
178	*Urtica dioica* L.	Lekh sisnu	Urticaceae	Hb	Di	Vg, Md	BG 24
179	*Vaccinium retusum* (Griff.) Hook. F. ex C.B. Clarke		Ericaceae	Hb	Di	Md	BG 06
180	*Vibernum cylindricum* Buch-Ham. ex D. Don	Malo	Sambucaceae	Sh	Di	Fw	BG 36
181	*Vibernum erubescens* Wall. ex Dc.	Bajrang	Sambucaceae	Sh	Di	Fw	BG 26
182	*Viola biflora* L.		Violaceae	Hb	Di	Md	BG 27
183	*Wikstroemia canascens* Wall. ex Mesin	Patuwa	Thymalaceae	Sh	Di	Fbr	BG 212
184	*Zanthoxyllum oxyphyllum* Edgew.	Ban timur	Rutaceae	Sh	Di	Md	BG 287
185	*Zanthoxylum armatum* DC.	Timur	Rubiaceae	Sh	Di	Md	BG 471

Note : Hr = herb, Sh = shrub, Tr = tree, Fr =fern, Gr = grass, Ep = epiphyte, Mo = monocot, Di = dicot, Vg = vegetable, Tb = timber, Md = medicine, Fdd = fodder, Rg = religious, Fw = fuelwood, Frt = fruit, Ps = poisonous, Fbr=fiber

Table 2: Prioritized plant species found in MPF

SN	Scientific name	Nepali name	Status
1	*Asparagus racemosus* Willd.	Satawari/ kurilo	Vulnerable (CAMP)
2	*Berginia ciliata* (Haw) Sternb.	Pakhanbed	Commercial threatened
3	*Choerospondias axillaris* (Roxb.) B.L. Burtt & A.W. Hill	Lapsi	Rare (DPR 2011)
4	*Cinnamomum glauscens* (Nees.) Nand. Mazz	Sugandha kokila	Protected
5	*Crateva unilocularis* Buch.-Ham.	Sibligan	Rare
6	*Daphne bholua* Buch.-Ham. ex D. Don	Lokta	Commercially threatened (Local assessment)
7	*Dioscorea deltoidea* Wall. ex Griseb.	Bhyakur/teme	CITES II, commercially threatened
8	*Paris polyphylla* Sm.	Satuwa	Vulnerable (CAMP)
9	*Phyllanthus emblica* L.	Amala	Medicinal Plants for research & development (DPR 2011)
10	*Rubia manjith* Roxb. ex Fleming	Majitho	Vulnerable (CAMP)
11	*Swertia chirayita* Roxb. ex Fleming) Karsten	Tite	Vulnerable (CAMP)
12	*Tinospora sinensis* (Lour.) Merr.	Gurjo	Vulnerable (CAMP)
13	*Zanthoxyllum armatum* DC.	Timur	Medicinal Plants for research & development (DPR 2011)

Conclusion

Since the declaration of protected forest in 2011, no botanical exploration was done in MPF. We conclude that MPF is a unique forest, rich in unique floral diversity due to its varying elevation and huge area. Altogether 185 plant species belonging to 74 families have been recorded from the Bajhkateri - Bhedikhor cluster which covers around 15% of land area out of total 13,671 ha area of MPF. Remaining area of MPF still untouched in terms of its floristic diversity and other scientific exploration. Several highly prioritized plant resources have been documented by this study which was previously unknown for MPF. We observed that the wetter northern face of MPF was very rich in orchid diversity during our research we recorded only two species of orchid from our experimental plot it means we did not focused more on epiphytic plant. This area might be the good area for orchid researcher. The local livelihood system depends heavily on traditions and values that are deeply rooted. Locals gave priority to those species that provide them with multitude of benefits. Habitat destruction, overharvesting of natural resources, wildfire, and unmanaged road construction are the major threats to the natural forest in MPF. Current conservation and management plans do not seem strict and effective, locals were unaware and less concerned regarding conservation and sustainability of MPF. We recommend that the forest officials of MPF should realize the urgency of conservation and locals should feel a sense of belonging of this unique hub of biodiversity by proposing effective and strict guidelines and policies to protect this forest. Local forest authorities should educate local peoples about the benefits they can get from sustainable usage of forest resources and should show ways to generate income. In addition, as large areas of this forest remained untouched in terms of scientific research, a detailed survey or inventory research should be done immediately in near future to document all the unique biodiversity of this forest. Conclusion

Author Contributions

BJ designed the research method. Both BJ and AN collected the data and analyzed the data. BJ led the writing.

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Plant diversity in Lumbini Area: Plants related to Gautam Buddha's Life Need Ecological Restoration

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Abstract

Plant diversity of Lumbini area was studied especially focusing on native plants, although large number of non-native species has been planted in the area. We have also compiled the plant species used by Lord Gautam Buddha during his life period through published literature. Altogether, 181 plant species belongs to 51 families were reported from this study. Of them, 41 families were dicot, seven were monocot and three were belongs to Fern and fern allies. 27 plant species were reported as plants used by Lord Gautam Buddha in his life period. 23 species belongs to 10 families were reported as invasive species whereas 39 species of 17 families were found as only tree species. The study area was found rich for Fabaceae and Asteraceae as previous studies in the low land or Terai regions of Nepal. Some of the common species in the ecological region have not been recorded during the survey, indicating that the sacred landscape needs immediate intervention for restoring the native species in Lumbini.

Keywords: Invasive plant species, Lumbini, Nepal, Plant diversity

Introduction

Plant diversity refers to the diversity of plants occurring in a specific region during particular era. It generally refers to the diversity of naturally occurring indigenous or native plants. A complete flora of country is necessary to reflect the whole plant diversity in the country, and the absence of flora severely hinders any scientific inquiry into plants (Shakya et al., 1997). A total of 2,15,644 species of plants out of 2,98,000 predicted have been catalogued on earth till-date. Apart, 8,600 plant species have been recorded from ocean out of estimated 16,600.

Nepal, a landlocked country located in the central part of main Himalayan range is floristically characterized by the presence of six adjoining floristic regions, namely central Asiatic in the North, Sino-Japanese in the North East, South East Asia-Malaysian in the South East, Indian in the South Sudano-Zambian in the South-West and Irano-Turranean in the West. The altitudinal variation ranges from about 60m to the top of the world (8,848.86 m) has made Nepal a rich country in plant bio-diversity. Nepal occupies a unique geographic position on earth possessing high altitudinal and climatic variation within the small area of 147, 181 km^2, ranging from 59 m above sea level to 8,848 m, the highest point in the world. Nepal is considered a crossroad of plant migration in the Himalayan region, with rich plant diversity due to the overlapping of eastern and western Himalayan plant elements (Shrestha & Joshi, 1996).

Nepal occupies a unique zone in the central Himalaya hosting many phytogeographical provinces comprised of various vegetation types including tropical lowland rain forest (*Shorea robusta* forests), temperate forests of oak and conifers in the mid hills to dwarf scrubs of rhododendron and alpine meadows in the higher regions (Miehe et al., 2015). Within Nepal the amalgamation of various floristic elements includes drier Western and Central Asiatic plant provinces, a more humid Sino-Japanese province, South East Asiatic elements penetrating into the foothills of Eastern Nepal, African-Indian desert elements towards the western part of Nepal and typical Indian floristic elements in the southern part (Welk, 2016). Moreover, Nepal is situated in the central portion of the Himalayas, which is the transitional zone between the floras of the eastern and western Himalaya (Shrestha & Joshi, 1996).

The existing checklists for Nepal record some 6076 species of flowering plants (Press et al., 2000) and 582 ferns (Fraser-Jenkins et al., 2015; Fraser-Jenkins & Kandel, 2019; Kandel & Fraser-Jenkins, 2020). However, expert assessment suggests that the numbers of flowering plants may rise to ~7000 when poorly known remote regions are fully explored. Information on plant endemism in Nepal Himalaya is not adequately known because Nepal is still struggling to complete the long-awaited Flora of Nepal project despite an early start of botanical exploration in Nepal Himalaya by Buchanan-Hamilton (1802-03) and N. Wallich (1820-21) (Miehe et al., 2015; Rajbhandari et al., 2017).

Nepal has 35 forest types, 75 vegetation units and 118 ecosystems. Nepal's botanical wealth is conserved through various acts and laws and particularly protected in 10 National Parks, 3 Wild-life Reserves, 1 Hunting Reserve, 6 Conservation Areas and 12 Buffer Zones as in-situ conservation. Plants are also conserved, as a part of ex-situ conservation, in national level Botanical Garden (National Botanical Garden, Godawari and Lalitpur) and 10 district level Botanical gardens at various parts of the country.

Lumbini

Lumbini Development Trust (LDT) was formed by the Lumbini Development Trust Act 1985 for the purposes of restoring the Lumbini Garden under the master plan. In the national level LDT was constituted in order to present before the people of the world and commitment of Government of Nepal to project goal and ideal of development of Lumbini. Lumbini is the birthplace of Gautama Gautam Buddha , the founder of Buddhism, who was born in the 7th or 6th century BC. According to Buddhist tradition, Maya Devi (or Mayadevi) gave birth to the Gautam Buddha on her way to her parent's home in Devadaha in the month of May in the year 623 BC. Feeling the onset of labor pains, she grabbed hold of the branches of a shade tree and gave birth to Siddharta Gautama, the future Gautam Buddha. The Gautam Buddha is said to have announced, "This is my final rebirth" as he entered the world. Buddhist tradition also has it that he walked immediately after his birth and took seven steps, under each of which a lotus flower bloomed. In 249 BC, the Buddhist convert Emperor Ashoka visited Lumbini and constructed four stupas and a stone pillar. Ashoka's Pillar bears an inscription that translates as: "King Piyadasi (Ashoka), beloved of devas, in the 20 year of the coronation, himself made a royal visit, Gautam Buddha Sakyamuni having been born here, a stone railing was built and a stone pillar erected to the Bhagavan ("blessed one") having been born here. Lumbini village was taxed reduced and entitled to the eight parts (only)".

Lumbini has been considered one of the most sacred places on earth amongst Hindus and Budhists. Because of birth place of Lord Budha and valuable historical importance, it has been enlisted by UNESCO as a world heritage site. The birth of Budha has connection with gardens, flowers and trees (Kausalyayana, 1985). During 7 and 6 centuries BC, Lumbini was a beautiful garden maintained by the Sakya dynasty of Kapilavastu and the Koliyas dynasty of Ramagrama (Bidari, 2004). In the Budhist literature, Lumbini is described as sacred grove with blooming *sal* trees and varieties of beautiful flowers (Kausalyayana, 1985). Thus, introduction of sacred species in the grove of Lumbini might be a regular practice after birth of Budha.

Lumbini is the 666th World Heritage Site and is the birth place of Lord Gautam Buddha (Siddartha Gautama, born in 623 BC in the famous gardens of Lumbini). Also famous for Ashok pillar and as a Buddhist pilgrimage centre, the site features the Harhawaa river catchment (21 km^2), the Telar mentioned by Chinese travelers as following close to the birthplace of Gautam Buddha. The area consists of grassland (400 ha) 58.8%, forest plantation (270 ha) 40%, and open bodies of water (10 ha) 1.5% and a plantation of over 65 species of more than 370,000 saplings, and a nesting place in 2005 of the 25 Sarus and 50 Blue bulls. The numbers of faunal species recorded in Lumbini includes 26 mammals, 207 birds, 39 herpeto and 44 fish species and records of 72 vascular plants.

With the establishment of Lumbini Development Trust in 1985, the area of the grove was extended and planted with hundreds of seedlings of trees belonging to various indigenous and exotic species. Among them, some were rare and endangered (Shrestha & Joshi, 1996). Similarly, 65 sacred plants of Lumbini area were reported by previous study (Bhattarai & Baral, 2009) Inventory of species, evaluation of distribution patterns, floristic composition and adaptation of species in the sacred grove may provide key information useful to promote conservation of rare and endangered species. This study, therefore, intends to present plant richness with special focus to the plants associated with Buddha's life and to shade lights on need of ecological restoration in Lumbini area. The objectives of the study are to enumerate the plant species at Lumbini Development Trust area, Categorize plants of Lumbini Development Trust (LDT) into different groups such as wetland plants, herbs, shrubs, trees, medicinal, Non timber forests products (NTFPS), invasive species etc. and suggest conservation strategy for the plant diversity in LDT.

Materials and Methods

Study Area

Lumbini is located in the southern Terai Plain, part of Indo-Gangetic Plain, about 100 m above sea level, belonging to a subtropical monsoon climate of Rupendehi District belongs to Province 5 (Figure 1). It's hot throughout the year and has obvious rainy and dry season, rich rainfall, and strong UV index, long sun hours but no snow days. Generally, June to September is the rainy season of Lumbini, when it's hot and humid with high humidity (99%) and frequent thunderstorms, lots of rains. June is hottest month, for the highest daytime temperature can rise to over 40°C. October to May of the following year is the dry season and the best time to Lumbini. January is the month with the lowest temperature. The soil type varies from sandy loam to clay and clay loam. The clay type soil has marsh lands and loam soil has extensive agricultural farms.

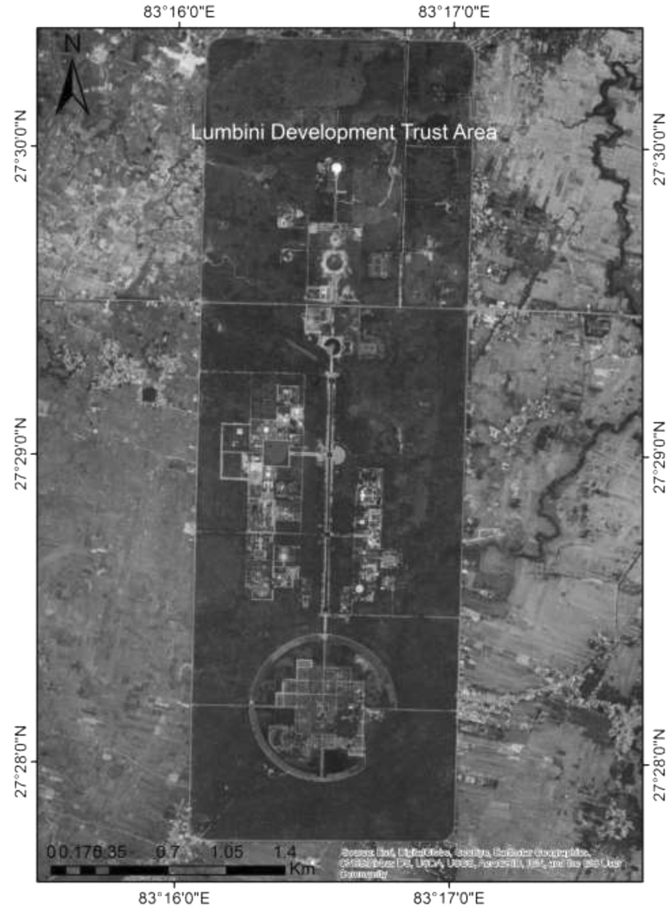

Figure 1: Aerial view of Lumbini Development Trust Area

Sampling

Field data was collected from LDT area during 1-10 January of 2019. A random cum purposive sampling method was used to include all the vegetation types within LDT. Transect walk was carried out along the forested as well as non-forested areas within LDT area. For the practical purpose, we divided the transect survey in three zones, Lumbini sacred garden zone, Monsatery zone and Crane Sanctuary zone. Plant survey was followed by the schematic sampling unit that was to include every vegetation type and habitat within LDT (Figure 1). We have collected the herbarium specimens of all plant species except those are very common plants.

Plant collection, Herbarium preparation and Identification

Plant specimens were collected within LDT area (single season: winter) covering all the habitat types and vegetation zones, wherever possible. The specimens were collected from each and also from building areas. Plant species were identified in the field with available literature. Specimens that were not identified in the field were collected, pressed and dried in order to prepare herbarium specimens. All the collected specimens were reconfirmed with the help of standard literatures, Hara & Williams 1979, Hara et al., 1982; Grierson & Long, 1983-2001; Pearce & Cribb, 2002; Stainton, 1972; Stainton, 1988; Wu et al., 1994-2008; Raskoti, 2009, and by herbarium study. Nomenclature of the species was followed www.tropicos.org and www.ipni.org.

Results and Discussion

Based on the sampling, all the plants were identified and are enumerated scientifically mentioning their correct scientific name, local name, genus and family. Further, life form of plant, category (Herb, shrub, tree, and climber), flowering time, fruiting time, population structure, use value will be described in the enumeration table. IUCN threat categories will be mentioned for rare, threatened and vulnerable plant species. Plant enumeration tale will be produced as in the given table.

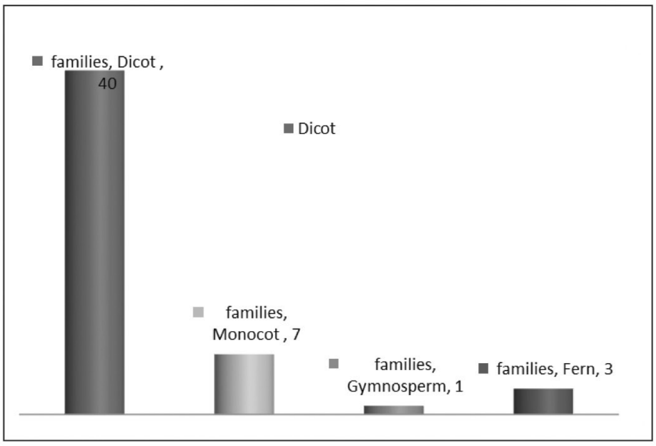

Figure 2: Different plants Groups in the study Area.

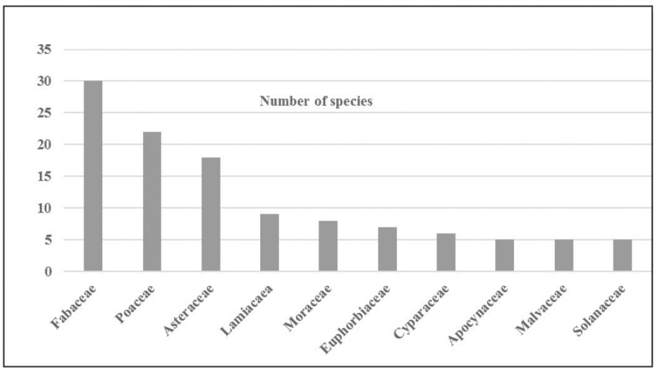

Figure 3: Top ten families recorded in Lumbini area

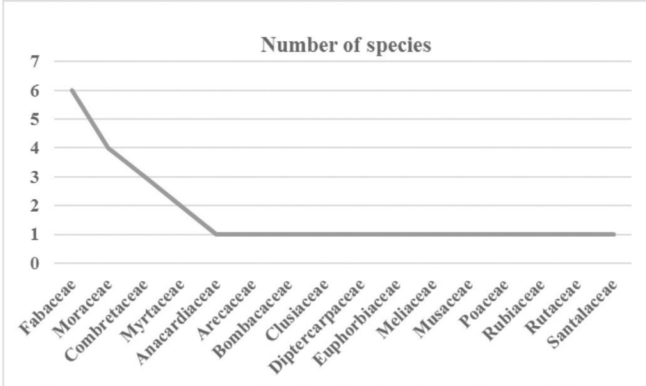

Figure 4: Plants used by Lord Gautam Buddha based on families in his life span

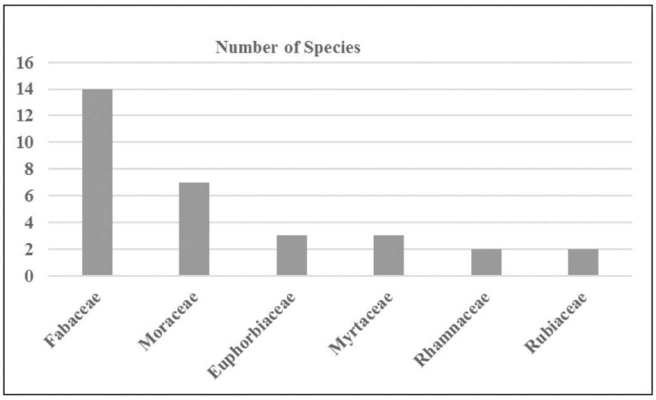

Figure 5: Six top tree plant families based on number of species.

Altogether, 181 species of 51 families were reported from Lumbini area (Annex I). Out of 51 families 41 were dicots, 7 families were monocot and three families were belongs to Fern and fern allies (Figure 2). Top ten families are pointed put (Figure 3). 23 species belongs to ten families were reported as invasive species (Table 2). 27 plants species belongs to 16 families were found used by Lord Gautam Buddha during his life time (Table 3). 42 species belongs to 17 families were noted as tree species (Figure 5).

Fabaceae, Poaceae and Asterace were found larger three families with 30, 22 and 18 species in each. Lamiaceae, Moraceae and Euphorbiaceae were followed to larger families with Nine, Eight and Seven species in each respectively. Fabaceae was found largest family for the plants used by Lord Gautam Buddha. He used six species of this family in his life period. (Table 3). *Saraca indica* belongs to family Fabaceae was the plant under which Lord

Gautam Buddha was borned. *Mesua ferrea* belongs to family Clusiaceae was the plant species used by Lord Gautam Buddha for attaining enlightenment. Other plants were used by Lord Gautam Buddha in his life span for didderent purposes. (Table 3; Figure 4). Asteraceae was found the largest family for invasive species with 9 species followed by Fabaceae and Amaranthaceae with three and two species correspondingly. Fabacea and Moraceae were two dominant families for tree species with fourteen and seven in each (Figure 5).

Studies indicated that there were around 354 species of plants species in LDT (Siwakoti, 2008), however in our recent vegetation survey in 2019, we have recorded only about 250 species including 40 tree species and other herbs and shrubs. Bhattarai and Baral reported total of 65 species of tree (angiosperms and gymnosperms including nine unidentified) in the sacred grove of Lumbini, indicating that Lumbini area was quite rich in tree diversity accounting about 11 percent of total tree species found in Nepal. The decrease in number of plant is due to single plant survey carried out during winter; which could not record more plant species. However, some very common species like *Woodfordia fruticosa, Terminalia bellirica, Cuscuta reflexa, Melia azedarach and Justicia adhatoda* have been found to be disappeared from the region, indicating the heavy anthropogenic pressure (construction activities, grazing, fire, and plantation of trees without knowing microhabitat and also by the encroachment of alien and invasive plant species both in terrestrial and aquatic environment). In this study also, Fabaceae and Asteraceae were reported as dominant families in the study area as reported in the previous studies (Pathak & Acharya 2014).

Table 1: List of the tree species in Lumbini Area

S.N.	Scientific name of tree species	Local name	Family	Uses/Remarks
1	*Shorea robusta* Gaertn.	Saal	Dipterocarpaceae	
2	*Acacia catechu* (L. f.) Willd.	Khayar	Fabaceae	
3	*Saraca indica* L.	Asoka	Fabaceae	
4	*Dalbergia sissoo* DC.	Sisso	Fabaceae	
5	*Ficus religiosa* L.	Peepal	Moraceae	
6	*Ficus benjamina* L.	Sami	Moraceae	
7	*Tectona grandis* L.f.	Teak, Sagun	Labiatae	
8	*Neolamarckia cadamba* (Roxburgh) Bosser	Kadam	Rubiaceae	
9	*Bombax ceiba* L.	Simal	Malvaceae	
10	*Azadirachta indica* A.Juss.	Neem	Meliaceae	
11	*Syzigium cumini* (L.) Skeels	Jamun	Myrtaceae	
12	*Aegle marmelos* (L.) Correa	Beel	Rutaceae	
13	*Zizyphus incurva* Roxburgh	Thulobayar	Rhamnaceae	
14	*Zizyphus rugosa* Lamarck	Sano bayar	Rhamnaceae	
15	*Haldina cardifolia* (Roxburgh) Ridsdale	Karma	Rubiaceae	
16	*Albizia labbeck* (L.) Benth.	Shirish	Fabaceae	
17	*Phyllanthus emblica* L.	Amala	Phyllanthaceae	
18	*Bauhinia purpurea* L.	Koiralo?	Fabaceae	
19	*Ficus racemosa* L.	Dumri	Moraceae	
20	*Artocarpus lakkocha* Wall. ex Roxb.	Badahar	Moraceae	
21	*Ficus lacor* Buch.–Ham.	Timila	Moraceae	
22	*Ficus* sp.	ban timila	Moraceae	fruit like litchi)
23	*Acacia nilotica* (L.) Willd. ex Delile	Babul	Fabaceae	
24	*Eucalyptus alba* Reinw. ex Blume	Masala	Myrtaceae	
25	*Leucaena leucocephala* (Lam.) de Wit	Ipilipil	Fabaceae	
26	*Delonix regia* (Bojer ex Hook.) Raf.	Gulmohar	Fabaceae	
27	*Salix* sp.		Salicaceae	
28	*Cassia fistula* L.	Rajbrikshya	Fabaceae	
29	*Callistemon citrinus* (Curtis) Skeels	Kalki, bottle brush	Myrtaceae	
30	*Terminalia alata* Heyne ex Roth.	Sajh	Combretaceae	

S.N.	Scientific name of tree species	Local name	Family	Uses/Remarks
31	*Ficus hispida* L.f.	Khasreto/Gular	Moraceae	
32	*Mallotus phillipinensis* (Lam.) Mull. Arg.	Sindhurey/Rohini	Euphorbiaceae	
33	*Thuja orientalis* L.	Dhupi	Cupressaceae	
34	*Pithecellobium dulce* (Roxburgh) Bentham		Fabaceae	
35	*Alstonia scholaris* (Linnaeus) R. Brown	Chatiwan	Apocynaceae	
36	*Annona reticulata* L.	Saripha	Annonaceae	
37	*Trewia nudiflora* L.	Setokath	Euphorbiaceae	
38	*Dalbergia latifolia* Roxb.	Satisaal	Fabaceae	
39	*Tamarindus indica* L.	Imli	Fabaceae	

Table 2: Invasive Plants in LDT

S.N.	Plant Name	Family	Nepali Name
1	*Ageratum conyzoides* L.	Asteraceae	Rawune, Gandhe
2	*Ipomoea aquatica* Forssk.	Convolvulaceae	Karmi ke Saag
3	*Nelumbo nucifera* Gaertn.	Nymphaeaceae	Kamal, Purain
4	*Nymphaea nouchali* Burm. f.	Nymphaeaceae	Malkokka, Kamal, Kaiya
5	*Lantana camara* L.	Verbenaceae	Kirne kanda, Ban Fanda
6	*Ageratina adenophora* (Spreng). King and H. Rob.	Asteraceae	Kalo Banmara
7	*Parthenium hysterophorus* L.	Asteraceae	Pati Jhar, Madhise Pati
8	*Ageratum haustonianum* Mill.	Asteraceae	Nilo Gandhe,
9	*Erigeron karvinskianus* DC	Asteraceae	Gane Jhar
10	*Alternanthera philoxeroides* Mart. Griseb.	Amaranthaceae	Jaljambhu
11	*Amaranthus spinosus* L.	Amaranthanceae	Kande Lunde, Kande Latte
12	*Bidens pilosa* L.	Asteraceae	Kalo Kuro
13	*Senna occidentalis* L.	Fabaceae	Tapre
14	*Senna tora* (L.) Roxb.	Fabaceae	Panbar
15	*Ipomoea carnea* ssp. fistulosa Mart. ex Choisy D" Austin	Convolvulaceae	Besaram, Sanai Phool
16	*Oxalis latifolia* Kunth.	Oxalidaceae	Chari Amilo
17	*Xanthium strumarium* L.	Asteraceae	Bhende Kuro, Bhaisi Kuro
18	*Chromolaena odorata* Spreng.	Asteraceae	Seto Banmara
19	*Eichhornia crassipes* (Mart.) Solms.	Pontederiaceae	Jalkumbhi
20	*Mimosa pudica* L.	Fabaceae	Lajjabati Jhar
21	*Mikania micrantha* Kunth.	Asteraceae	Lahare Banmara
22	*Hyptis suaveolens* (L.) Poit	Lamiaceae	Ban Babari, Thulo Mirre
23	*Leersia hexandra* Sw.	Poaceae	

Table 3: Plants Related to Gautam Buddha 's Life

S.N.	Plant Name	Family	Nepali Name	Relationship with Buddha's life
1	*Aegle marmelos* (L.) Correa	Rutaceae	Bel	
2	*Albizia lebbeck* (L.) Benth.	Fabaceae	Siris	
3	*Artocarpus integrifolia* L. f.	Moraceae	Rukh Katahar	
4	*Azadirachta indica* L.	Meliaceae	Neem	Medicine
5	*Bauhinia variegata* L.	Fabaceae	Koiralo	
8	*Bombax ceiba* L.	Bombacaceae	Simal	
7	*Butea monsperma* (Lam.) Kuntze	Fabaceae	Palans	
8	*Cassia Fistula* L.	Fabaceae	Tapre	
9	*Dalbergia sissoo* Roxb. ex DC.	Fabaceae	Sisau	Kosambi Talk about leaves
10	*Ficus benghalensis* (L.) Gasp.	Moraceae	Bar	Nigrodharma Monastery
11	*Ficus conglomerate* Roxb.	Moraceae	Dumri	
12	*Ficus religiosa* L.	Moraceae	Peepal	Enlightenment Tree
13	*Mangifera indica* L.	Anacardiaceae	Aam	Miracle tree
14	*Mesua ferrea* L.	Clusiaceae	Nageshwor	Gautam Buddha s attained enlightenment
15	*Musa paradisia* L.	Musaceae	Kera	
16	*Neolamarckia cadamba* (Lam.) A. Rich. ex Walp.	Rubiaceae	Kadam	

S.N.	Plant Name	Family	Nepali Name	Relationship with Buddha's life
17	*Phyllanthus emblica* L.	Euphorbiaceae	Amala	Medicne for Monks and Nuns
18	*Santalum album* L.	Santalaceae	Chandan	Gandhakuti
19	*Saraca indica* (Roxb.) de Wilde	Fabaceae		Birth tree
20	*Shorea robusta* Gaertn.	Diptercarpaceae		Birth tree, Gautam Buddha passed away between Sal tree
21	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jamun	Meditation tree
22	*Syzygium jambos* (L.) Alston	Myrtaceae	Gulab Jamun	Siddhartha meditated under Jambu tree at age of 7
23	*Terminalia alata* Heyne ex Roth	Combretaceae	Asna	
24	*Terminalia chebula* Retz.	Combretaceae	Harro	
26	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro	
26	*Thrinax radiate* Lodd. ex Schult. & Schult.f.	Arecaceae		Arrow Competion
27	*Bambusa vulgaris* Schrad. *ex* J.C Wendl	Poaceae		Bamboo groove

Table 4: Medicinal Properties of Plants Related to Gautam Buddha 's Life

SN	Plant Name	Nepali Name	Uses	References
1	*Aegle marmelos* (L.) Correa	Bel	Yellow diarrhea, Dysentery, Jaundice, Anorexia, Hemorrhoids	बिल्वं सांग्राहकदीपनीयवातकफप्रशमनानाम्। (चरक संहिता सूत्रस्थान २५)
2	*Albizia lebbeck* (L.) Benth.	Siris	Poisoning, Headache, Skin diseases, Cough, Wounds, Worm infestations	शिरीषविषघ्नानां.....। (चरक संहिता सूत्रस्थान २५)
3	*Artocarpus integrifolia* L. f.	Rukh Katahar	Skin diseases, Snake bite, Diarrhea, Glandular swelling, Laxative	
4	*Azadirachta indica* L.	Neem	Urticaria, Fever, Skin diseases, Diabetes mellitus, Itching, Wounds, Vomiting, Worm infestation, Hemorrhoids, Abdominal colic, Eye disease	Medicine निम्बस्तिक्तरस: शीतो लघु: श्लेष्मास्रपित्तनुत्। कुष्ठकण्डूवणान्हन्ति लेपाहाअरादिशीतल:॥ अपक्वं पाचयेच्छोफं वर्ण पक्वं विशोधयेत्। (धन्वन्तरी निघण्टु)
5	*Bauhinia variegata* L.	Koiralo	Goiter, Chicken pox, Dysuria, Skin diseases, Bleeding disorders	कोविदारस्य ..... पुष्पं ग्राहिप्रशस्तं च रक्तपित्ते विशेषत:॥ (चरक संहिता सूत्रस्थान २७)
8	*Bombax ceiba* L.	Simal	Diarrhoea, Wounds, leucorrhoea, Acne vulgaris, Bleeding hemorrhoids	कुत्सित:शाल्मलि:प्रोक्तो रोचन: कूटशाल्मलि: । कूटशाल्मलिकस्तिक्त: कटुक: कफवातनुत्॥ भेद्युष्ण: प्लीहजठरयकृद्गुल्मविषापह:। भूतानाहविबन्धास्रमेद:शूलकफापह:॥ (भावप्रकाश निघण्टु)
7	*Butea monosperma* (Lam.) Kuntze	Palans	Filariasis, Worm infestation, Infertility, Abdominal Colic, Skin diseases, Itching	किंशुकं कफपित्तघ्नम्। (सुश्रुत संहिता सूत्रस्थान ४५)
8	*Cassia Fistula* L.	Tapre	Jaundice, Goiter, Skin diseases, Rheumatoid Arthritis, Gout, Inflammation, Fever	ज्वरहृद्रोगवातासृगुदावर्तादिरोगिषु। राजवृक्षोअधिकं पथ्यो मृदुर्मधुरशीतल:॥ बाले वृद्देक्षते क्षीणे सुकुमारे च मानवे। योज्यो मृद्वनपायित्वादिशेषाच्चतुरङ्गुल:॥ (चरक संहिताकल्पस्थान ८)
9	*Dalbergia sissoo* Roxb. ex DC.	Sisau	Stimulant, Gonorrhea, Leprosy, Boils	Kosambi Talk about leaves
10	*Ficus benghalensis* (L.) Gasp.	Bar	Hemostatic, Wounds, Inflammation, Arthritis, Skin diseases, Diarrhea, Dysentery, Diabetes mellitus	Nigrodharma Monastery
11	*Ficus conglomerate* Roxb.	Dumri	Inflammation, Wounds, Abortion	
12	*Ficus religiosa* L.	Peepal	Ulcers, Skin diseases, Anti-bacterial, Purgative	Enlightenment Tree
13	*Mangifera indica* L.	Aam	Hemostatic, Wounds, Heart diseases, Aphrodisiac, Bleeding disorders, Anorexia, General weakness	Miracle tree

SN	Plant Name	Nepali Name	Uses	References
14	*Mesua ferrea* L.	Nageshwor	Bleeding Hemorrhoids, Hiccup, Menorrhagia, Dysentery, Infertility, Skin Diseases, Gout, Fever, Vomiting, Thirst, Poisoning	Gautam Buddha s attained enlightenment केसरनवनीतशर्कराभ्यासात् ....। अर्शांसि अपयान्ति रक्तानि॥ (चरक संहिताचिकित्सास्थान १४र२१०)
15	*Musa paradisia* L.	Kera	Laxative, Diarrhea, Dysentery, Ulcerative colitis, Gout, Hypertension	
16	*Neolamarckia cadamba* (Lam.) A. Rich. ex Walp.	Kadam	Tonic, Fever, Snake bite, Stomatitis	
17	*Phyllanthus emblica* L.	Amala	Diabetes, Hiccup, Fever, Bleeding Hemorrhoids, Leucorrhoea, Bleeding disorders, Dysuria, Flu, Gout, Jaundice, Anemia, Antioxidant, Aphrodisiac, Hiccup, Burns, Gastritis, Constipation, Inflammation, Hair disease, Eye disease, Anorexia, Hypertension, Infection	Medicine for Monks and Nuns आमलकीवयःस्थापनानाम्। (चरक संहिता सूत्रस्थान २५)
18	*Santalum album* L.	Chandan	Diabetes, Vomiting, Leucorrhoea, Fever, Burning sensation, Itching, Skin diseases, Bleeding disorder, Worm infestation	Gandhakuti चन्दनं दुर्गन्धहरदाहनिर्वापणलेपनानाम्॥ (चरक संहिता सूत्रस्थान २५)
19	*Saraca indica* (Roxb.) de Wilde		Menorrhagia, Renal stone, Dyspepsia, Worm infestation, Poisoning, Heart diseases, Dysuria	Birth tree अशोकःशीतलस्तिक्तो ग्राही वर्ण्यःकषायकः। दोषावचीतृष्णादाहकृमिशोफविषास्रजित्॥ (भावप्रकाश निघण्टु)
20	*Shorea robusta* Gaertn.		Astringent, Antihelminthic, Wounds, Aphrodisiac, Tonic, Dysentery, Gonorrhea	Birth tree, Gautam Buddha passed away between Sal tree
21	*Syzygium cumini* (L.) Skeels	Jamun	Bleeding disorder, Irritable bowel syndrome, facial melanosis, Diabetes mellitus, diarrhea, vomiting, Burning sensation, Wound	Meditation tree जाम्बवं वातजननानां ..... अग्र्यं। (चरक संहिता सूत्रस्थान २५/३९)
22	*Syzygium jambos* (L.) Alston	Gulab Jamun	Tonic, diuretic, Diarrhea, Gout, Wounds, Stomatitis	Siddhartha meditated under Jambu tree at age of 7
23	*Terminalia alata* Heyne ex Roth	Asna	Heart disease, Diarrhoea, Diuretic, Sore, Hemostasis	
24	*Terminalia chebula* Retz.	Harro	Indigestion, Diabetes mellitus, Acid Peptic disorders, Syphillis, Skin diseases, Wound, Vomiting, Dysuria, Eye diseases, Worm infestation, Renal Calculi, Cough, Flu	व्रण्यमुष्णं सरं मेध्यं दोषघ्नं शोफकुष्ठनुत्। कषायं दीपनं चाम्लं चक्षुष्यं चाभयाफलम्॥ (सुश्रुत संहिता सूत्रस्थान ४६)
26	*Terminalia bellirica* (Gaertn.) Roxb.	Barro	Vitiligo, Renal Calculi, Flu, Diarrhoea, Fever, Vomiting, Thirst	भेदनं लघु रुक्षोष्णं वैस्वर्य कृमिनाशनमुदुपाक्याक्षां कषायं कफपित्तजित्॥ विभीतको मदकरस् कफमारुतनाशनस (सुश्रुत संहिता सूत्रस्थान ४६)
26	*Thrinax radiate* Lodd. ex Schult. & Schult.f.			Arrow Competition
27	*Bambusa vulgaris* Schrad. *ex* J.C.Wendl	Bans	Inflammation, Wounds, Dyspepsia, Antihelminthic, nausea, vomiting, Tuberculosis, Bleeding disorders, Fever, General Weakness	Bamboo groove

Missing Key Plant Species in Lumbini

Some key species of the region including *Justicia adhatoda, Cuscuta reflexa, Melia azedarach, Woodfordia fruticosa, Terminalia bellirica* are not recorded in natural habitat in LDT during the recent plant survey in 2019. This could be due to higher anthropogenic pressure such as forest fire, unplanned plantation of exotic plant species, unmanaged disposal of solid wastes and encroachment of invasive plant species in the region. This has been a serious conservation issue in the region. We have presented some common species that were not recorded in the recent plant survey in Lumbini in 2019.

Conclusion

This study reveals that Lumbini development trust area was found rich in the flora and the area was dominant by Fabaceae and Asteraceae. We also investigated the 27 plants used by Lord Gautam Buddha in his life period. Also, the invasive plant species are spreading very rapidly along the Lumbini area, both in land and in water. There is great threat for native species from fire, unmanaged plantation, from invasive plant encroachment and rampant waste disposal and in the area. There is an urgent need for ecological restoration in Lumbini and to develop Lumbini as a sacred garden in order to preserve its historical and religious value.

Author Contributions

First Author visits the site and prepares first Ms. Second and Third authors help to identify species and to make tables.

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Annex 1: List of enumerated plants from Lumbini Area.

S.N.	Scientific Name	Family	Local Name
1	*Andrographis paniculata* (Burm.f.) Nees	Acanthaceae	
2	*Hygrophila auriculata* (Schumach.) Heine	Acanthaceae	
3	*Rungia pectinata* (L.) Nees	Acanthaceae	
4	*Sagittaria trifolia* L.	Alismataceae	
5	*Achyranthes aspera* L.	Amaranthaceae	Datiwan, Apamarga
6	*Amaranthus spinosus* L.	Amaranthaceae	Lunde, Kandelunde, Katari
7	*A.hybridus* subsp. *cruentus* (L.) Thell.	Amaranthaceae	
8	*Mangifera indica* L.	Anacardiaceae	Aap
9	*Annona reticulata* L.	Annonaceae	Ramphal
10	*Alstonia scholaris* (L.) R. Br.	Apocynaceae	Chativan
11	*Calotropis gigantea* (L.) Dryand.	Apocynaceae	Aank, Seto Aank, Baramase Aank, Arka
12	*Cascabela thevetia* (L.) Lippold, Feddes Repert.	Apocynaceae	
13	*Catharanthus roseus* (L.) G. Don	Apocynaceae	Sadabaharful
14	*Ichnocarpus frutescens* (L.) W.T. Aiton	Apocynaceae	Dudhelahara
15	*Cryptolepis buchananii* Roem. & Schult.	Asclepiadaceae	
16	*Ageratum conyzoides* (L.) L.	Asteraceae	Gandhe, Boke Ghas
17	*Ageratum houstonianum* Mill.	Asteraceae	Nilo Gandhe
18	*Anaphalis* sp.	Asteraceae	
19	*Artemisia* sp.	Asteraceae	Patti
20	*Bidens pilosa* L.	Asteraceae	Kurro
21	*Blumea lacera* (Burm.f.) DC.	Asteraceae	Gandejhar
22	*Chromolaena odorata* (L.) R.M. King & H.Rob	Asteraceae	Setobanmara
23	*Cirsium wallichii* DC.	Asteraceae	
24	*Eclipta prostrata* (L.) L.	Asteraceae	
25	*Emilia sonchifolia* (L.) DC. ex DC.	Asteraceae	
26	*Inula cappa* (Buch.-Ham. ex D. Don.	Asteraceae	Gaitihare, Kanpate
27	*Mikania micrantha* Kunth	Asteraceae	
28	*Parthenium hysterophorus* L.	Asteraceae	Gajarejhar
29	*Sonchus asper* (L.) Hill	Asteraceae	Mula pate, Omche
30	*Spilanthes acmella* (L.) L.	Asteraceae	Latoghas, Marati
31	*Tridax procumbens* (L.) L.	Asteraceae	
32	*Xanthium strumarium* L.	Asteraceae	Bhote Kuro
33	*Bidens* sp.	Asteraceae	Kuro
34	*Bombax ceiba* L.	Bombacaceae	Simal
35	*Cynoglossum lanceolatum* Forssk.	Boraginaceae	KanikeKuro
36	*Nasturtium officinale* R.Br.	Brassicaceae	Khole sag
37	*Cannabis sativa* L.	Cannabaceae	Ganja
38	*Canna indica* L.	Cannaceae	Sarbada
39	*Cleome viscosa* L.	Cleomaceae	Hurhure, Bantori
40	*Chenopodium album* L.	Chenopodiaceae	Bethe
41	*Terminalia elliptica* Willd.	Combertaceae	Sanj
42	*Combretum indicum* (L.) DeFilipps	Combretaceae	Madhumalati
43	*Terminalia arjuna* (Roxb. ex DC.) Wight & Arn.	Combretaceae	Arjun, Kahulo, Kahu
44	*Terminalia bellirica* (Gaertn.) Roxb.	Combretaceae	Barro
45	*Terminalia chebula* Retz.	Combretaceae	Harro
46	*Commelina benghalensis* L.	Commelinaceae	Kane jhar
47	*Ipomea aquatic* Forsskal	Convolvulaceae	Karmi sag
48	*Ipomea carnea* subsp. *fistula*	Convolvulaceae	Ajambari, Bisari Jhar
49	*Momordica charantia* L.	Cucurbitaceae	Tite Karela
50	*Juniperus recurva* Buch.-Ham. ex D. Don	Cupressaceae	Dhupi, Guggal
51	*Cyperus compactus* Retz.	Cyperaceae	
52	*Cyperus difformis* L.	Cyperaceae	
53	*Fimbristylis acicularis* R.Br.	Cyperaceae	
54	*Fimbristylis littoralis* Gaudich.	Cyperaceae	
55	*Fimbristylis ovata* (Burm.f.) J.Kern	Cyperaceae	
56	*Schoenoplectus supinus* (L.) Palla	Cyperaceae	
57	*Dioscorea* sp.	Dioscoreaceae	Gittha, Ban Tarul
58	*Shorea robusta* Gaertn.	Dipterocarpaceae	Sal
59	*Croton bonplandianus* Baill.	Euphorbiaceae	

S.N.	Scientific Name	Family	Local Name
60	*Euphorbia hirta* L.	Euphorbiaceae	Dudhejhar
61	*Jatropha curcas* L.	Euphorbiaceae	Sajiban
62	*Mallotus philippensis* (Lam.) Mull. Arg.	Euphorbiaceae	Sindure
63	*Ricinus communis* L.	Euphorbiaceae	Ader
64	*Trewia nudiflora* L.	Euphorbiaceae	Gutel, Vellor, Ramrittha
65	*Phyllanthus urinaria* L.	Euphorbiaceae	Kanthad
66	*Saraca indica* L.	Fabaceae	Ashoka tree
67	*Acacia auriculiformis* Benth.	Fabaceae	
68	*Acacia catechu* (L.f.) Willd.	Fabaceae	Khayar
69	*Acacia nilotica* (L.) Delile	Fabaceae	Babul
70	*Arbus precatorius* L.	Fabaceae	Ratogedi
71	*Caesalpinia bonduc* (L.) Roxb.	Fabaceae	Gainde Kanda, Kanju, Kande Kuberachhya
72	*Cajanus cajan* (L.) Millsp.	Fabaceae	Arhar
73	*Cassia sophera* L.	Fabaceae	
74	*Dalbergia latifolia* Roxb.	Fabaceae	Satisal
75	*Dalbergia sissoo* DC.	Fabaceae	Sissoo
76	*Delonix regia* (Hook.) Raf.	Fabaceae	Gulmohor
77	*Desmodium triflorum* (L.) DC.	Fabaceae	Bakhre Ghas, Bhatmase Phool, Kairochi
78	*Mimosa pudica* L.	Fabaceae	Lajabatijhar
79	*Phanera purpurea* (L.) Benth.	Fabaceae	Koeralo
80	*Pithecellobium dulce* (Roxb.) Benth.	Fabaceae	Jilebi
81	*Senna occidentalis* (L.) Link	Fabaceae	Tapre
82	*Senna tora* (L.) Roxb.	Fabaceae	Tapre
83	*Sesbania* sp.	Fabaceae	Dhaincha
84	*Tamarindus indica* L.	Fabaceae	Imili
85	*Vicia angustifolia* L. ex Reichard	Fabaceae	Kutlikosa.
86	*Bauhinia* sp.	Fabaceae	Tanki, Koiralo
87	*Flemengia macrophylla* (Willd.) Merr.	Fabaceae	Thulo Bansapti, Bansapti, Bhatwasi
88	*Trigonella* sp.	Fabaceae	Tinpaate Jhaar
89	*Saracca indica* L.	Fabaceae	Ashoka tree
90	*Albizia lebbeck* (L.) Benth.	Fabaceae	Siris
91	*Senna alata* (L.) Roxb.	Fabaceae	Sano Tapre
92	*Mucuna pruriens* (L.) DC.	Fabaceae	Kauso, Kothcha
93	*Phyllodium pulchellum* (L.) Desv	Fabaceae	
94	*Indigofera heterocarpon* (L.) DC.	Fabaceae	Sakhino
95	*Desmodium gangeticum* (L.) DC.	Fabaceae	
96	*Anisomeles indica* (L.) Kuntze	Lamiaceae	Raato Chaarapaate
97	*Hyptis suaveolens* (L.) Poit.	Lamiaceae	Ban tulsi
98	*Leucas indica* (L.) R. Br. ex Vatke	Lamiaceae	
99	*Mentha sp.*	Lamiaceae	Pudina
100	*Pogostemon benghalensis* (Burm.f.) Kuntze	Lamiaceae	Rudilo
101	*Tectona grandis* L.f.	Lamiaceae	Teak
102	*Mentha spicata* L.	Lamiaceae	Pudina, Patame, Babari
103	*Salvia plebeian* R. Br	Lamiaceae	
105	*Lygodium flexuosum* (L.) Sw.	Lygodiaceae	Janailahara
106	*Woodfordia fruticosa* (L.) Kurz	Lythraceae	Dhayero
107	*Abutilon indicum* (L.) Sweet	Malvaceae	
108	*Urena lobata* L.	Malvaceae	
109	*Sida rhombifolia* Linn.	Malvaceae	Sano Chilya, Balu
110	*S. cordata* (Burm. f.) Borss.	Malvaceae	
111	*Thespesia lampas* (Cav.)	Malvaceae	Kapaseful
112	*Azadirachta indica* A. Juss.	Meliaceae	Neem
113	*Cissampelos pareira* L.	Menispermaceae	Batulepati
114	*Tinospora sinensis* (Lour.) Merr.	Menispermaceae	Gurjo
115	*Tiliacora acuminata* (Lam.) Hook. f. &Thoms.	Menispermaceae	Rukh Kaane
116	*Cissampelos pariera* L.	Menispermaceae	Jundar Gano, Jugar Gano, Batulpate
117	*Artocarpus lakoocha* Roxb.	Moraceae	Badahar
118	*Ficus benghalensis* L.	Moraceae	Bar
119	*Ficus benjamina* L.	Moraceae	Sami
120	*Ficus hispida* L.f.	Moraceae	Kharseto, Kharawa

S.N.	Scientific Name	Family	Local Name
121	*Ficus lacor* Buch.-Ham.	Moraceae	Kabhro, Pakadi, Palaksa
122	*Ficus racemosa* L.	Moraceae	Dumari
123	*Ficus religiosa* L.	Moraceae	Peepal
124	*Streblus asper* Lour.	Moraceae	Bariyara
125	*Callisteomon citrinus* (Curtis) Skeels	Myrtaceae	Kalkiful
126	*Eucalyptus* sp.	Myrtaceae	Masala tree
127	*Syzygium cumini* (L.) Skeels	Myrtaceae	Jamun
128	*Jasminum polyanthum* Franch.	Oleaceae	Chameli
129	*Nyctanthes arbor-tristis* L.	Oleaceae	Parijat
130	*Helminthostachys zeylanica* (L.) Hook.	Ophioglossaceae	Mayur Khutte
131	*Oxalis corniculata* L.	Oxalidaceae	Chariamilo
132	*Phyllanthus emblica* L.	Phyllanthaceae	Amala
133	*Phyllanthus reticulatus* Poir.	Phyllanthaceae	Sikani
134	*Piper longum* L.	Piperaceae	Pipala
135	*Scoparia dulcis* L.	Plantaginaceae	Chini Jhar, Mitha Jhar
136	*Dactyloctenium aegyptium* (L.) Willd.	Poaceae	
137	*Apluda mutica* L	Poaceae	Dakle Khar, Dakle Jhar, Sali Banso
138	*Arundo donax* L.	Poaceae	Thulonarkat
139	*Brachiaria villosa* (Lam.) A. Camus	Poaceae	
140	*Cynodon dactylon* (L.) Pers.	Poaceae	Dubo
141	*Eleusine indica* (L.) Gaertn.	Poaceae	Kodeghans
142	*Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult.	Poaceae	
143	*Eragrostis atrovirens* (Desf.) Trin. ex Steud.	Poaceae	Banso
144	*Eriochloa procera* (Retz.) C.E. Hubb.	Poaceae	
145	*Heteropogon contortus* (L.) P.Beauv. ex Roem. & Schult.	Poaceae	Arthunge
146	*Imperata cylindrica* (L.) Raeusch.	Poaceae	Siru
147	*Leersia hexandra* Sw.	Poaceae	Karaute Jhar
148	*Oplismenus burmannii* (Retz.) P. Beauv.	Poaceae	
149	*Oryza rufipogon* Griff.	Poaceae	Jungali Dhan, Tinni
150	*Panicum repens* L.	Poaceae	
151	*Phragmites karka* (Retz.) Trin. exSteud.	Poaceae	Sano Narkot
152	*Saccharum spontaneum* L. subsp. aegyptiacum (Willd.) Hack.	Poaceae	Kans, Jhaksi, Selme
153	*Saccharum spontaneum* L.	Poaceae	Kas
154	*Sporobolus diander* (Retz.) P. Beauv.	Poaceae	
155	*Setaria* sp.	Poaceae	
157	*Eragrostis tenella* (L.) P. Beauv. ex Roem. & Schult.	Poaceae	
158	*Rumex* sp.	Polygonaceae	Halhale
159	*Eichhornia crassipes* (Mart.) Solms	Pontederiaceae	Jalkumbhi
160	*Potamogeton lucens* L.	Potamogetonaceae	
161	*Anagalis arvensis* L.	Primulaceae	
162	*Androsace umbellata* (Lour.) Merr.	Primulaceae	
163	*Pteris vittata* L.	Pteridaceae	
164	*Ranunculus sceleratus* L.	Rananculaceae	
165	*Rosa* sp.	Rosaceae	
166	*Anthocephalus chinensis* (Lam.) A. Rich. ex Walp.	Rubiaceae	Kadamb
167	*Haldina cordifolia* (Roxb.) Ridsdale	Rubiaceae	Karma
168	*Hedyotis corymbosa* (L.) Lam	Rubiaceae	
169	*Aegle marmelos* (L.) Correa	Rutaceae	Bel
170	*Murraya koenigii* (L.) Spreng.	Rutaceae	Karipatta
171	*Azolla* sp.	Salviniaceae	
172	*Physalis peruviana* L.	Solanaceae	
173	*Solanum virginanum* L.	Solanaceae	
174	*Solanum aculeatissimum* Jacq.	Solanaceae	Thulo Bihi
175	*Solanum anguivi* Lam.	Solanaceae	Sano Bihi
176	*Solanum nigrum* L.	Solanaceae	Kali gedi
177	*Typha* sp.	Typhaceae	Patrer
178	*Pouzolzia zeylanica* (L.) Benn. & R. Br.	Urticaceae	
179	*Clerodendrum viscosum* Vent.nom. superfl.	Verbenaceae	Bhati
180	*Lantana camara* L.	Verbenaceae	Masinokanda, Ban Phada
181	*Cayratia trifolia* (L.) Domin	Vitaceae	

Wood Anatomy of Some Nepalese Species of Genus *Boehmeria*

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Abstract

In Nepal, Boehmeria is an important genus of family Urticaceae represented by 11 different species. The species are *B. canescens, B. rotundifolia, B. platyphylla, B. densiflora var. penduliflora, B. glomerulifera, B. minuticymosa, B. kamley, B. polystachya, B. ternifolia, B. clidemioides and B. hamiltoniana.* Wood structure of eighteen samples belonging to eleven Nepalese plant species of genus *Boehmeria* was studied. The study showed the presence or absence of growth ring, diffuse porous wood, alternate inter vessel pit, simple perforation, septate fiber tracheid, apotracheal, marginal and paratrecheal vescicentric parenchyma and uni and multiseriate homogeneous rays. Tyloses, sheath cell and crystals present or absent. Identification key is prepared on the basis of wood characters.

Keywords: Key characters, Nepalese *Boehmeria* species, Urticaceae, Wood structure

Introduction

There are 50-100 species in the genus *Boehmeria* of the nettle family Urticaceae (Chang, 1989). In Nepal, there are altogether 11 species (Rajbhandari et al., 2012).These species are perennial herbs, shrubs and small trees. Although related to nettles, this genus does not have stinging hairs. The taxonomy of the genus *Boehmeria* is very controversial. Earlier 10 species of *Boehmeria* was reported (Press et al., 2000). However, later Acharya and Yonekura (2002) added two species *B. kamley* and *B. minuticymosa*. Similarly in 2002, they proposed a new combination *B. densiflora* var. *penduliflora* (Wedd.ex D.G.Long) N. Acharya & Yonek by discussing the status of B. penduliflora Wedd. ex D.G. Long and B. densiflora Hook & Arn. *Boehmeria rugulosa* was changed into *Pouzolzia rugulosa*. Anatomical studies of the Urticaceae were done by Tippo (1938), Kachroo and Bhat (1982), Bonsen and Welle (1984), Metcalfe and Chalk(1950). But until now wood anatomical study on the Nepalese species of genus *Boehmeria* has not been done so far. The main objective of the study was to highlight the wood structure of Nepalese plant species of the genus *Boehmeria* and to identify based on wood character.

Materials and Methods

Eighteen wood samples belonging to eleven Nepalese plant species of the genus *Boehmeria* are collected from different places Godawari, Royal Botanical Garden, and Central Nepal (Table 1). Some are taken from the KATH herbarium sheet. All are with voucher specimens deposited in Kathmandu (KATH). The species are *B. canescens*, *B. rotundifolia*, *B. platyphylla*, *B. densiflora* var. *penduliflora*, *B. glomerulifera*, *B. minuticymosa*, *B. kamley*, *B. polystachya*, *B. ternifolia*, *B. clidemioides*, *B. hamiltoniana*. Samples are boiled in water in order to soften the material so that the section can be taken easily. Sections were taken using a sliding microtome at a thickness of 30µm and stained with safranin 'o', and fast green. Light microscopic studies of sections and maceration are carried out following the methods of Baas & Zhang (1986). Vessel density, vessel diameter, vessel element length, fiber element length and diameter, ray density, ray height cells, and some other characters are measured and compared. A recommendation in the IAWA List of Microscopic Features for Hardwood Identification (IAWA Committee 1989) was followed. Microscopic slides of wood and their voucher specimens are deposited at National Herbarium and Plant Laboratories, Godawari, Nepal.

Results and Discussion

Quantitative wood characters of eleven Nepalese species, *B. canescens*, *B. rotundifolia* var. *platyphylla*, *B. platyphylla*, *B. densiflora* var. *penduliflora*,

Table 1 : Some Nepalese species of genus *Boehmeria* collected from different places

S.N.	Name of the Plants	Specimen no.	Locality	Altitude (m)
1	*Boehmeria canescens* Wedd.	959	Godawari	1500
2	*Boehmeria canescens* Wedd.	200609	Godawari	1500
3	*B. densiflora* Hook & Arn. Var. penduliflora (Wedd. ex D.G. Long) N. Achrya & Yonek	200607	Godawari	1500
4	*B. glomerulifera* Miq.	9255516	Sukuthum	1650
5	*B. glomerulifera* Miq.	9455147	Yakleghar-Sar	2170
6	*B. kamley*. N. Achrya & Yonek	11054	Harelo-Chichile	1790
6	*B. minuticymosa* N. Achrya & Yonek	2359	Grang	1000
8	*B. platyphylla* D. Don	9495071	Sarjung	750
9	*B. polystachya* Wedd.	8571178	Choarma-Kyama	2600-2760
10	*B. polystachya* Wedd.	9154241	Baidep-Num	950
11	*B. clidemioides* Miq.	6307137	Taplejung-Danra	1000
12	*B. hamltoniana* Wedd.	6307103	Ghatte-khebang	1550
13	*B. rotundifolia* D. Don	394	Chinkhola	1220
14	*B. rotundifolia* D. Don	200610	Godawari	1500
15	*B. ternifolia* D. Don	6224	Danda kateri	1950
16	*B. ternifolia* D. Don	9495156	Sarjung khola	1600
17	*B. ternifolia* D. Don	9495166	Sarjung khola	1600
18	*B. ternifolia* D. Don	200608	Godawari	1500

B. glomerulifera, *B. minuticymosa*, *B. kamley*, *B. polystachya*, *B. ternifolia*, *B. clidemioides*, *B. hamiltoniana* of the genus *Boehmeria* are given in. Table l. Wood structure of 11 species of the genus *Boehmeria* is described as follows and the described specimen no. is star marked.

Boehmeria canescens Wedd. No.959, 200609*

Growth ring distinct, demarcated by radially flattened fiber tracheids, marginal parenchyma and tangentially arranged small pores near the growth ring (Figure 1a) Wood diffuse porous, diffusely arranged, mostly solitary or in radial multiple of 2-6, few in cluster multiple(Figure 1a) . Number of pore per square mm is 20-38 (27). Solitary pores are oval or round in outline 38-150 (101) and 38-100 (71) µm in radial and tangential diameter respectively and thin walled (1.2 µm). Pores are attached to one or both sides of the ray cells. Pores are 70-360 (205) µm long. Vessel perforation simple. End wall oblique with 45^{o} angle slope Inter-vessel pit is oval, round, angled (5-8µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 1d). Tyloses absent.

Wood parenchyma apotracheal, marginal and paratracheal. Apotracheal parenchyma sparsely diffused and paratracheal parenchyma scanty vescicentric (Figure 1b). Cell oval, angular, square in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 10-28 (16) and 8-38 (21) µm in radial and tangential diameter respectively and thin walled (Figure 1a). No. of cells per strand is 2-8. Pit simple. Vessel-parenchyma pit oval, horizontally elongated (5-20µm in diameter) and half bordered (Figure 1d). A row of 6-8 cluster crystals are present (Figure 1g).

Fiber tracheids constitute the ground mass of the wood and compactly arranged. Cells oval, round, square, angular in outline 8-23 (14) µm and 12-24 (18) µm in radial and tangential diameter respectively and thin and moderately thick walled (2.5-5µm in diameter) (Figure 1a). Fiber tracheids septate (2septa/cell), 375-650 (551)µm long (Figure 1c). Pit oval, half bordered with excluded aperture and noted in tangential and radial longitudinal section.

Ray uni and multiseriate (11), homogeneous, 2-3 rays per mm. Body cell consists of wholly of upright cells and few square cells. Uniseriate rays are few, 1- 7cells (50-475 µm) in height. Multiseriate rays are 2-11 cells (50-125 µm) in width and 375-4500 µm in height (Figure 1c). Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 25-75, 50-200 and 25-50µm in radial, vertical and tangential diameter respectively (Figure 1c,e). Sheath cell presents. Pit simple. Ray vessel pit is oval, elongated, half bordered (4-20µm in diameter) (Figure 1e). Simple and chambered cluster crystals present (Figure 1f).

Boehmeria densiflora var. *penduliflora* (Wedd. ex D.G. Long) Acharya & Yonek No. 200607

Growth ring indistinct, demarcated by radially flattened fiber tracheids and tangentially arranged small pores near the growth ring (Figure 2a). Wood diffuse porous, radially arranged, mostly solitary or in radial multiple of 2-4. Number of pore per square mm ranges from 6-9. Solitary pores oval or round in outline, 38-125(84) µm and 38-100(66) µm in radial and tangential diameter respectively and thick walled (4µm in diameter) (Figure 2a). Pores are 75-650 (364) µm long. Pores attached to one or both sides of the ray cells. Vessel perforation simple. End wall oblique with 45° angle slope. Inter-vessel pit is oval, round, angled (5-8µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 2d). Tyloses present (Figure 2a).

Wood parenchyma apotracheal, marginal and paratracheal. Apotracheal parenchyma sparsely diffused and paratracheal parenchyma scanty vescicentric (Figure 2b). Cell oval, angular, square in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 8-40 and 10-40µm in radial and tangential diameter respectively and thin walled. 2-12 cells per strand (Figure 2c). Pit simple. Vessel-parenchyma pit oval, horizontally elongated (5-15µm in diameter) and half bordered (Figure 2d). Crystals absent. Darkley stained substance present.

Fiber tracheids constitute the ground mass of the wood and compactly arranged. Cells oval, round, square, angular in outline, 10-35 (22) and 10-20 (18) µm in radial and tangential diameter respectively and thin and moderately thick walled (4µm in diameter) (Figure 2a). Fiber tracheids septate, 420-610 (546) µm long (Figure 2c). Pit oval, half bordered with excluded aperture and noted in tangential and radial longitudinal section.

Ray uni and multiseriate (6), homogeneous, 2-3 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 2e,f). Uniseriate rays are few, 1-34cells, 50-2830 (533) µm in height. Multiseriate rays are 2-6 cells (µm) in width and 330-more than 6330 µm in height with long uniseriate tails (Figure 2c). Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 20-25, 25-100 and 13-38 µm in radial, vertical and tangential diameter respectively. Sheath cell present. Pit simple. Ray vessel pit is oval, elongated, half bordered (5-20µm in diameter) (Figure 2f). Crystals absent.

Boehmeria glomerifolia Miq. No. 9255516*, 9455147

Growth ring absent. Wood diffuse porous. Pore density ranges from 53-66, mostly solitary or in radial multiple of 2-4. Solitary pore is oval or round in outline, 30-70 (51) and 30-100 (52)µm in radial and tangential diameter respectively and thin walled(Figure3a). Pores are 80-350 (230) µm long. Vessel perforation simple. End wall oblique with 45° angle slope. Inter-vessel pit oval, round, angled (5-12µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 3d). Tyloses and pith flecks present (Figure 3a).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma diffuse and paratracheal parenchyma scanty vescicentric (Figure 3b). Cell oval in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 4-19 (10) and7-29 (18) µm in radial and tangential diameter respectively and thin walled. 2-6 cells per strand. Pit simple. Vessel-parenchyma pit oval, horizontally elongated (5-14µm in diameter) opposite and half bordered (Figure 3d). Crystals absent.

Fiber tracheids constitute the ground mass of the wood and radially arranged. Cells oval, round, angular in outline, 5-17 (12) and 5-17 (11)µm in radial and tangential diameter respectively and thick walled (3µm in diameter) (Figure3a). Fiber tracheids are 408-720 (569)µm long (Figure 3c). Pit oval, half bordered with excluded aperture and not seen in tangential longitudinal section.

Ray uni and multiseriate (6), homogeneous (Figure 3c). No. of rays per mm ranges from 11-26. Body cell consists of wholly of upright cells and few square cells (Figure 3e). Uniseriate rays are few, 1- 10cells (120-672 µm) in height. Multiseriate rays are 2-6 cells (48-168µm) in width and 960-7920 in height with long uniseriate tails. Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 15-30, 15-160 and15-30µm in radial, vertical and tangential diameter respectively. Pit simple. Ray vessel pit is oval, elongated, half bordered (5-14µm in diameter) (Figure 3f). Crystals absent.

Boehmeria Kamley Acharya & Yonek No. 11054

Growth ring indistinct, demarcated by radially flattened fiber tracheids, marginal parenchyma and tangentially arranged small pores near the growth ring (Figure 4a). Wood diffuse porous. Pore density ranges from 54-69, mostly solitary or in radial multiple of 2-5. Solitary pore is oval or round in outline, 15-110(60) and 20-70(53)µm in radial and tangential diameter respectively and slightly thick walled (Figure 4a). Pores are 120-420(287) µm long. Vessel perforation simple. End wall oblique with 45^{o} angle slope. Inter-vessel pit oval, round, angled (4-10µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 4d). Tyloses and pith flecks present (Figure 4a,c).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma diffuse and paratracheal parenchyma scanty vescicentric (Figure 4b). Cell oval in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 10-29(14) and 7-36(14) µm in radial and tangential diameter respectively and thin walled. 2-8 cells per strand. Pit simple.Vessel-parenchyma pit oval, horizontally elongated (5-17µm in diameter) alternate and half bordered (Figure 4d). Crystals present.

Fiber tracheids constitute the ground mass of the wood and radially arranged. Cells oval, round, angular in outline,7-19(13) and 7-17(13)µm in radial and tangential diameter respectively and moderately thick walled (5µm in diameter) (Figure 4a,b). Fiber tracheids septate,1-3 per cell. 300-650(484)µm long (Figure 4c). Pit oval, half bordered with excluded aperture and not seen in tangential longitudinal section.

Ray uni and multiseriate (5), homogeneous. No.of rays per mm range from 18-26. Body cell consists of wholly of upright cells and few square cells (Figure 4e). Uniseriate rays are few, 1- 13 cells (20-300 µm) in height. Multiseriate rays are 2-5 cells (24-72µm) in width and 360-8832 (2633)µm in height with long uniseriate tails (Figure 4c). Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 15-30, 20-120 and10-25 µm in radial, vertical and tangential diameter respectively. Pit simple. Ray vessel pit is oval, elongated, half bordered (5-12µm in diameter) (Figure 4f). Cluster crystals and sheath cells present (Figure 4d).

Boehmeria minuticymose Acharya & Yonek No. 2359

Growth ring absent. Wood diffuse porous, radially arranged near the pore region. Pore density ranges from , mostly solitary or in radial multiple of 2-9. Solitary pore is oval or round in outline, 40-100(68) and 20-6(43)µm in radial and tangential diameter respectively and slightly thick walled (Figure 5a). Pores are 180-350 µm long.Vessel perforation simple. End wall oblique with 45^{o} angle slope. Inter-vessel pit oval, round, angled (3-5µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 5d). Tyloses present and spiral thickenings noticed in small pores (Figure 5a,e).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma diffuse and paratracheal parenchyma scanty vescicentric (Figure 5b). Cell oval in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 7-24(15) and 10-26(16) µm in radial and tangential diameter respectively and thin walled. 2-11 cells per strand (Figure 5c). Pit simple. Vessel-parenchyma pit oval, horizontally elongated (4-12µm in diameter) opposite and half bordered (Figure 5d). Crystals present.

Fiber tracheids constitute the ground mass of the wood and radially arranged. Cells oval, round, angular in outline,10-19(13) and 10-14(11)µm in radial and tangential diameter respectively and moderately thick walled (5µm in diameter) (Figure

5b). Fiber tracheids septate, 200-420(325)µm long (Figure 5c). Pit oval, half bordered with excluded aperture and not seen in tangential longitudinal section.

Ray uni and multiseriate (12), homogeneous (Figure 5b). Uniseriate rays very few. No. of rays per mm ranges from 7-15. Body cell consists of wholly of upright cells and few square cells (Figure 5f). Uniseriate rays are few, 1-10 cells (150-300 µm) in height. Multiseriate rays are 2-12 cells (40-80µm) in width and to indifinite height with long uniseriate tails. (Figure 5c) Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 10-15, 10-90 and15-40µm in radial, vertical and tangential diameter respectively. Aggregate rays noted. These rays are 700-820µm in width Pit simple. Ray vessel pit is oval, elongated, half bordered (µm in diameter) (Figure 5g). Crystals present (Figure 5h).

Boehmeria platyphylla D.Don No.9495071*, 6307113

Growth ring distinct, demarcated by thickness of the fiber tracheids and marginal parenchyma cells(Figure 6b). Wood is diffuse porous. Pores are diffusely arranged, mostly solitary, radial or in cluster multiple of 2-4. No. of pores per mm.ranges from 53-70. Solitary pores are oval or round in outline.40-100(68) and 30-80(50)µm in radial and tangential diameter respectively and thin walled (Figure 6a,b). Pores are generally attached to the ray cell. Pores are 100-400µm long.Vessel perforation is simple. End wall is oblique with its slope 45° angle. Inter-vessel pit is oval, round (3-8µm in diameter), bordered with included lenticular aperture and alternately arranged compactly (Figure 6d). Tyloses are present. (Figure 6a).

Wood parenchyma apotracheal, marginal and paratracheal. Apotracheal parenchyma sparsely diffused and paratracheal parenchyma scanty vescicentric (Figure 6b). Cell oval, radially flattened and tubular in outline, 5-45and5-60 µm in radial and tangential diameter respectively and thin walled. 2-8 cells per strand (Figure 6c). Pit simple. Vessel-parenchyma pit oval, horizontally elongated (7-19µm in diameter) and half bordered (Figure 6d). Simple crystals present.

Fiber tracheids and libriform fibers constitute the ground mass of the wood and compactly arranged (Figure 6b). Cells are oval, round, square, in outline 5-20 and 5-15 µm in radial and tangential diameter respectively and moderately thick walled (5µm in diameter) (Figure 6b). Fibers are µm long and septate (2 septa) (Figure 6c). Pit is oval, half bordered with excluded aperture.

Ray uni and multiseriate (3), homogeneous, 5-8 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 6g). Uniseriate rays are few, 1-6 cells (180-350µm) in height. Multiseriate rays 2-3 cells (40µm) in width and 450-2200µm in height with uniseriate tail of cells. (Figure 6c) Multiseriate ray consists of upright or square cells. Upright or square cells are vertically elongated, square in outline in 10-30, 35-80 and 8-20 µm in radial, vertical and tangential diameter respectively. Sheath cell present. Pit simple. Ray vessel pit oval, elongated and half bordered (5-20µm in diameter) (Figure 6f). Simple crystals present.

Boehmeria polystachya Wedd. No. 8571178*, 9154241

Growth ring absent. Wood diffuse porous, diffusely arranged. Pores mostly solitary, or in radial multiple of 2-4. Pore density ranges from 72-119. Solitary pores are oval, angular in outline. 30-100(60) and 20-70(45)µm in radial and tangential diameter respectively and thin walled. Pores are generally attached to the ray cell. Pores are 70-400(216)µm long. Vessel perforation simple. End wall is oblique with its slope 45° angle. Inter-vessel pit is oval, round (5-7µm in diameter), bordered with included lenticular aperture, compact and alternately arranged (Figure 7e). Tyloses absent. Darkly stained substance presents in the pore. Spiral thickening noticed in pore (Figure 7f).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma scanty, diffuse, paratracheal parenchyma scanty vescicentric (Figure 7b). Cell oval, radially or tangentially elongated near the pore in outline, 50-70 and 60-120µm in radial and tangential diameter respectively and thin walled. 2-6 cells per strand. Pit simple. Vessel-parenchyma pit oval, horizontally elongated (4-22µm in diameter) and half bodered (Figure 7e). Chamber cluster crystals absent. Darkly stained substance noticed mostly in the parenchyma cell near the pore.

Fiber tracheids constitute the groundmass of the wood and compactly arranged. Cells oval, angular, square, in outline 7-19(13) and 7-19(11)µm in radial and tangential diameter respectively and thick walled (4µm in diameter) (Figure 7a). Fibers are 350-450(400)µm long and septate (Figure 7c). Pit is round, half bordered with excluded aperture, seen in both TLS and RLS.

Ray uni and multiseriate, homogeneous, 2-3 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 7d). Uniseriate rays are few, 1-17cells(120-1200(653)µm) in height. Multiseriate rays 2-5cells(20-150µm) in width and 1600-3000(2200)µm in height with long uniseriate tail (Figure 7c). Multiseriate ray consists of upright or square cells. Upright or square cells are vertically elongated, oval in outline in tangential diameter, 10-30(20), 30-120(67) and 15-30(22)µm in radial, vertical and tangential diameter respectively. Sheath cell presents. Pit simple. Ray vessel pit oval, elongated and half bordered (5-17µm in diameter) (Figure 7g). Aggregate rays present. Chambered cluster crystals present in aggregate cell.

Boehmeria rotundifolia var. *pachyphylla* D. Don. 200610*, 4795

Growth ring distinct, demarcated by radially flattened fiber tracheids and tangentially arranged small pores near the growth ring (Figure 8 a). Wood diffuse porous. Pores are diffusely arranged but tangentially arranged near the growth rings. Pore density ranges from 64-133. Pores are mostly solitary rarely in radial multiple of 2-5. Multiple cluster group are found near the growth ring. Solitary pore oval or round in outline. 25-100(54) and 25-75(48)µm in radial and tangential diameter respectively and thin walled (2µm in diameter). Pores attached to one or both sides of the ray cells (Figure 8a). Pores are 75-400(236) µm long Vessel perforation simple (Figure 8c). End wall oblique with 45^{o} angle slope Inter-vessel pit is oval, round, angled (5-8µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 8d). Tyloses absent.

Wood parenchyma apotracheal and paratracheal. Apotracheal parenchyma sparsely diffused and paratracheal parenchyma scanty vescicentric. Cell oval, angular, square in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma, 15-25(20) and 5-25(16) µm in radial and tangential diameter respectively and thin walled (Figure 8a,b). 2-6 cells per strand. Pit simple. Vessel-parenchyma pit oval, horizontally elongated (3-15µm in diameter) and half bordered (Figure 8c). Simple crystals present. Darkley stained substance present.

Fiber tracheids constitute the ground mass of the wood and radially arranged. Cells oval, round, square, angular in outline, 15-10(12) and 10-20(16) µm in radial and tangential diameter respectively and moderately thick walled (2µm in diameter) (Figure 8b). Fiber tracheids septate, 300-560 µm long(Figure 8c). Pit oval, half bordered with excluded aperture.

Ray uni and multiseriate(6), homogeneous, 5- rays per mm (Figure 8c). Body cell consists of wholly of upright cells and few square cells (Figure 8e). Uniseriate rays are few, 1- 10 cells (250-3200 µm) in height. Multiseriate rays are 2-6 cells(µm) in width and 450-9000(3050) µm in height with long uniseriate tails (Figure 8c). Upright or square cells are vertically elongated, hexagonal in outline in tangential section, 10-20, 40-170 and 10-25µm in radial, vertical and tangential diameter respectively. Multiseriate rays are dumbell like structure in tangential section. Sheath cell presents. Pit simple. Ray vessel pit is oval, elongated, half bordered (3-10µm in diameter) (Figure 8f). Cluster crystals present (Figure 8c),

Boehmeria ternifolia D.Don No.6224. 9495156, 9495166, 200608*

Growth ring distinct, demarcated by radially flattened 1-2 layer of fiber tracheids and marginal parenchyma

(Figure 9a). Wood diffuse porous, diffusely arranged, 46-53 pore per square mm, mostly solitary rarely in radial multiple of 2-7. Solitary pores oval or round in outline. 20-50(30) and 20-30(22) µm in radial and tangential diameter respectively and thin walled (Figure 9a,b). Pores attached to one or both sides of the ray cells. Pores are 100-400(225) µm long. Vessel perforation simple. 2-3 perforation is noted in a single pore in sample no. 9495156. End wall oblique with 45^{o} angle slope Inter-vessel pit is oval, round, angled (5µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged (Figure 9d). Tyloses present.

Wood parenchyma marginal, apotracheal and paratracheal. Apotracheal parenchyma diffuse in uniseriate band and paratracheal parenchyma scanty vescicentric(Figure 9a,b). Cell oval, angular, square in apotracheal parenchyma and polygonal, tubular, radially elongated in paratracheal parenchyma,4-10 and 6-20µm in radial and tangential diameter respectively and thin walled. 2-7 cells per strand. Pit simple. Vessel-parenchyma pit oval, horizontally elongated (5-µm in diameter) and half bordered (Figure 9). Crystals present.

Fiber tracheids constitute the ground mass of the wood and compactly arranged. Cells oval, round, square, angular in outline 8-15 and 8-20 µm in radial and tangential diameter respectively and thin and moderately thick walled (3µm in diameter) (Figure 9b). Fiber tracheids are 300-700 µm long and septate (2-3septa) (Figure 9c). Pit oval, half bordered with excluded aperture.

Ray uni and multiseriate(5), homogeneous, 10-13 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 9e). Uniseriate rays are few, 1- 2cells (20-25 µm) in height. Multiseriate rays are 2-6 cells (30-80µm) in width and 1500-7500(3570) µm in height with long uniseriate tails (Figure 9c). Upright or square cells are vertically elongated, in outline in tangential section, 5-10, 15-40 and5-10 µm in radial, vertical and tangential diameter respectively. Multiseriate rays are dissected by parenchymatous cells Pit simple. Ray vessel pit is oval, elongated, half bordered (µm in diameter) (Figure 9f). Simple and cluster crystals present.

Boehmeria clidemioides Miq.No. 6307137

Growth ring absent. Wood diffuse porous, diffusely arranged. Pores mostly solitary, or in radial multiple of 2-4. Pore density ranges from 72-263. Solitary pores are oval, angular in outline. 20-60 (40)and 20-60(38)µm in radial and tangential diameter respectively and thin walled. (Figure 10a) Pores are generally attached to the ray cell. Pores are 300-450(374)µm long. Vessel perforation simple. End wall is oblique with its slope 45^{o} angle. Inter-vessel pit is oval, round (5-7µm in diameter), bordered with included lenticular aperture, compact and alternately arranged (Figure 10d). Tyloses present (Figure 10a,c).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma scanty, diffuse and paratracheal parenchyma vescicentric (Figure 10a). Cell oval, radially or tangentially elongated near the pore in outline, 5-10 and 12-24µm in radial and tangential diameter respectively and thin walled. 2-6 cells per strand (Figure 10b). Pit simple. Vessel-parenchyma pit oval, horizontally elongated (7-19µm in diameter) and half bodered (Figure 10e). Simple crystal present (Figure 10g).

Fiber tracheids constitute the groundmass of the wood and compactly arranged. Cells oval, angular, square, in outline 7-24(17) and 12-17(14)µm in radial and tangential diameter respectively and thick walled (4µm in diameter) (Figure 10a). Fibers are 300-520(448)µm long and septate(Figure 10b). Pit is round, half bordered with excluded aperture, seen in both TLS and RLS.

Ray uni and multiseriat (6), homogeneous, 5-7 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 10f). Uniseriate rays are few, 1-10cells (428-720(592)µm) in height. Multiseriate rays 2-6cells (30-100µm) in width and 1200-2160 (1598)µm in height with long uniseriate tail (Figure 10c). Multiseriate ray consists of upright or square cells. Upright or square cells are vertically elongated, oval in outline in tangential diameter, 3-6(5), 20-200(95) and 3-5(4)µm in radial, vertical and tangential diameter respectively. Sheath cell presents. Pit simple. Ray vessel pit oval, elongated and half bordered (7µm in diameter) (Figure 10e).

Boehmeria hamiltoniana Wedd. No.6307103

Growth ring absent. Wood diffuse porous, diffusely arranged. Pores mostly solitary, or in radial multiple of 2-4. Pore density ranges from 28-53. Solitary pores are oval, angular in outline. 20-60(39) and 30-50(39)µm in radial and tangential diameter respectively and thin walled (Figure 11a). Pores are generally attached to the ray cell. Pores are 80-350(229)µm long (Figure 11b). Vessel perforation simple. End wall is oblique with its slope 45^{o} angle. Inter-vessel pit is oval, round (5µm in diameter), bordered with included lenticular aperture, compact and alternately arranged (Figure 11c).

Wood parenchyma apotracheal, and paratracheal. Apotracheal parenchyma in short uniseriate band, diffuse, paratracheal parenchyma vescicentric (Figure 11a). Cell oval, radially or tangentially elongated near the pore in outline, 10-20(13) and 10-20(16)µm in radial and tangential diameter respectively and thin walled. 2-5 cells per strand (Figure 11b). Pit simple. Vessel-parenchyma pit oval, horizontally elongated (5-17µm in diameter) and half bodered (Figure 11d).

Fiber tracheids constitute the groundmass of the wood and compactly arranged. Cells oval, angular, square, in outline 10-20(15) and 15-20(18)µm in radial and tangential diameter respectively and thick walled (4µm in diameter) (Figure 11a). Fibers are 300-700(536)µm long and septate (Figure 11b). Pit is round, half bordered with excluded aperture.

Ray uni and multiseriate(5), homogeneous, 8-15 rays per mm. Body cell consists of wholly of upright cells and few square cells (Figure 11e). Uniseriate rays are few, 1-20cells (100-800(317)µm) in height. Multiseriate rays 2-7cells(48-120µm) in width and 312-4320(2167)µm in height with long uniseriate tail(Figure 11b). Multiseriate ray consists of upright or square cells. Upright or square cells are vertically elongated, oval in outline in tangential diameter, 10-25(17), 20-80(47) and 10-20(14)µm in radial, vertical and tangential diameter respectively. Sheath cell presents. Pit simple. Ray vessel pit oval, elongated and half bordered (5-12µm in diameter) (Figure 11f). Aggregate rays present. Cluster crystals present (Figure 11g).

General wood anatomical character of the genus *Boehmeria* is summarized as follows.

Growth ring distinct, indistinct or absent demarcated by radially flattened few layer of fiber tracheids, marginal parenchyma and tangentially arranged small pores near the growth ring.

Wood is diffuse porous. Pores are radially arranged, mostly solitary or in radial multiple of 2-4(-9), rarely in multiple cluster. Solitary pores are angular, oval or round in outline and thin walled. Pores are generally attached to the ray cell. Vessel perforation is simple. End wall is oblique with its slope 45^{o} angle. Inter-vessel pit is oval, round alternate, bordered with included lenticular aperture and compactly arranged. Tyloses, spiral thickenings and pith flecks are present or absent.

Wood parenchyma is marginal, apotracheal, and paratracheal. Apotracheal parenchyma is sparsely diffused or diffused in uniseriate and paratracheal parenchyma vescicentric Cell is oval, radially flattened and tubular in outline and thin walled. No. of cells per strand is 2-12. Pit is simple. Vessel-parenchyma pit is oval, horizontally elongated and half bodered. Simple and chamber cluster crystals are present or absent.

Fiber tracheids and libriform fibers constitute the ground mass of the wood and compactly arranged. Cells are oval, round, square in outline and thick walled Septa is present or absent. Pit is oval, half bordered with excluded aperture.

Ray is uni and multiseriate, homogeneous. Body cell consists of wholly of upright cells and few square cells. Upright or square cells are vertically elongated, square in outline in tangential section. Sheath cell present or absent. Ray cell is interrupted by parenchymatous cell. Pit is simple. Ray vessel pit is oval, elongated and half bordered. Simple and chambered cluster crystals are present or absent.

The study shows presence of growth ring in *Boehmeria canescens, B. ternifolia, B. platyphylla, B. rotundifolia* are indistinct in *B. densifl*ora var. *penduliflora*, *B. Kamley,* absent in *B. minuticymose, B. hamiltoniana, B. clidemioides B. polystachya* and *B. glomerifolia.* Growth ring is demarcated by radially flattened 2-3 layer of fiber tracheids, marginal parenchyma and tangentially arranged small pores near the growth ring. Wood is diffuse porous. Pores are radially arranged, mostly solitary or in radial multiple of 2-4(-9), rarely in multiple cluster. Solitary pores are angular, oval or round in outline ranges from 20-216 and 15-300 µm in radial and tangential diameter respectively and thin walled. Smallest diameter is noted in the species *B. ternifolia* and *B. hamiltoniana* highest in the species *canescens*. Pores are generally attached to the ray cell. Pores are 104-412 µm long, short in *ternifolia* and long in *B. densifolia*. Vessel perforation is simple. End wall is oblique with its slope 45^o angle. Inter-vessel pit is oval, round (µm in diameter), alternate, bordered with included lenticular aperture and compactly arranged. Tyloses are noted in the species minuticymosa, *B. Kamley. B. Ternifolia, B*. densifolia. *B*. clidemioides, *B. glomerifolia* and *B. platyphylla*. Spiral thickenings are noted in the species polystachya and minuticymosa. Pith flecks are noted in *B. Kamley, B.* densifolia. Wood parenchyma is marginal, apotracheal, and paratracheal except in *B. minuticymose, B. hamiltoniana, B. polystachya, B. clidemioides* and *B. glomerifolia* where marginal parenchyma is absent. Apotracheal parenchyma is sparsely diffused or in short uniseriate band in the species *B. ternifolia, B. hamiltoniana* and scanty vescicentric paratracheal parenchyma except in *B. polystachya, B. rotundifolia* and *B. minuticymosa* where it is vescicentric. Cell is oval, radially flattened and tubular in outline, No. of cells per strand is 2-12. Pit is simple. Vessel-parenchyma pit is oval, horizontally elongated and half bordered. Crystals are absent in *B. densifolia, B. glomerifolia, B. clidemioides and B. hamiltoniana*. Fiber tracheids and libriform fibers constitute the ground mass of the wood and compactly arranged. Cells are oval, round, square, in outline and moderately thick walled. Septa is present except in *B. glomerifolia* and *B. polystachya*, 1-3 septa per cell. Fibers are long pointed ends. Pit is oval, half bordered with excluded aperture. Ray is uni and multiseriate, homogeneous. Body cell consists of wholly of upright cells and few square cells. Uniseriate rays are few, 1-34cells(µm) in height. Multiseriate rays are 2-6(-12)cells in width and very high in height with uniseriate long tail. Multiseriate ray consists of upright or square cells. Upright or square cells are vertically elongated, square in outline in tangential diameter and µm in radial, vertical and tangential diameter respectively. Sheath cell present. Ray cell is interrupted by parenchymatous cell. Pit is simple. Ray vessel pit is oval, elongated and half bordered (µm in diameter). Chambered cluster crystals are present except in *B. densifolia, B. glomerifolia, B. clidemioides.* In the species *B. canescens* chamber crystals are in 1-8 vertical rows. On the basis of these characters, 11 species of the genus *Boehmeria* are identified.

The anatomical characters showed that the genus *Boehmeria* is highly specialized as having high pore density, thin walled tyloses, short vessel length and septate fibers. Tippo (1938) concluded from his study of the Moraceae and presumed allies that septate fibers are more specialized than non septate fibers.

Identification key characters of 11 species of the genus *Boehmeria*

A tentative key is prepared on the basis of wood anatomical characters which are as follows:

Growth ring present or absent. Wood diffuse porous. Vessel perforation simple. Inter-vessel pit alternate. Spiral thickening present or absent in the pore. Tyloses and pith flecks present or absent. Wood parenchyma marginal, apotracheal and paratracheal. Fiber tracheid septate or unseptate. Rays homogeneous, uniseriate and multiseriate. Cluster crystal present or absent in axial parenchyma and ray cells. Sheath cell present or absent in ray cell. *Boehmeria*

A. Growth ring distinct.
  B. canescens, B. ternifolia, B. platyphylla, B. rotundifolia
  Aa. Tyloses present *B. ternifolia, B. platyphylla,*
    Aaa. Apotracheal parenchyma sparsely diffused. *B. platyphylla*
    Aab. Apotracheal parenchyma diffuse in short uniseriate band. *B.ternifolia*
  Ab. Tyloses absent. *B. canescens, B. rotundifolia*
    Aba. Paratracheal parenchyma scanty

vescicentric and chamber cluster crystal in 1- 8 vertical rows in ray cell. *B. canescens*

Abb. Paratracheal parenchyma vescicentric, chamber cluster crystal not in 1-8 vertical rows in ray cell *B. rotundifolia*

B. Growth ring indistinct *B. Kamley, B. densifolia*

Ba. Chamber cluster crystal present. Septa present in fiber tracheid. *B. Kamley*

Bb. Chamber cluster crystal absent. Septa absent in fiber tracheid. *B. densifolia*

C. Growth ring absent. *B. minuticymose, B. hamiltoniana, B. clidemioides B. glomerifolia, B. polystachya*

Ca. Tyloses present *B. minuticymose, B. clidemioides. B. glomerifolia*

Caa Chamber cluster crystal present. Spiral thickening noted in pore *B. minuticymose*

Cab. Chamber cluster crystal absent.

Cab1 Paratracheal parenchyma scanty vescicentric *B. clidemioides*

Cab2 Paratracheal parenchyma vescicentric *B. glomerifoli*

Cb. Tyloses absent. *B. hamiltoniana B. polystachya,*

Cba. Apotracheal parenchyma diffuse in short uniseriate band. Paratracheal parenchyma scanty vescicentric *B. hamiltoniana*

Cbb. Apotracheal parenchyma sparsely diffused. Paratracheal parenchyma vescicentric. *B. glomerifolia*

Conclusion

The study shows that wood structure is found very similar in all the studied species of the genus *Boehmeria*. Differentiation is pronounced in their quantitative wood characters. So it is very difficult to distinguish on the species level based on wood anatomical characters only.

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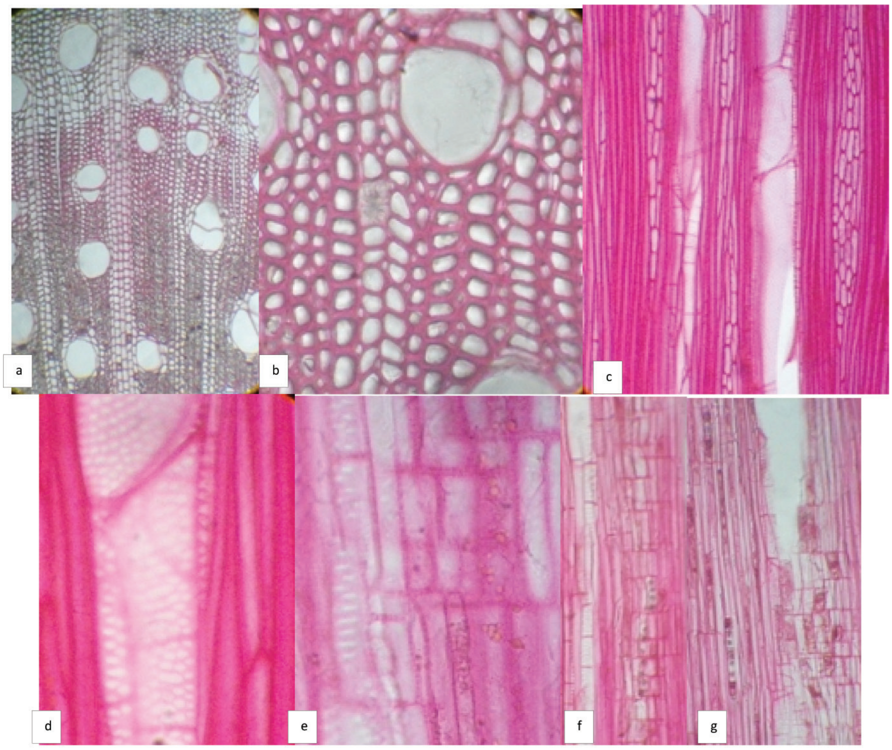

Figure 1: a & b. Cross section of *B.canescens* sp.no.200609 showing diffuse porous wood, distinct growth ring in (a) and scanty vescentric paratracheal parenchyma, apotracheal parenchyma and crystal in ray cell in(b), c & d, TLS showing fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (c), inter-vesssel pit ,vessel-parenchyma pit in(d), e, f & g RLS showing upright ray cell and ray vessel pit in (e), cluster crystal in ray cell in(f), and row of cluster crystal in parenchymatous cell in (g). Mgn. 60x (a), 150x (b,c,f,g), 600x(d,e)

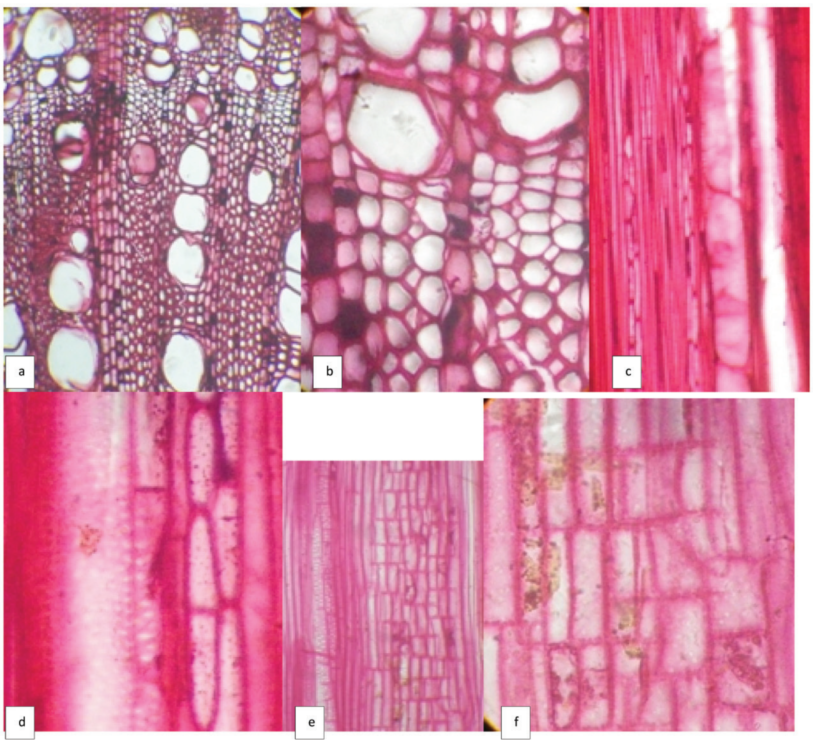

Figure 2:. a & b. Cross section of *B.densiflora*var. *penduliferasp*.no.200607 showing diffuse porous wood, indistinct growth ring and tyloses in (a) and marginal,scanty vescentric paratracheal and apotracheal parenchyma in(b), c & d, TLS showing fibertracheid, parenchymatous cell and uni and biseriate ray cell in (c), inter-vesssel pit and vessel parenchyma pit jn(d), e & f RLS showing upright ray cell in (e), and ray vessel pit in (f). Mgn. 150x (a,c,e), 600x(b,d,f)

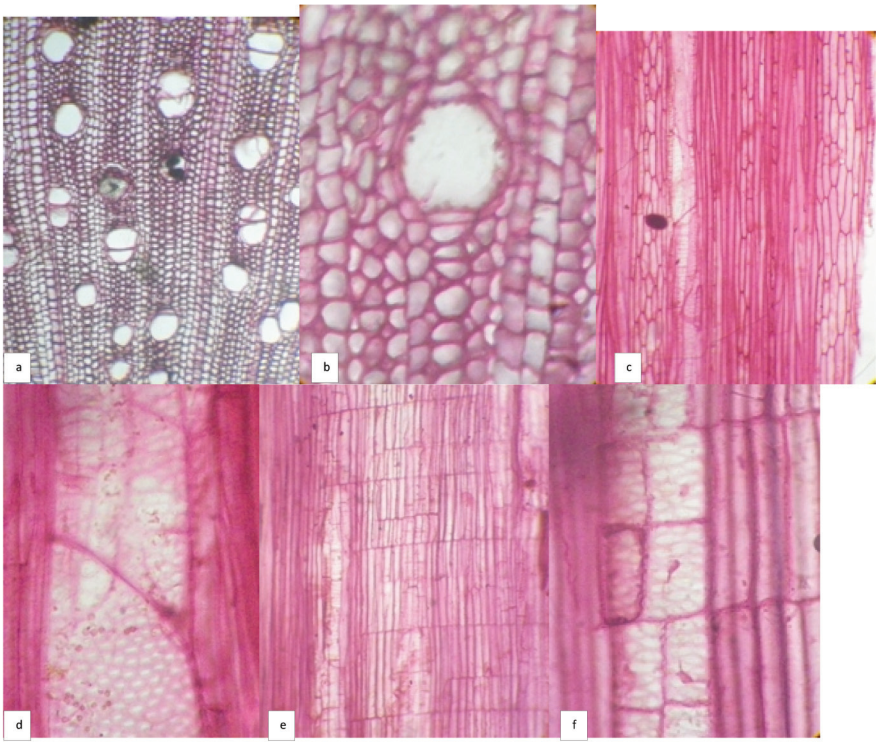

Figure 3: a &b, Cross section of *B.*glomerifolia sp.no.9255516 showing pore and tyloses in(a)and scanty vescentric paratracheal parenchyma in(b), c & g, TLS showing pore, fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (c), inter-vesssel pit, and vessel-parenchyma pit in (d), e & f ,RLS showing upright ray cell in (g), and ray vessel pit in (f). Mgn. 150x (a,c,e), 600x(b,d,f)

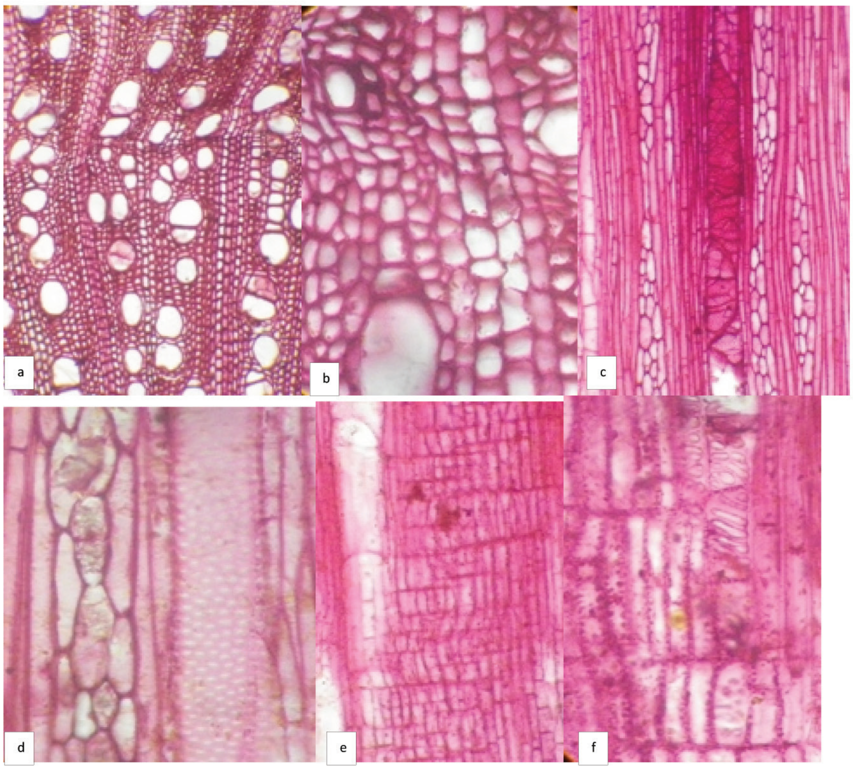

Figure 4: a &b, Cross section of *B.Kamley* sp.no.11054 showing pore and tyloses in(a)and growth ring and vescentric paratracheal parenchyma in(b), c & d, TLS showing pore with tyloses, fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (c), inter-vesssel pit ,vessel-parenchyma pit and cluster crystal in (d), e & f RLS showing upright ray cell in (e), ray vessel pit in (f). Mgn. 150x (a,c,e), 600x(b,d,f)

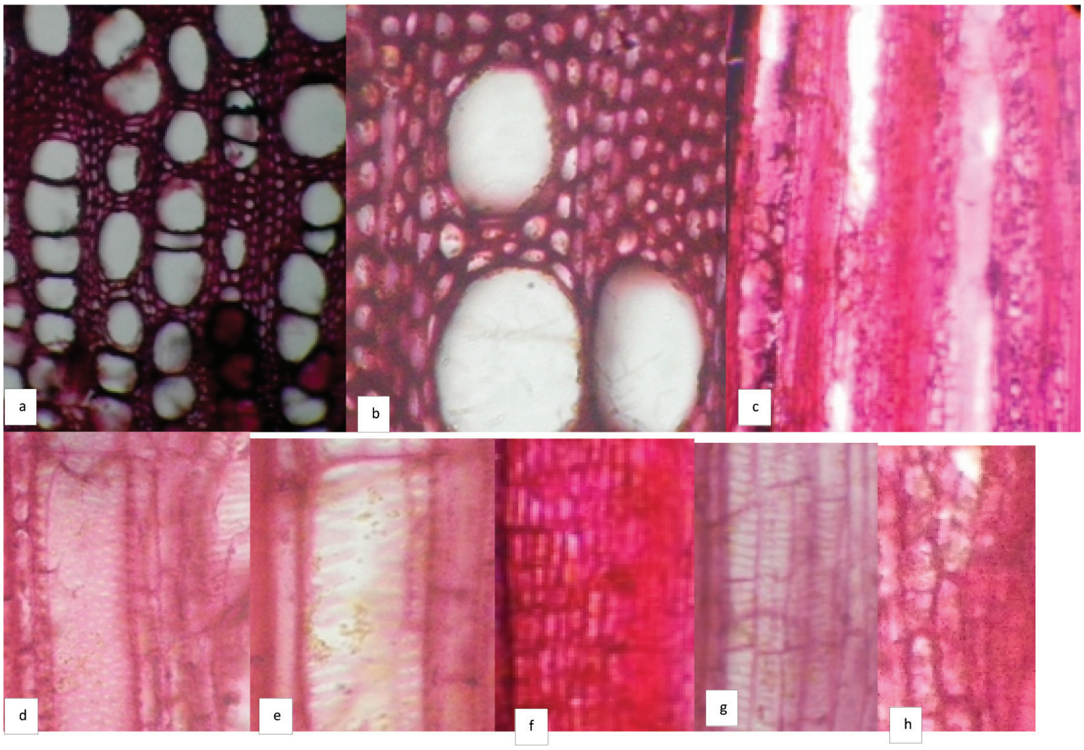

Figure 5: a &b, Cross section of *B.minuticymosa* sp.no. 2359 showing diffuse porous wood and tyloses in(a)and vescentric paratracheal parenchyma in(b), c,d & e, TLS showing pore with tyloses, fibertracheid and multiseriate ray cell in (c), inter-vesssel pit in (d), vesselparenchymA PIT IN (e). f, g & h RLS showing homogeneous upright ray cell in (f), ray vessel pit in (g) and cluster crystal in (h). Mgn. 150x (a,c,f), 600x(b,d,e,g,h)

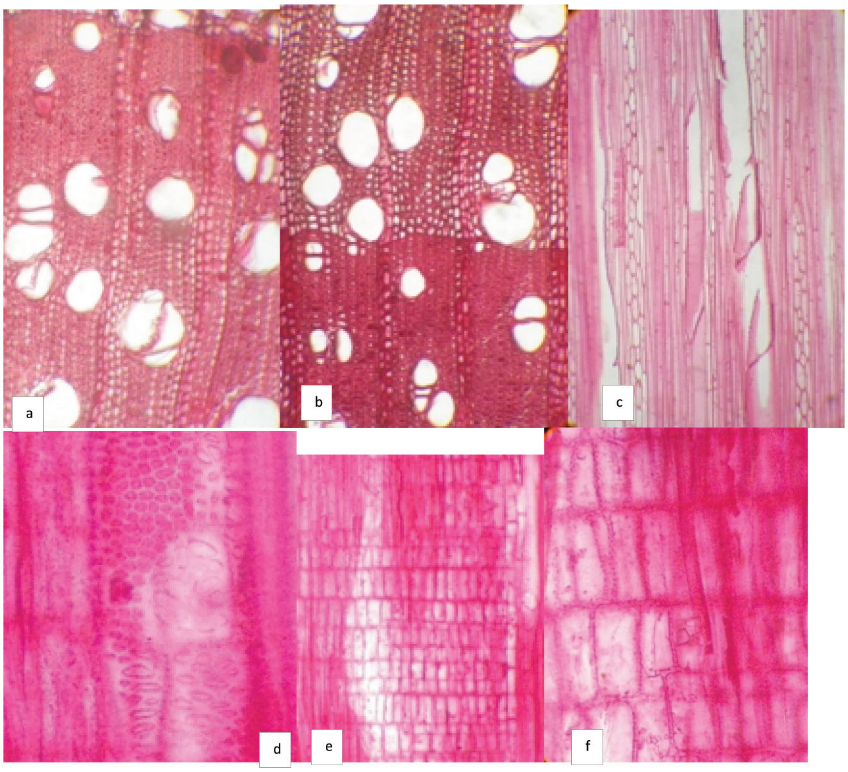

Figure 6: a & b. Cross section of *B.platyphylla* sp.no.9496071,showing diffuse porous wood, , tyloses in (a), growth ring and marginal and scanty vescentric paratracheal parenchyma in(b), c & d, TLS showing fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (c), inter-vesssel pit and vessel-parenchyma pit jn(d), e & f RLS showing upright ray cell in (e), and ray vessel pit in (f). Mgn. 150x (a,b,c,e), 600x(d,f)

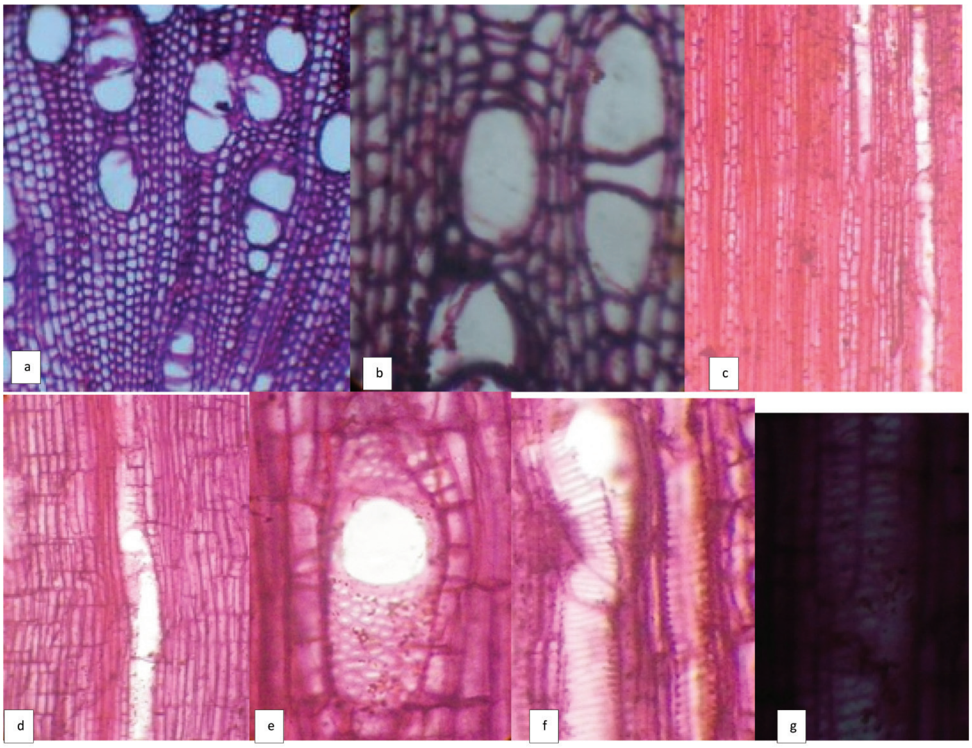

Figure 7: a&b, Cross section of *B.polystachya*sp.no.8571178 showing diffuse porous wood, in(a) and vescentric paratracheal parenchyma in(b), c, TLS showing pore, fibertracheid, parenchymatous cell and multiseriate ray cell in (c), in (d), d,e,f & g RLS showing upright ray cell in (d), oval perforation, inter -vesssel pit ,vessel-parenchyma pit in (e) spiral thickening in (f) and ray-vesssel pit in (g). Mgn. 150x (a,c,d), 600x(b,e,f,g)

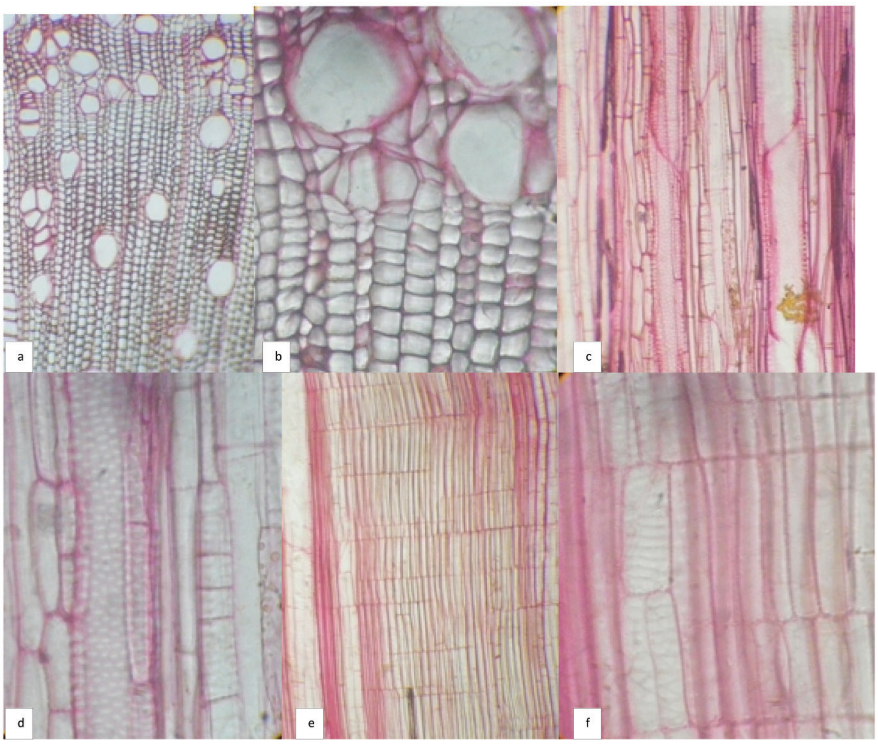

Figure 8: a & b. Cross section of *B.rotundifolia* var.pachyphylla no. 200610,showing diffuse porous wood, indistinct growth ring in (a), and marginal and scanty vescentric paratracheal and apotracheal parenchyma in(b), c & d, TLS showing septate fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (c), inter-vesssel pit and vessel-parenchyma pit and stranded parenchymatous cell jn(d), e & f ,RLS showing upright ray cell in (e), and ray vessel pit in (f). Mgn. 150x (a,c,e), 600x(b,d,f)

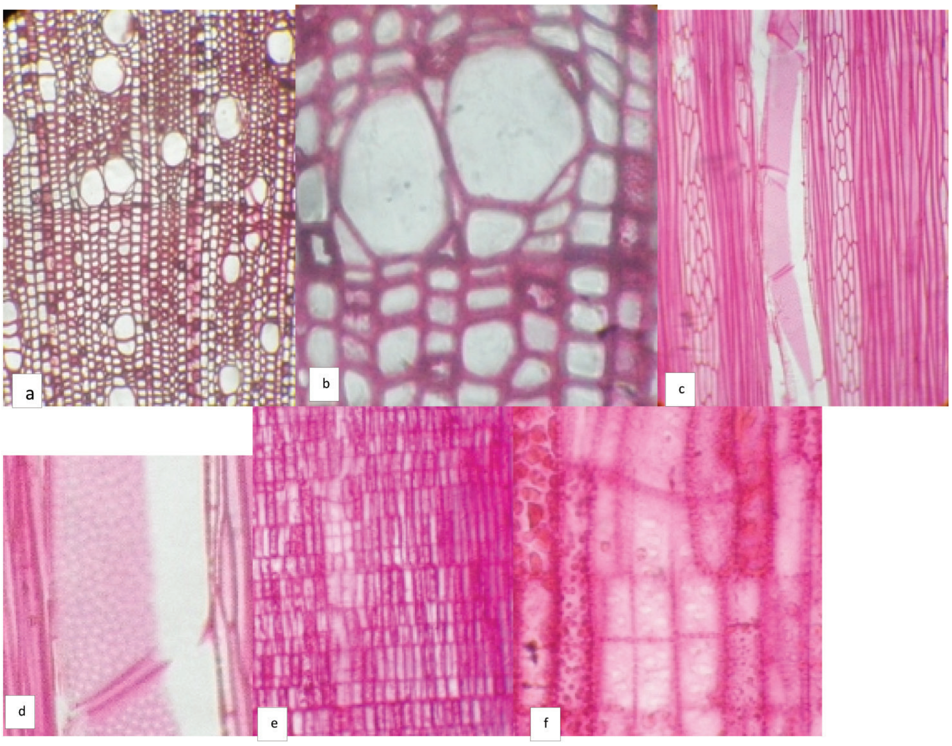

Figure 9: a & b. Cross section of *B.ternifolia* sp.no.200608 showing diffuse porous wood, growth ring in (a) and marginal,scanty vescentric paratracheal and apotracheal parenchyma in(b), c & d, TLS showing fibertracheid, parenchymatous cell and multiseriate ray cell in (c), inter-vesssel pit jn(d), e & f RLS showing upright ray cell in (e), and ray vessel pit in (f). Mgn. 150x (a,c,e), 600x(b,d,f)

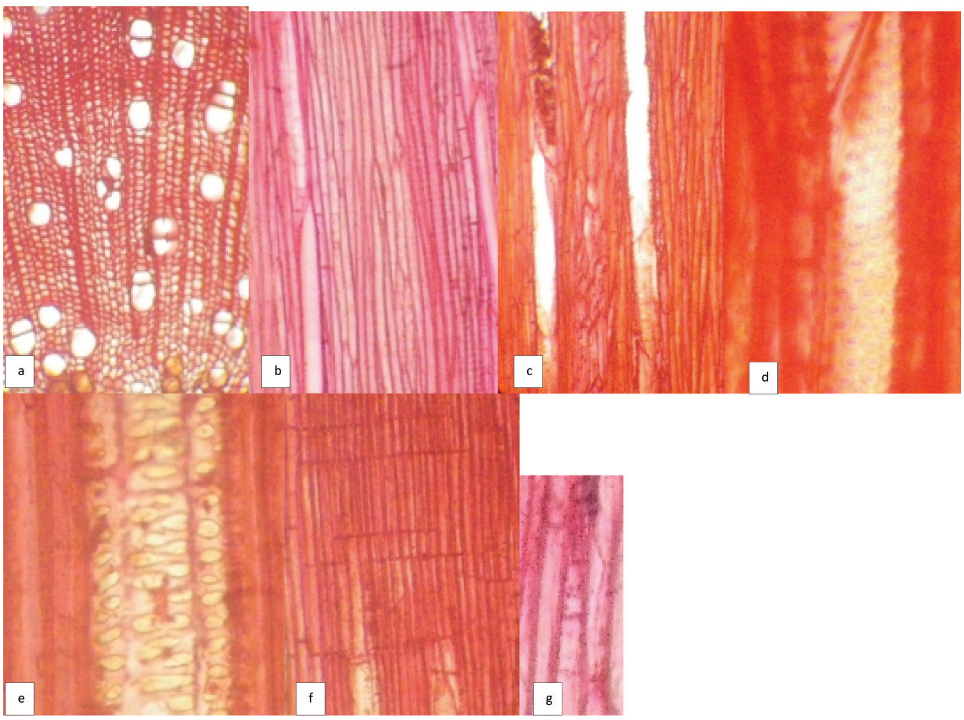

Figure 10: a, Cross section of *B.clidemioides* sp.no.6307137 showing diffuse porous wood, tyloses and scanty vescentric paratracheal parenchyma in (a), b,c d and e, TLS showing pore, fibertracheid, parenchymatous cell and uniseriate ray in (b), multiseriate ray cell in (c), inter-vessel pit in (d) and vessel-parenchyma pit in (e) f & g RLS showing upright ray cell in (f), and simple crystal in (g). Mgn. 150x (a,b,c,f), 600x(d,e,g)

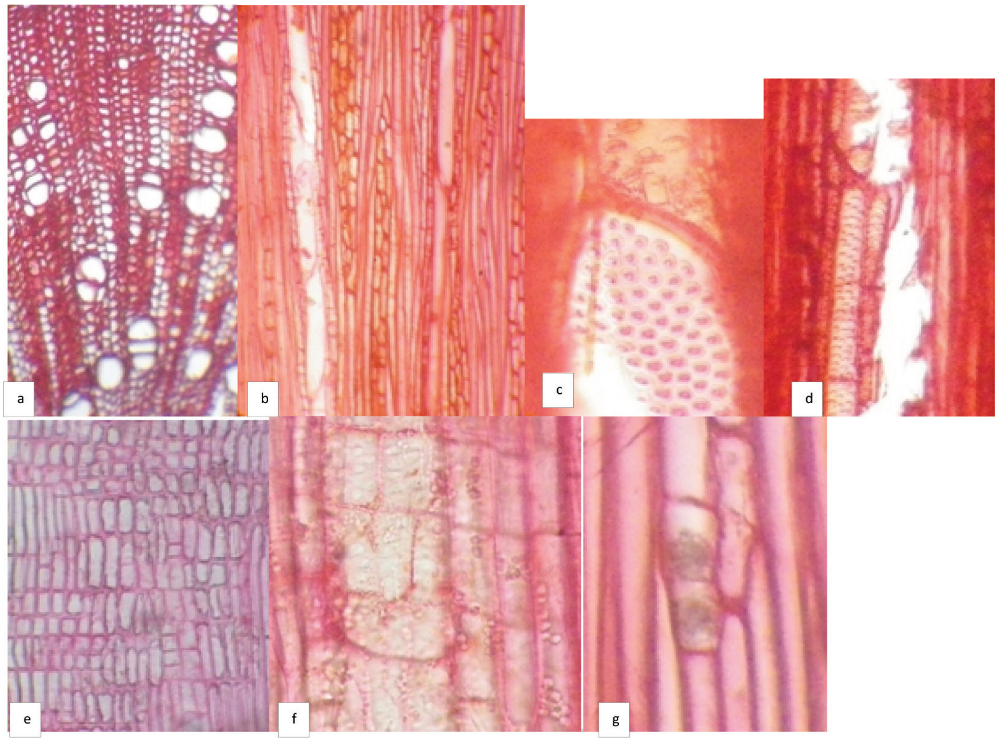

Figure 11: a , Cross section of *B.hamiltoniana* sp.no.630703 showing diffuse porous wood, scanty vescentric paratracheal parenchyma and uniseriate apotracheal parenchyma in(a), b,c ,d&g, TLS showing fibertracheid, parenchymatous cell and uni and multiseriate ray cell in (b), inter-vesssel pit in(c),vesselparenchyma pit jn(d) and cluster crystal in (g), e & f RLS showing upright ray cell in (e), ray vessel pit in (). Mgn. 150x (a,c,d,e), 600x(c,f,g)

Diversity of Naturalized Plant Species across the Land Use Types of Kathmandu District, Central Nepal

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Abstract

Biological invasions is one of the leading threats to biodiversity after habitat destruction. Rapid expansion of invasive plants in Nepal have threatened biodiversity, crop productivity, ecosystems as well as human health, and it has emerged as a new environmental problem in Nepal. The present study was conducted to explore the diversity of naturalized plant species across major land use types in Kathmandu valley. Altogether 18 plots of 10m × 10m were sampled with three replicate plots in six different land use types. A checklist of 90 vascular plant species was prepared; among them nearly half (41 spp.) were naturalized and ca.32% (13spp.) of these naturalized species were invasive alien plant species (IAPS). Among 13 IAPS, *Ageratum houstonianum* Mill.and *Lantana camara* L. had the highest frequency and coverage, respectively. Proportion of the naturalized species as well as the IAPS were higher in highly modified land use types with high disturbance (i.e., road side and grazing land) than in less disturbed natural land use types (i.e., *Pinus* forest and Mixed forest). Mean coverage of IAPS was the highest in road side. Overall, this study concludes that modified and highly disturbed land use types of the Kathmandu district were dominated by naturalized plant species (including both invasive alien plants and non-invasive naturalized) than natural land use types.

Keywords: Grazing land, Invasive alien plant species, Non-invasive naturalized plant species, Road side, Urban ecosystems

Introduction

Invasibility is the susceptibility of an environment to the colonization and establishment of individuals from species not currently part of the resident community (Davis et al., 2005). Species that have been transported from one region to another are defined as alien or exotic to that newly occupied region (Richardson et al., 2000). Most of these species fail to establish self-perpetuating populations, but those that do have become naturalized (Sax & Brown, 2000). Naturalized species serve as a pool of species from which some species turn out to be invasive (Senan et al., 2012). The alien plant species with self-regenerating population become problematic if they spread widely and cause significant negative impacts on native diversity and ecosystems (Sharma et al., 2005).

Biological invasions are impacting all components of ecosystem including biodiversity (Vila et al., 2011), at both local and global scales (Mack et al., 2000). The Invasive alien plant species (IAPS) are able to compete with native plants for resources, space and potential change in below and above ground environment of native plant community (Mack & D'Antonio, 2003). They bring changes in species richness, composition, growth and developments of native plants through altering soil biota. It also transforms diverse native community in to monoculture type vegetation dominated by single IAPS (Reinhart & Callaway, 2004).

As biological invasions is a worldwide problem, it becomes an increasing problem in case of Nepal too. The biological invasion has emerged as a new environmental problem in Nepal, with direct impact to biodiversity conservation, ecosystem services and economic development (Shrestha, 2019). The wide range of habitats and environmental conditions make Nepal especially vulnerable to the establishment of invasive species of foreign origin (Kunwar, 2003). In Nepal, 179 species of alien plants have been naturalized and 26 species turn out to become invasive (Shrestha et al., 2019). Four IAPS of Nepal; *Chromolaena odorata* (L.) R.M. King & H. Rob., *Eichhornia crassipes* (Mart.) Solms, *Lantana camara* L. and *Mikania micrantha* Kunth. are included in the list of hundred of the world's worst invasive species (Lowe et al., 2000).

Climate change, land use and human disturbance are major driving factors for invasiveness of alien plants (Hobbs, 2000). Land use change and disturbance are major factors which govern the biological invasions, whichpromote major changes in species composition and abundance (Jesse et al., 2018). Human activities like migrations, transportation, roadway construction, tourism and farming practices further favor the process of invasion (Vitousek et al., 1997). Together with these factors diversity of native species also play a major role in plant invasion, nearly 70% of the variation in exotic plant richness among sites around the world is explained by native richness (Lonsdale, 1999). Generally, a community with high diversity of native plant species is supposed to harbor less diversity of naturalized species and *vice versa* (Biotic Resistance hypothesis; Tilman, 1997).

There is a large data gap and paucity of information about the diversity of naturalized plant species across the land use types in our study area. The main aim of this research work is to address the data gap to some extent by identifying the land use types which are more prone to plant invasion by analyzing cover, frequency and percentage share of IAPS, native as well as non-invasive naturalized plants across the different land use types. Results of this study can play an important role for prioritizing management options to control biological invasions.

Materials and Methods

Study area

This study was carried out in the urban areas of Kathmandu district; a part of Bagmati province, Central Nepal. Study was conducted within the geographical range of 27° 39' 38.952"N - 27° 39' 57.1428"N latitude and 85° 17' 36.9636"E - 85° 17' 43.0728" E longitude (Figure 1).With the survey of valley, we identified six different land use types (road side, grazing land, agricultural land, *Pinus* forest, mixed forest and wetland), located in the same climatic and ecological region for vegetation sampling in Chovar, Balkhu, Kalanki and Tokha areas. The climate of the study area is sub-tropical type.

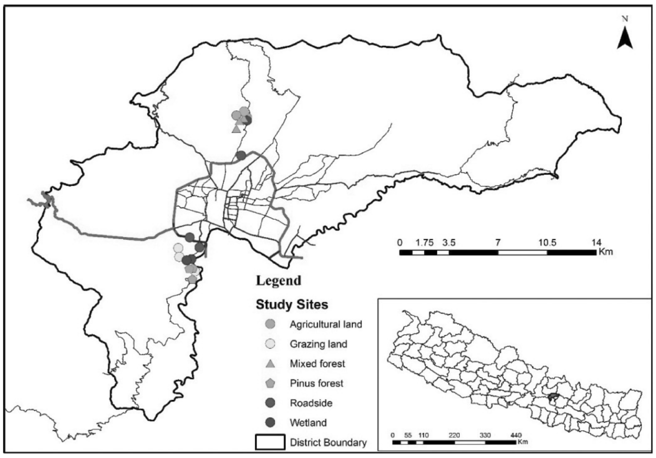

Figure 1: Map of the study area.

Due to comparatively low disturbance; *Pinus* forest, mixed forest and wetland were considered as comparatively less modified land use types, whereas, road side was considered as highly modified. Similarly, grazing land and agricultural land were also slightly modified land use types and agricultural land was seasonal fallow land, where farmer used the land for cultivation in one season and left the land fallow until the next season. We sampled the agricultural land during a fallow period after the harvest of a crop and before the cultivation of the next crop. Detail of individual land use types selected for the present study has been presented in Table 1.

Vegetation sampling

The present study was based on the field survey conducted during September and October of 2019. (10m×10m) sampling plot design was followed for Vegetation analysis across six different land use types. In each land use type, three replicate plots (10m×10m) were sampled; altogether 18 plots were sampled in six land use types. In each land use type, plot locations were chosen subjectively in

Table 1: Feature of the individual land use types selected for the present study.

Land use types	Location	Disturbance type	Dominant IAPS
Road side	Ringroad (Balkhu, Kalanki and Basundhara)	High vehicle movement and anthropogenic activities.	*Parthenium hysterophorus* L., *Lantana camara* L., *Xanthium strumarium* L.
Grazing land	Kritipur	Grazing of livestock as well as other anthropogenic disturbances.	*Parthenium hysterophorus* L., *Bidenspilosa* L., *Lantana camara* L.
Agricultural land	Tokha	Seasonal fallow land (anthropogenic disturbances).	*Ageratum houstonianum* Mill., *Bidenspilosa* L., *Ageratum conyzoides* L.
Pinus forest	Chovar	Undisturbed land use type; protected from livestock grazing, logging and other anthropogenic disturbances.	*Lantana camara* L., *Ageratina adenophora* (Spreng.) R.M. King & H. Rob., *Ageratum houstonianum* Mill.
Mixed forest	Tokha	Undisturbed land use type; protected from livestock grazing and logging.	*Lantana camara* L., *Ageratina adenophora* (Spreng.) R.M. King & H. Rob., *Ageratum houstonianum* Mill.
Wet land (Swamp area)	Balkhu and Tokha	Undisturbed land use type protected from anthropogenic disturbances	*Myriophyllum aquaticum* (Vell.) Verdc., *Alternanthera philoxeroides* (Mart.) Griseb., *Ageratum houstonianum* Mill.

topographically uniform areas, with adjacent plots at a distance of ca.50m. The geographic location (latitude, longitude and elevation) was measured by Global Positioning System (GPS) (model Garmin eTrex 10).

Collection, identification and categorization of vascular plants

Each vascular plants present within the 10m×10m plots were collected and cover of IAPS was also recorded on the basis of Daubenmire cover classification (Daubenmire, 1959). This technique classifies cover in to six categories as: 1) 0-5%, 2) 5-25%, 3) 25-50%, 4) 50-75%, 5) 75-95%, and 6) 95-100%, based on visual estimation method considering each plot as 100 percent. Collected plants were tagged and pressed properly and also field note of each collected plant was prepared. Furthermore, the plant species which were identified during field work were reconfirmed through different literature as well as expert consultation. Most of the species were identified by using appropriate manuals, flora and monographs, relevant taxonomic literature and online database. Flowering Plants of Makawanpur (Chapagain et al., 2016), Flora of China (http://www.efloras.org), tropicos (http://www.tropicos.org) were used for identification and catalogue of Life (http://www.catalogueoflife.org; last accessed on 4th June 2020) was followed for the accepted names. Some of the plants were also identified by comparing herbarium specimen at National Herbarium and Plant Laboratories, Lalitpur, Nepal. The dried specimens (naturalized only) were mounted on the herbarium sheet (43cm×29cm) together with herbarium level (15cm×10cm) and were deposited at National Herbarium and Plant Laboratories, Lalitpur, Nepal.

Identified species were further categorized as native, non-invasive naturalized and invasive ones. The species which were categorized as invasive according to Shrestha (2019) were considered as IAPS. Likewise, non-invasive naturalized were confirmed based on the list of 179 naturalized species of Nepal (Global Register of Introduced and Invasive Species (GRIIS) by Shrestha et al. (2019) and the species which are not included in GRIIS were categorized as native species for Nepal.

Numerical Analysis

Frequency of IAPS: Frequency of each IAPS in the study area (using data of all eighteen plots) was calculated according to Zobel et al. (1987), e.g. by dividing the number of plots in which species occurred by total number of plots and multiplying by 100.

Cover of IAPS: First of all, Daubenmire cover classification was converted in to cover percentage by using mid value of each cover class following Zobel et al. (1987). Cover calculation was done by using following formula:

Cover of individual species,

$$\text{Cover \%} = \frac{\text{Sum of mid value of cover class of particular species}}{\text{Total number of sampling plot}}$$

Mean cover of each land use type =

$$\frac{\text{Sum of cover of all IAPS in all replicate plot of a landuse}}{\text{Number of replicate plots}}$$

Results and Discussion

A total of 90 vascular plants were recorded in six different land use types of Kathmandu district. Among them, 13 were invasive alien plant species (IAPS) which accounted 50% of total IAPS of Nepal. The remaining 28 species were non-invasive naturalized species and 49 were native species (Table 2).

Percentage share of different categories and mean cover of IAPS across land use types

The highest percentage share of IAPS was found in road side (27%) followed by grazing land (24%) and the least percentage was found in *Pinus* forest (12%). Likewise, non-invasive naturalized contributed the highest percentage in grazing land (36%) followed by road side (32%) and the least contribution was found in *Pinus*forest (19%). Whereas, *Pinus* forest (69%) showed the highest percentage share of native species followed by mixed forest (65%) and the least percentage share of native plants was found in grazing land (40%) and road side (41%) (Figure 1).When cover of all IAPS was combined, road side had the highest cover (82%) followed by grazing land (77%) and agricultural land (74%) and it was the lowest in wetland (22%) (Figure 2).

Land use change causes fluctuation in the level of resources i.e. soil nutrients, light, water etc. which may facilitate plant invasion (Davis et al., 2000), therefore it is considered as the determining factor

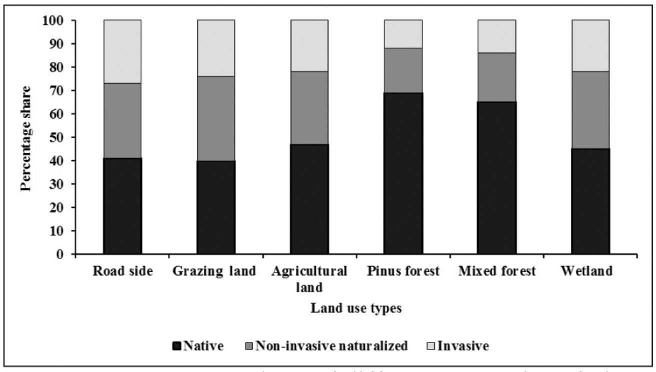

Figure 1: Percentage share of different categories of plants across different land use types.

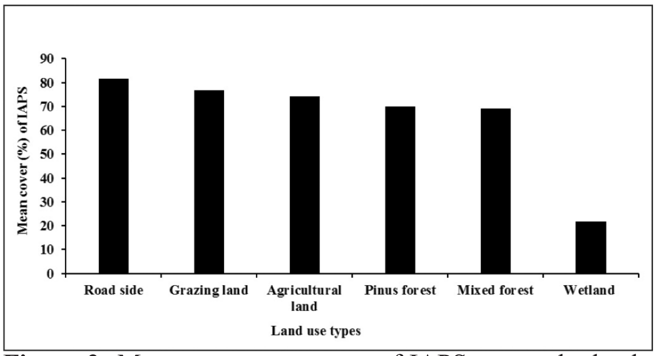

Figure 2: Mean cover percentage of IAPS across the land use types.

for the distribution of alien plant (non-invasive naturalized and invasive) species (Lonsdale, 1999). Among the six land use types studied, the highest percentage share of IAPS was found in road side followed by grazing land. A similar finding was also reported by Pauchard & Alaback (2004). Similarly, grazing land showed the highest percentage share of non-invasive naturalized species followed by road side. Both categories showed that road side and grazing land were colonized by a high number of naturalized species. Mean cover of IAPS also supported this finding as road side and grazing land had the highest cover of IAPS.

The more disturbed the vegetation is, higher the chances of occurrence of the IAPS in that area (Rastogi et al., 2015). In our study roadside and grazing land considered as moderately modified land use types; affected by various disturbance factors in terms of high vehicle movement, grazing intensity as well as other different anthropogenic factors. Such disturbances increase propagule pressure and ultimately increase the invasiveness (Rouget & Richardson, 2003). This was further supported by Parendes & Jones (2000), who concluded that nearer the distance from road, water resources and settlement area higher will be the chance of invasion.

Pinus forest contributed the least percentage of naturalized (IAPS and non-invasive naturalized) and the highest percentage of native species, this was also supported by biotic resistance hypothesis. According to this hypothesis a community with high diversity of native plant species is supposed to harbor less diversity of naturalized species and *vice versa* (Tilman, 1997).

Frequency and cover of IAPS

Among 13 recorded IAPS, *Ageratum houstonianum, Bidenspilosa* and *Lantana camara* were three most frequent species with ca.67, 62 and 56 frequency percentages, respectively. Whereas, *Myriophyllum aquaticum* and *Ipomoea carnea* subsp. *Fistulosa* (ca. 6% each) were the least frequent IAPS (Figure 3).

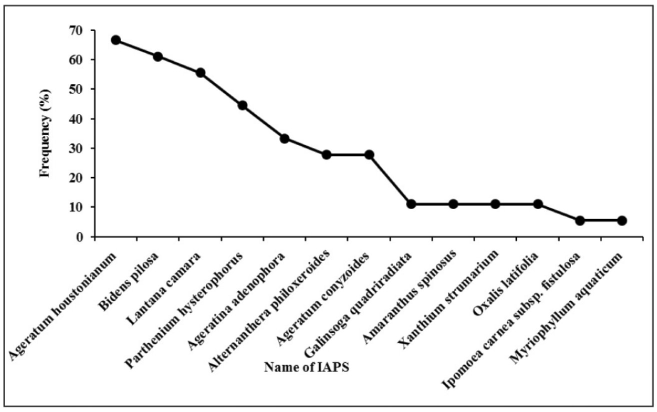

Figure 3: Frequency percentage of IAPS.

Lantana camara was the species with the highest coverage followed by *Parthenium hysterophorus* and *Ageratum houstonianum*, whereas, *Ipomoea carnea* subsp.*fistulosa* was the species with the least coverage (Figure 4).

Ageratum houstonianum was the most frequent species and was present in almost all plots. Prolific seed production and good dispersal ability (Lamsal et al., 2019) can be attributed to high frequency of *Ageratum houstonianum.* It has been reported that *Ageratum houstonianum* is one such problematic IAPS in Nepal with widespread distribution in the mid-hills and the plain areas along roadsides,

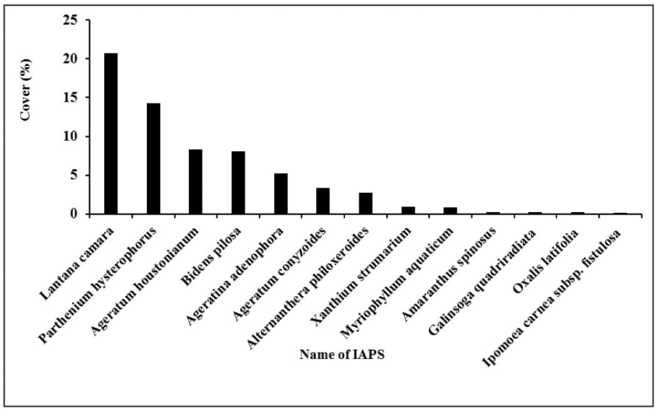

Figure 4: Cover percentage of IAPS.

protected national parks, agricultural fields, fallow lands as well as agro-ecosystem of Chitwan - Annapurna landscape (Shrestha et al., 2018). Production of high number of seeds is the important survival strategy of *Bidens pilosa*. A single plant species of *Bidens pilosa* can produce 3000-6000 seeds (Bartolome et al., 2013). Dhakal et al. (2018) also concluded *Bidens pilosa* as the second most frequent species in Siwalik regions of Nepal.

Myriophyllum aquaticum is a plant of stagnant or slow moving waters, rooting in shallow areas with emergent stems or floating stems extending over deeper water (Orchard, 1981). In our research, wetland is only one land use type suitable for the growth of this species, therefore *Myriophyllum aquaticum* is the least frequent IAPS (found near Balkhu area).

Lantana camara accounted for the high coverage among 13 recorded IAPS, followed by *Parthenium hysterophorus*. Various dispersal agents, easy dispersal pathway and strong root system (Priyanka & Joshi, 2013) might be the reason behind high coverage of *Lantana camara.* The roots of *Lantana camara* gives new flush even after repeated cuttings (Priyanka & Joshi, 2013). Relatively high coverage of *Parthenium hysterophorus* might be due to the ability of species to germinate and establish over a wide range of temperature and photoperiod of introduced habitat (Williams & Groves, 2006). In addition, high number of seed production per plant (20,000) and easy spread (Belgeri et al., 2012) further accelerates its abundance.

Conclusion

Altogether 90 vascular plant species were recorded from Kathmandu district, Central Nepal. Among them, nearly 54% were native and 46% were naturalized (13 spp. invasive and 28 spp. non-invasive naturalized). Highly modified and disturbed land use types such as road side and grazing land had high number and cover of IAPS as well as non-invasive naturalized as compare to natural and less disturbed habitat such as *Pinus* forest and mixed forest. *Ageratum houstonianum* was the most frequent species followed by *Bidens pilosa, Lantana camara* and *Parthenium hysterophorus*. Whereas, *Lantana camara* had the highest cover, followed by *Parthenium hysterophorus, Ageratum houstonianum* and *Bidens pilosa*. Those land use types which had high number of naturalized species including IAPS may serves as sources of propagules for further invasion. Therefore, such land use types should be monitored earlier as compared to those which have less number of naturalized species.

Author Contributions

All the authors were involved in data collection, concept development, research designing, defining of intellectual content and literature research. K. Gautam, Y. Gurung, S. Pokhrel, B. Shrestha, S. BK,S. Hitang, N. Shrestha and M. Bajracharya collected the data, whereasR. Paudel and G.D. Joshi collected and analyzed the data, and prepared manuscript.

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Table 2: Checklist of recorded vascular plants with their category from Kathmandu district

S.N.	Botanical Name	Category
1	*Parthenium hysterophorus* L.	I
2	*Bidens pilosa* L.	I
3	*Galinsoga quadriradiata* Ruiz. & Pav.	I
4	*Amaranthus spinosus* L.	I
5	*Alternanthera philoxeroides* (Mart.) Griseb.	I
6	*Ageratum houstonianum* Mill.	I
7	*Lantana camara* L.	I
8	*Ageratum conyzoides* L.	I
9	*Ipomoea carnea* sub sp. *fistulosa* (Mart.) ex Choisy D.F. Austin	I
10	*Xanthium strumarium* L.	I
11	*Ageratina adenophora* (Spreng.) R. M. King & H. Rob.	I
12	*Oxalis latifolia* Kunth.	I
13	*Myriophyllum aquaticum* (Vell.) Verdc.	I
14	*Eleusine indica* (L.) Gaertn.	N
15	*Justicia simplex* D. Don.	N
16	*Eragrostis pilosa* (L.) P. Beauv.	N
17	*Sigesbeckia orientalis* L.	N
18	*Achyranthes aspera* L.	N
19	*Cynodon dactylon* (L.) Pers.	N
20	*Solanum nigrum* L.	N
21	*Centella asiatica* (L.) Urb.	N
22	*Cuscuta cassytoides* Nees. ex. Engelm.	N
23	*Rumex nepalensis* Speng.	N
24	*Artemisia indica* Willd.	N
25	*Oplismenus burmanni* (Retz.) P. Beauv.	N
26	*Triumfetta rhomboidea* Jacq.	N
27	*Tectaria coadunata* (J.Sm.) C. Chr.	N
28	*Persicaria limbata* (Meisn.) H. Hara	N
29	*Ziziphus mauritiana* Lam.	N
30	*Digitaria ciliaris* (Retz.) Koeler	N
31	*Acmella paniculata* (DC.) R. K. Jansen.	N
32	*Spermadictyon suaveolen s*Roxb.	N
33	*Agave vivipara* L.	N
34	*Alnus nepalensis* D. Don.	N
35	*Rubia manjith* Roxb.	N
36	*Rubus ellipticus* Sm.	N
37	*Cassia fistula* L.	N
38	*Flemingia strobilifera* (L.) W.T. Aiton	N
39	*Syzygium cumini* (L.) Skeels.	N
40	*Urena lobata* L.	N
41	*Dalbergia sissoo* Roxb. ex. DC.	N
42	*Pinus roxburghii* Sarg.	N
43	*Calotropis gigantean* (L.) W.T. Aiton	N
44	*Diplazium esculentum* (Retz.) Sw.	N
45	*Falconeria insigis* Royle.	N
46	*Phyllanthus urinaria* L.	N
47	*Barleria cristata* L.	N
48	*Saccharum officinarum* L.	N
49	*Imperata cylindrica* (L.) P. Beauv.	N
50	*Athyrium cuspidatum* (Bedd.) M. Kato.	N
51	*Eragrostis tenella* (L.) P. Beauv. ex Roem & Schult.	N
52	*Pyracantha crenulata* (D. Don) M. Roem.	N

S.N.	Botanical Name	Category
53	*Globba racemosa* Sm.	N
54	*Plantago major* L.	N
55	*Lygodium flexuosum* (L.) Sw.	N
56	*Digitaria longiflora* (Retz.) Pers.	N
57	*Sida cordata* (Burm.f.) Borss.Waalk	N
58	*Cyperus brevifolius* (Rottb.) Hassk.	N
59	*Fimbristylis dichotoma* (L.) Vahl.	N
60	*Mangifera indica* L.	N
61	*Lyonia ovalifolia* (Wall.) Drude	N
62	*Crassocephalum crepidioides* (Benth.) S. Moore	NIN
63	*Datura metel* L.	NIN
64	*Trifolium repens* L.	NIN
65	*Sonchus asper* (L.) Hill.	NIN
66	*Amaranthus hybridus* L.	NIN
67	*Euphorbia hirta* L.	NIN
68	*Eclipta prostrate* (L.) L.	NIN
69	*Corchorus aestuan s*L.	NIN
70	*Sida cordifolia* L.	NIN
71	*Evolvulus nummularius* (L.) L.	NIN
72	*Drymaria cordata* (L.) Willd. exSchult.	NIN
73	*Solanum aculeatissimum* Moench.	NIN
74	*Erigeron Canadensis* L.	NIN
75	*Dactyloctenium aegyptium* (L.) Willd.	NIN
76	*Duranta erecta* L.	NIN
77	*Alternanther asessilis* (L.) R.Br. ex DC.	NIN
78	*Oxalis corniculata* L.	NIN
79	*Cestrum nocturnum* L.	NIN
80	*Solanum torvum* SW.	NIN
81	*Sida rhombifolia* L.	NIN
82	*Sida acuta* Burm. f.	NIN
83	*Grevillea robusta* A. Cunn. ex R. Br.	NIN
84	*Ipomoea nil* (L.) Roth.	NIN
85	*Euphorbia heterophylla* L.	NIN
86	*Axonopus compressus* (Sw.) P. Beauv.	NIN
87	*Oxalis corniculata* L.	NIN
88	*Psidium guajava* L.	NIN
89	*Paspalum distichum* L.	NIN
90	*Nasturtium officinale* W.T. Aiton	NIN

Note: I= Invasive, N= Native, NIN= Non-Invasive Naturalized

Field Survey of *Nardostachys jatamansi* in Manedada, Gaurishankar Conservation Area, Ramechhap, Nepal

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Abstract

Nardostachys jatamansi is one of the most traded species in Nepal. The present study was conducted to know the availability of *Nardostachys jatamansi* in Manedada, Gaurishankar Conservation Area. Sampling was done by quadrat method at four different altitudinal belts with 50 m difference in between the range from 3800-3950 m asl. Altogether 12 quadrats of 5 m × 5 m were laid down. The number of individuals of *N. jatamansi* and other associated species were counted. The frequency, density, cover and Importance Value Index (IVI) of all the species were determined. Ten individuals of *N. jatamansi* were uprooted from each 5 m × 5 m quadrat randomly, dried for one month and weight was measured. Furthermore, rhizome samples from all the quadrats were collected and mixed for the quantification of essential oil. *N. jatamansi* was the most frequent species in the study area. The density of the species ranged from 64 to 84 per square m with the highest cover ranging from 37% to 41% in the study area. The study area was found rich for *N. jatamansi* with an IVI ranging from 140.9 to 151.8. The collective weight of 10 rhizomes varied significantly with the elevation. The density, cover and rhizome weight were highest at 3850 m asl. The average essential oil content in the rhizome sample was 0.9 %. The richness of *N. jatamansi* in study area might be due to the restriction on the collection of the species by the authorities of Gaurishankar Conservation Area.

Keywords: CITES, Essential oil, Jatamansi, Outcrop, Population, Rhizome

Introduction

Sustainable harvesting practices for wild species have been encouraged globally as an important area for the future prospects (CBD, 2006; UN, 2008). Many dimensions like ecological, biological, sociocultural, political and economic are considered to achieve sustainable use of non-timber forest products (NTFPs) (Hutton & Dickson, 2001; Ghimire et al., 2005). The problems that are being faced in sustainable harvest are: lack of knowledge on management practices and estimation of harvest levels for long term persistence (Ticktin, 2004).

Nardostachys jatamansi (D.Don) DC. (Syn. *Nardostachys grandiflora* DC., local name: Jatamansi) is one of the highly traded species belonging to the family Caprifoliaceae. It is a perennial herb growing in rocky slopes, rock outcrops, meadows, shrub land and forests of Himalayan region from 3200 to about 5000m asl in Nepal (Press et al., 2000; Ghimire et al., 2008). Herbarium deposition in National Herbarium and Plant Laboratories (KATH) and Tribhuvan University Central Herbarium (TUCH) shows that the *N. jatamansi* is distributed in 21 districts of Nepal, while the five-year management plan of Division Forest Office shows its distribution in 28 districts of Nepal (Ghimire & Dhakal, 2019).

N. jatamansi is prioritized by Government of Nepal for research and economic development (DPR, 2017). It is also a major species among 13 prioritized NTFP species by Government of Nepal for Agro-technology development (DPR, 2017). Recently, the various programs for its cultivation have been promoted in Nepal (DPR, 2019). It is one of the important commodities for supporting the livelihood of rural people of mountainous regions in Nepal.

N. jatamansi has been enlisted in Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES) appendix II in 1997 as its population has been declining due to over exploitation, overharvesting of its rhizome for commercial trade throughout its range countries

(India, Nepal, Bhutan) (Mulliken, 2000). The Forest Regulations, 1995 has banned to export the species from Nepal which was amended in 2001 and allow the export of the species in processed form (Nepal Gazette, 2001). Since then, the semi-processed products (essential oil and marc) from rhizomes have been exporting to different countries. The average annual export of Jatamansi marc in the period (2013-2017) was about 253.8 tons (Ghimire & Dhakal, 2019). CITES Secretariat, Geneva as well as Control of International Trade of Endangered Wild Fauna and Flora (CITES) Act, 2017 of Nepal had again banned the trade of Jatamansi in 2017. In 2019 after the submission of Non-detrimental findings (NDF) of Jatamansi to CITES Secretariat, CITES Secretariat, Geneva had provided quota (382.7 tons dry weight of rhizome) as mentioned in the Non-detrimental findings for the export. Now Nepal can only export Jatamansi marc and oil equivalent to 382.7 tons of dry rhizome. NDF is a conclusion provided by a Scientific Authority that the export of specimens of a particular species will not impact negatively on the survival of that species in the wild. The non-detriment finding of each traded species should be prepared by Scientific Authority before an export or import permit granted for a specimen of an Appendix-I and II species (CITES). NDF is based on the best available scientific information. Population status is one of the key indicators of NDF. Status of the *N. jatamansi* population had been studied in few *N. jatamansi* resource districts of Nepal (Ghimire et al., 1999; Chhetri & Gautam, 2015; Shrestha & Shrestha, 2012).The main objective of the current study was to know the availability of *Nardostachys jatamansi* in Gaurishankar Conservation Area. This study has been conducted to support the preparation of NDF of *N. jatamansi*.

Materials and Methods

Study area

The study was conducted in west facing slope of Manedada of Chipleni Protected Forest, Gokulganga Rural Municipality-1, Ramechhap district, Central Nepal in October 2019. It lies in Gaurishankar Conservation Area (GCA), one of the protected areas of Nepal (Figure 1). GCA covers an area of 2,179 sq. km encompassing 2 Municipalities and 8 Rural Municipalities (RM) of three districts, Sindhupalchok, Dolakha and Ramechhap of Bagmati province of the country. GCA is rich in biodiversity which comprises of 16 major vegetation types of subtropical to alpine vegetation and harbors 565 plant species (NTNC, 2010).

Manedada is the trekking route of Jatapokhari and Panchpokhari. The Gokulganga RM ranges in the altitudinal gradient of 2000 to 4500 m asl which comprises the area of 198 sq. km, a population of 20,074, and major ethnic groups are Sherpa, Chhetri, Newar, and Kami (CBS, 2011). The area was found rich for medicinal and non-timber plants like *Aconitum spicatum* (Bikh), *Giradiana diversifolia* (Allo), *Cautleya spicata* (Gagleto), *Edgeworthia gardneri* (Argeli), *Artimisia vulgaris* (Titepati) etc.

Short questionnaire and interaction were carried out with local people and with key informants to know the status, trade and conservation attempts for high value medicinal plants with special focus on *N. jatamansi.*

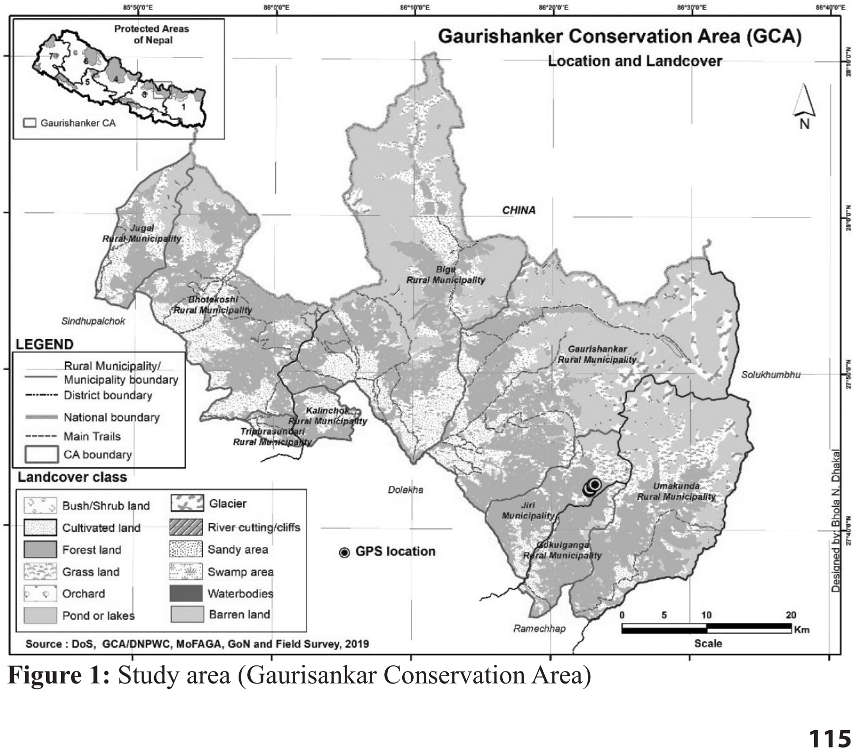

Figure 1: Study area (Gaurisankar Conservation Area)

Sampling method

N. jatamansi rich area at the study site was identified by the interaction with local people. Known sites were sampled by quadrat methods following Zobel et al. (1987). *N. Jatamansi* was found from 3800 at the study site. Thus, four different altitudinal belts with difference of 50 m in the range at 3800-3950 m asl were selected for sampling (Figure 2). Due to physical constriction and discontinuous distribution of *N. Jatamansi*, three plots of 5 m × 5 m at purposive were made at each altitudinal belt. Then three small quadrats of 1 m × 1 m were laid down randomly in each plot. Individuals of *N. jatamansi* and other associated species in each small quadrat were counted. Percentage cover of each species in the quadrat was measured. Frequency (F), relative frequency (RF), density (D), relative density (RD), cover and relative cover (RC) were determined following Zobel et al. (1987). Individuals of *N. jatamansi* were not observed at 3950 m. Soil samples were collected from each plot and the pH of mixed soil sample was measured using pH meter. Ten individuals of *N. jatamansi* were uprooted from each 5 m × 5 m plots randomly, all the rhizomes were separated and packed in the news paper and brought into the laboratory. They were shade dried for one month and collective weight of 10 individuals was measured using a digital balance. Furthermore, more rhizome samples from all the quadrats were collected and mixed for the quantification of essential oil.

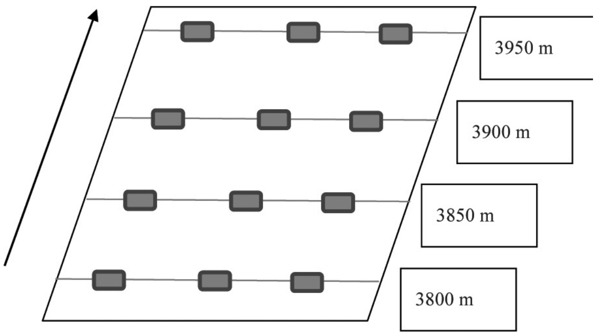

Figure 2: Schematic sampling design for plant survey of *Nardostachys jatamansi*.

Quantitative analysis

The density, frequency, and abundance of tree species, shrubs and herbs were determined with the following formula as per Zobel et al. (1987).

(a) Frequency (%) = Number of quadrats in which the species occurred × 100 / Total number of quadrats studied.

Relative frequency = Frequency of the species A / Total frequency of all species × 100

(b) Density / m^2= Total number of individuals of a species in all quadrats / Total number of quadrats studied

Relative density = Number of individuals of the species A measured / Total number of individuals of all the species × 100

(c) Cover: It was estimated by visual estimation method.

Relative cover = Cover of the species A / Total cover of all the species × 100

d) Importance Value Index: This index was calculated by summing the percentage values of the relative frequency, relative densities and relative cover.

Extraction and quantification of the Essential oil

Five hundred gram of fresh weight of rhizome was taken randomly from the study sites. It was dried in shade for one month. All the waste material were removed and again weighed. The essential oil content in the dried sample was extracted by hydro distillation method using the Clevenger apparatus which was repeated three times for the sample. The volume in ml of the oil was taken at room temperature.

Statistical analysis

One-way ANOVA was performed to test the significance difference of means for the weight of 10 rhizomes among the elevation belt, and Fisher's Least Significant Difference (LSD) post hoc comparisons were also performed using Statistical Package of Social Sciences (SPSS version 20.0.0).

Results and Discussion

The collective weight of 10 rhizomes varies significantly with the altitude ($P<0.001$) (Figure 3). The weight of rhizome was found higher at the altitude 3850 m asl. There was the presence of more bushy shrubs like *Rhododendron anthopogon*, *R. lepidotum* at 3850 m asl which could have added more moisture and fertility to the soil. Moist and fertile soil might have led to the accumulation of more weight to the rhizomes of *N. jatamansi* which is also supported by Larson (2002). According to Larson (2002) abiotic factors may have a large impact on yield.

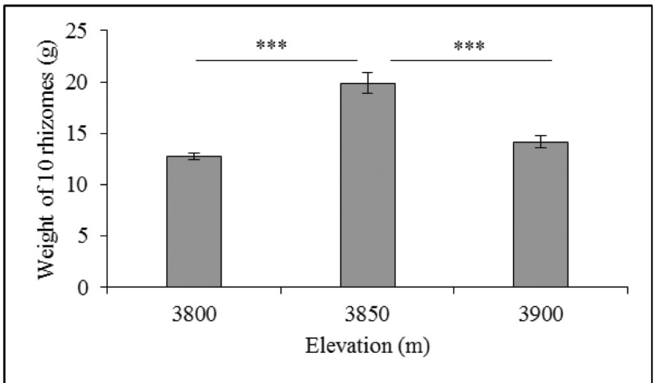

Figure 3: Weight of rhizome along various altitudinal belts. Values are means (n = 3) ± SD. Data were analyzed with one-way ANOVA and LSD post hoc comparisons; ***p < 0.001.

N. jatamansi was the most frequent species in the study area except at 3800 m asl. The density of the species ranged from 64 to 84 per m^2 with the highest cover ranging from 37% - 41% in the study area (Table 2). The highest density and the cover were reported from 3850 m asl (Table 2). The study area was found rich for *N. jatamansi* with an Importance Value index (IVI) ranging from 140.9 to 151. 8. Likewise, *Potentilla microphylla, Rhododendron lepidotum, Euphorbia stracheyi*, *R. setosum* were dominant species in the study area (Table 2). The highest value of *N. jatamansi* might be due the favorable slopes and grassland for it. Also, the restriction on the collection of the species by the authorities of GCA might be the reason for

Table 1: Status of *N. jatamansi* in each plot at various altitudinal belt.

Altitude (m asl)	Plot (5 m×5 m)	Density/m^2	Weight of 10 rhizomes (g)
3800	P1	5.7	12.7
	P2	131.7	12.4
	P3	106	13.1
3850	P4	25	20.9
	P5	111.3	18.9
	P6	116.7	19.8
3900	P7	29	13.6
	P8	56.7	14.1
	P9	107.7	14.8
3950	P10	0	0
	P11	0	0
	P12	0	0

Table 2: Summary of frequency, density and cover of the species in various altitudinal belt

S. N.	Name of species	3800 m asl			3850 m asl			3900 m asl		
		Frequency (%)	Density/ m^2	Cover (%)	Frequency (%)	Density/ m^2	Cover (%)	Frequency (%)	Density/ m^2	Cover (%)
1	*Nardostachys jatamansi* (D.Don) DC	88.89	81.11	37.69	100.00	84.33	41.12	100.00	64.44	37.06
2	*Rhododendron lepidotum* Wall. ex G. Don	66.67	1.33	20.66	44.44	0.56	6.59	44.44	0.44	7.76
3	*R. anothopogon* D.Don	11.11	0.11	1.33	0.00	0.00	0.00	0.00	0.00	0.00
4	*R. setosum* D.Don	33.33	0.33	3.80	33.33	0.56	7.05	66.67	0.78	11.42
5	*Euphorbia stracheyi* Boiss	55.56	0.78	1.27	11.11	0.22	0.44	11.11	0.11	0.48
6	*Aconitum spicatum* (Brühl) Stapf	22.22	0.44	0.41	0.00	0.00	0.00	0.00	0.00	0.00
7	*Anaphalis contorta* (D. Don) Hook. fil.	33.33	0.67	0.91	0.00	0.00	0.00	0.00	0.00	0.00
8	*Gentiana depressa* D.Don	0.00	0.00	0.00	0.00	0.00	0.00	33.33	1.22	1.81
9	*Potentilla microphylla* D.Don	100.00	3.56	7.29	100.00	2.44	7.07	66.67	0.89	2.05
10	*Rehum* sp.	0.00	0.00	0.00	33.33	0.33	6.95	0.00	0.00	0.00
11	*Circium* sp.	33.33	0.44	0.64	55.56	1.56	2.98	66.67	1.11	2.79
12	Grass (Common name - Chake)	100.00	4.56	25.98	100.00	4.00	27.78	100.00	5.44	36.62

Table 3: Importance Value Index (IVI) of the species in various altitudinal belt

S. N.	Name of species	3800 m asl				3850 m asl				3900 m asl			
		Relative Frequency	Relative density	Relative cover	IVI	Relative Frequency	Relative density	Relative cover	IVI	Relative Frequency	Relative density	Relative cover	IVI
1	*Nardostachys jatamansi* (D. Don) DC	16.33	86.90	37.69	140.92	20.93	89.72	41.12	151.76	20.45	86.57	37.06	144.09
2	*Rhododendron lepidotum* Wall. ex G. Don	12.24	1.43	20.66	34.33	9.30	0.59	6.59	16.49	9.09	0.60	7.76	17.44
3	*R. anothopogon* D. Don	2.04	0.12	1.33	3.49	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
4	*R. setosum* D. Don	6.12	0.36	3.80	10.28	6.98	0.59	7.05	14.62	13.64	1.04	11.42	26.10
5	*Euphorbia stracheyi* Boiss	10.20	0.83	1.27	12.31	2.33	0.24	0.44	3.01	2.27	0.15	0.48	2.91
6	*Aconitum spicatum* (Brühl) Stapf	4.08	0.48	0.41	4.97	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	*Anaphalis contorta* (D. Don) Hook. fil.	6.12	0.71	0.91	7.75	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	*Gentiana depressa* D. Don	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	6.82	1.64	1.81	10.27
9	*Potentilla microphylla* D.Don	18.37	3.81	7.29	29.47	20.93	2.60	7.07	30.60	13.64	1.19	2.05	16.89
10	*Rehum* sp.	0.00	0.00	0.00	0.00	6.98	0.35	6.95	14.28	0.00	0.00	0.00	0.00
11	*Circium* sp.	6.12	0.48	0.64	7.24	11.63	1.65	2.98	16.27	13.64	1.49	2.79	17.92
12	Grass (Common name - Chake)	18.37	4.88	25.98	49.23	20.93	4.26	27.78	52.97	20.45	7.31	36.62	64.39

its high IVI. It shows that the area is rich for high value medicinal plants like *N. jatamansi*, *Aconitum spicatum*, and aromatic *Rhododendron* species too.

The average pH of soil was found to be 6.6.

Essential oil percentage

The average essential oil of the rhizome sample was found to be 0.9 % (Table 4) which is lower than the essential oil extracted from the rhizome sample from Jumla (1.52%) and Humla (1.9%) collected in same month (Kadel, 2011). Similarly, the rhizome sample collected from Lauribina (3900m) in October yield 2% essential oil (Pradhan & Paudel, 2014). The variation in oil percentage could be drying periods and their quality as well as geographical location.

Though the *N. jatamansi* is not common in the study area, the occurrence of the plants in the known pocket area is adequate. West facing slope was found to be the most favorable for *N. grandiflora* in the study area. Larsen (2002) and Ghimire (1999) also reported *N. Jatamansi* at about 3800 m on west facing slope of Chaudabise Valley, Jumla and Ponger lake site, Manang with representative abundance. According to the local people, rhizome of *N. jatamansi* has not been harvested extensively since last ten years for trade. Hence, based on our survey and local perception, it can be said that the study site is the pocket area for *N. jatamansi*. Yet, if the collection of the *N. jatamansi* is opened for trade, only 10% rhizome harvesting should be allowed in five-year rotation period as the size of rocky outcrop populations would return to initial values within 5 years, only after 10% rhizome harvesting (Ghimire et al., 2008).

Conclusion

From the study we can conclude that the study site is rich for Jatamansi population due to undisturbed habitat. Essential oil content is comparatively lower than other places like Jumla, Humla, Rasuwa. This indicates the quality of rhizome at this site is not so better.

Table 4: Essential oil (%) of dry rhizome of *Nardostachys jatamansi*

Fresh wt. of Rhizome including debris (g)	Dry wt. of cleaned rhizome (g)	Decrease in weight (%)	Oil (%)
500	141.5	71.7	0.9

Author Contributions

First author was involved in concept development, research designing, literature review. All Authors collected the data. Statistical analysis was done by second author. First author, second author and fourth author analysed data, and prepared manuscript. First author and second author edited and reviewed the manuscript. Kalpana Sharma (Dhakal), as a corresponding author, is the guarantor for this article.

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Effects of Slope Aspect on *Ageratina adenophora* (Spreng.) King & H. Rob. Density and Galls Formed by Its Natural Enemy *Procecidochares utilis* Stone, 1947 in Makwanpur, Nepal

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Abstract

A forest killer plant, *Ageratina adenophora* (Spreng.) King & H. Rob., has become a highly problematic weed in Nepal. Its control and management is a challenging issue. Studies on different factors that impact on its invasiveness are still deficient. On the other hand, assessment of its biological control agent, the *Procecidochares utilis* Stone, 1947 in Nepal remains untouched. This study aims to analyze the impacts of slope aspect on *A. adenophora* density and the galls formed by *P. utilis* in Central Nepal. The study revealed that the slope aspect influences the *A. adenophora* plant density, number of gall-bearing plants and gall density. These parameters were the highest in the south-east facing slope comparing to the north-west facing slope indicating that the infestation by *P. utilis* depends on the aspects. The findings of this study will have significance in developing management strategies for *A. adenophora* with the application of *P. utilis* as a biological control agent in Nepal.

Keyword: Biocontrol agent, Biological control, Forest killer plant, Gall fly, Invasive alien species, Kalo banmara

Introduction

Ageratina adenophora (Spreng.) King & H. Rob., commonly called the '*forest killer plant*' or '*Kalo Banmara*' in Nepali, is one of the naturalized invasive alien species in Nepal (Tiwari et al., 2005). It is a member of the family Asteraceae and a perennial herbaceous plant having a height of about 1-3 m. It has severely colonized different habitats such as fallow lands, agroecosystems, roadsides, degraded areas and forests (Tiwari et al., 2005; Thapa et al., 2015; Poudel et al., 2019). Its distribution range is tropical to lower temperate region throughout the country (Shrestha, 2016). It has been recognized as a noxious invasive alien plant throughout the world as it has wide negative impacts on the native ecosystems. For example, it can alter soil physicochemical and biological properties, and has broader negative impacts on native biodiversity (Tiwari et al., 2005; Balami et al., 2017, 2019; Poudel et al., 2019; Thapa et al., 2017; 2020a; 2020b).

Several eco-geographical factors such as elevation, native species diversity and distribution, canopies of trees, disturbances and soil moisture are reported as the factors affecting distribution and abundance of *A. adenophora* (Thapa et al., 2016; Yang et al., 2017). However, information on the relationship between biotic/abiotic factors and *A. adenophora* invasiveness is still limited. On the other hand, the control and management of this plant is a challenging issue (Wan et al., 2010). Its minute and easily dispersible seeds, long-term seed bank in the soil, fast germination and growth rate, vegetative mode of reproduction and good adaptability in varied conditions of soil and habitats are the key characteristics responsible for its rapid colonization in novel range (Wan et al., 2010). Several methods have been proposed and implemented in different parts of the world for its control and management. Several physical, chemical and biological methods of control and management of *A. adenophora* are recommended (Poudel et al., 2019). Among them, biological control using *Procecidochares utilis* Stone, 2047, a natural enemy of this plant, has been proven to be one of the most promising methods, as this method is not only natural and environment-friendly, but also cost-effective.

P. utilis (Diptera: Trypetidae), an insect, is a natural enemy of *A. adenophora* found in its native range (Heystek et al., 2011). It forms galls in the stem of the plant and therefore it is called as the gall fly. The larvae of the insect grow inside the gall and due to the galls, the plants become stunted, the number of flowers and seeds are reduced, and ultimately, plants may even die (Bennett & Van Staden, 1986). The environmental and invasion biologists have given much attention to the application of *P. utilis* as the biological control agent of *A. adenophora.* This insect has been introduced to many countries such as New Zealand, Australia, South Africa, China etc. (Kluge, 1991). Successful control of *A. adenophora* by this agent has been reported from Hawaii, USA but the effective results from other countries including India and China are yet to be confirmed (Buccellato et al., 2012; Yang et al., 2017).

In the context of Nepal, Balami & Thapa (2017) have initiated damage assessment in leaves of *A. adenophora* and compared the damage with native *A. nepalensis* but they have not focused on the damage caused by the *P. utilis* galls. Shrestha (2016) highlighted that *P. utilis* has spread all over Nepal but its damage level is insignificant. Some of the studies showed that the elevation gradient (Poudel et al., 2020) and moisture conditions (Goeden, 1978; Li et al., 2006) affect the galls forming activities. The in-depth investigation regarding other factors, which have positive or negative impacts on the galls, is yet to be explored. The knowledge of such factors affecting *P. utilis* and its galls in *A. adenophora* could have a great contribution to the application strategies of biological control agents. In this study, we have investigated whether there are effects of slope aspect on the density of *A. adenophora* and the galls formed by *P. utilis* in an invaded community forest of Makwanpur district, Bagmati Province, Nepal.

Materials and Methods

Study site

This study was conducted in Takhtar Community Forest at Thaha Municipality-9, Chitlang of Makwanpur district (Bagmati Province), Nepal (Figure 1). The forest (27°24'59.99"N and 85°01'60.00"E, elevation 1750 to 1900 m asl) lies behind the famous Chandragiri hill about 22 km from the capital city Kathmandu towards the south-western part of Kathmandu valley. The community forest covers an area of about 158 ha and expands from south-east to north-west slope. Each of the slope aspects of the forest is disturbed by anthropic activities such as lopping, trampling and grazing. Both the slope aspects are therefore heavily invaded by invasive *A. adenophora* (personal observation).

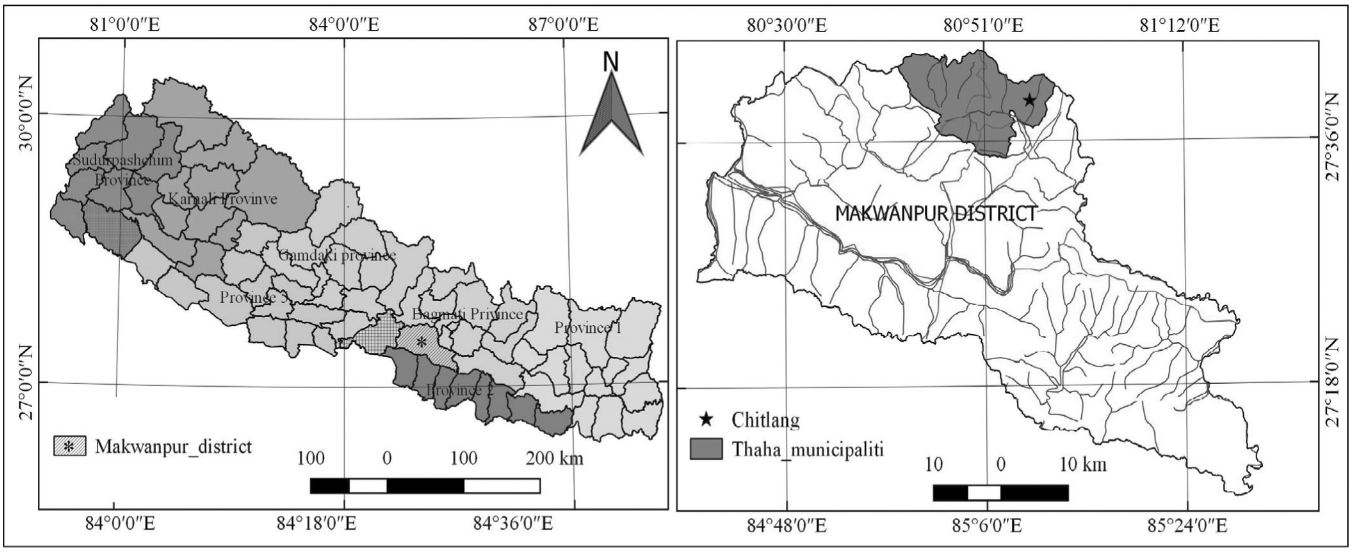

Figure 1: Study area map, Makwanpur district, Bagmati Province, Nepal.

The north-east slope was denser in terms of number of trees and the canopy gap was lesser than the south-east slope. The lower belt of the forest was the mixed type where *Morella esculenta* (Buch.-Ham. ex D. Don) I. M. Turner, *Schima wallichii* (DC.) Korth., *Lyonia ovalifolia* (Wall.) Drude, *Berberis aristata* DC., *Rubus ellipticus* Smith, *Viburnum* spp. were the major plant species. The upper belt of the forest was dominated by Pine trees.

Quadrat sampling

A total of 40 quadrats of size 1×1 m^2 each were sampled in the *A. adenophora* invaded sites of the community forest. Out of 40 quadrats, 20 quadrats were sampled at each of south-east and north-west aspects of the forest. In each aspect, five parallel transects of length about 20 m each were laid and in each transect, 4 quadrats were sampled. The length of each transect was 20 m and the distance between the two adjacent transects was 10 m. The distance between the two adjacent quadrats was at least 5 m.

Gall assessment

In each quadrat sampled, the number of individual plants of *A. adenophora* (erect stems from rootstocks) was counted as the density per plot. The number of plants having galls formed by *P. utilis* was counted from each plot. The number of galls per plot and per plant were also calculated.

Statistical analysis

The densities of *A. adenophora,* numbers of gall bearing plants per quadrat and the numbers of galls per plant in south-east and north-west facing slopes of the study site were compared using independent sample t-test. Mann-Whitney U-test was applied to compare the total number of galls per quadrat as the data were not normally distributed. The software R (version 4.0.3) was used for the analysis. The *p*-value <0.05 was considered for the significant differences in the mean value.

Results and Discussion

The density of *A. adenophora* in the south-east facing slope of the Takhtar Community Forest was greater than in the north-west facing slope. The number of *A. adenophora* in the south-east slope was 79.45±5.34 individuals/quadrat while the number was 57.55±3.54 individuals/quadrat in the north-west facing slope (t = 3.414, df = 38, p = 0.001, Figure 2).

The densities of gall bearing individuals of *A. adenophora* (number of gall bearing plants/quadrat) in the south-east and north-west facing slopes differed significantly. In the south-east facing slope, the number of gall-bearing plants was the highest i.e. 12.2±1.45 plants/quadrat whereas there were 6.6±0.57 gall bearing plants/quadrat in the north-west facing slope (t = 3.595, df = 38, p < 0.001, Figure 3). The gall-bearing plants in the south-east aspect was 15.36±1.64% while in the north-east aspect the gall-bearing plants were 11.47±1.62% (df = 38, t = 1.51, p = 0.056; Table 1).

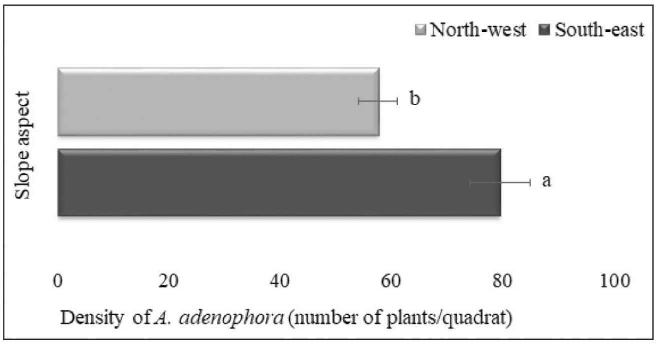

Figure 2: Densities of *A. adenophora* in south-east and north-west facing slopes in Takhtar Community Forest, Chitlang, Makwanpur, Nepal. Different letters to the right of the error bars indicate significant difference at 5% level of significance as determined by independent sample t-test.

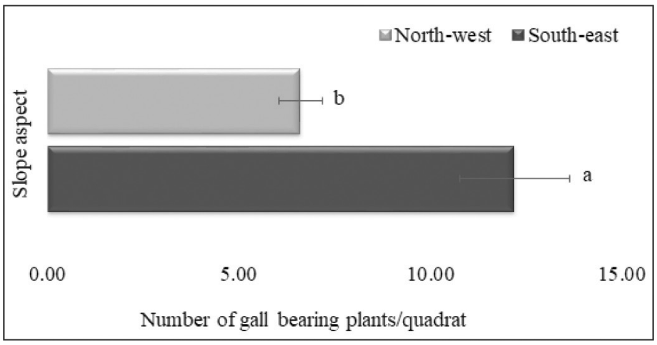

Figure 3: Number of gall-bearing plants in the south-east and north-west facing slopes of Takhtar Community Forest, Chitlang, Makwanpur, Bagmati Province, Nepal. Different letters to the right of the error bars indicate significant difference at 5% level of significance as determined by independent sample t-test.

Table 1: Percent of gall-bearing plants/quadrat in Takhtar Community Forest, Chitlang, Makwanpur, Bagmati Province, Nepal

S.N.	No. of Plant/quadrat	Total gall plant/quadrat	% of gall plants/quadrat
South-east	79.45±5.35	12.2±1.45	15.36±1.64
North-west	57.55±3.54	6.6±0.57	11.47±1.62

Similarly, the number of galls formed by *P. utilis* per quadrat (gall density) also differed by the slope aspects. The number of galls per quadrat was the highest in the south-east facing slope that was 14.35±1.7 while there were only 7.9±0.73 galls/quadrat in the north-west facing slope (U = 79.5, p = 0.001, Figure. 4a). However, the numbers of galls per plant per quadrat in the two slope aspects did not show any significant difference. The number of galls per plant in the south-east and north-west facing slopes were 0.19±0.021 and 0.15±0.021 galls/plant/quadrat, respectively (Figure 4b, t = 1.28, df =38, p = 0.214).

The results of our study showed that the density of *A. adenophora* (erect stems from rootstocks) differs with the slope aspect. The density was high in the south-east facing slope than the north-west facing slope of the studied forest (Figure 2). Similarly, the densities of gall bearing plants (number of gall bearing erect stems/quadrat) and galls (number of galls/quadrat) were also affected by the slope aspect. Both of these parameters were high in the south-east facing slope (Figures 3 and 4) but, interestingly, the number of galls per plant per quadrat was similar in both types of slope aspects (Figure 4b).

As the *A. adenophora* is one of the aggressively invading alien species in all types of habitats such as roadside, fallow lands, and forests in different physiographic zones (Tiwari et al., 2005; Thapa et al., 2016; Poudel et al., 2019), it is interesting and essential to observe various factors affecting its distribution and abundance. Such studies would have great significance in understanding the invasion behavior of *A. adenophora* and the information could be useful for developing strategies for its control and management. In the context of having limited information regarding the effects of topographic factors on *A. adenophora,* this study has revealed that, in the area under study, the south-east slope may be more suitable for luxuriant growth of *A. adenophora* in comparison to the north-west slope.

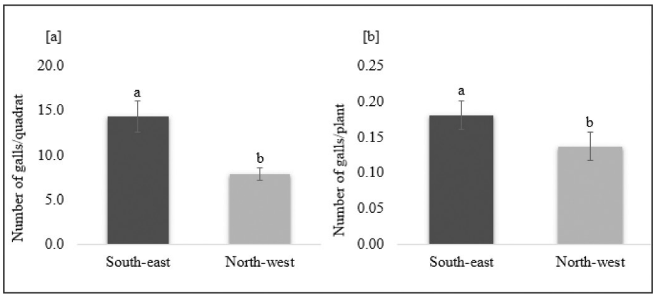

Figure 4: Numbers of galls per quadrat (gall density) [a] and numbers of galls per plant per quadrat [b] in the south-east and north-west facing aspects of Takhtar Community Forest, Chitlang, Makwanpur, Bagmati Province, Nepal. Different letters above the error bars indicate significant difference at 5% level of significance as determined by Mann-Whitney U-test in Figure 4a and independent sample t-test in Figure 4b.

Chaudhary et al. (2019) have shown higher concentration of *A. adenophora* in the north and north-west direction and lower concentration in the south-east direction in Gokerneshwergad watershed of Kailash Sacred Landscape (KSL) in western Himalaya, India. This finding is contrasting to the findings of our study. Based on these findings, it can be expected that there might be other associated factors that interact with the slope aspect to influence the invasion severity of *A. adenophora.*

Previous studies have confirmed that the density and cover of *A. adenophora* are high in the open canopies (Song et al., 2017; Thapa et al., 2016). Light is another factor affecting *A. adenophora.* Wang et al. (2004) have concluded that *A. adenophora* has ability to grow healthily in a wide range of light intensities and Zheng et al. (2012) concluded that the plant's performance can be decreased with low irradiance. Regarding the soil factor, some studies have focused on the effect of *A. adenophora* on soil physicochemical and biological parameters (Thapa et al., 2017; Zhao et al., 2019; Wu et al., 2020) but, during the invasion, what type of soil is preferred by *A. adenophora* is rarely explored. Wang and Feng (2005) have concluded that the *A. adenophora* invasion can be promoted by enhanced soil nitrogen because it is able to acclimate to a wide range of nitrogen environments and grow better in higher nitrogen environments. Therefore, extensive studies to correlate soil physicochemical parameters with *A. adenophora* density and abundance are recommended.

Another objective of this study was to know whether there is a difference in the number of galls formed by *P. utilis* between the south-east and north-west slopes as the information regarding the effect of slope aspect on the galls was deficient. A study conducted by Poudel et al. (2020) showed that elevation is an important abiotic factor having a strong effect on gall abundance and gall size. They found high abundance and the size of gall abundance at mid-elevation (1940 to 2000 m asl). Our study has revealed that, in the study area, the insect prefers the south-east facing slope for breeding activities because the gall bearing plants and the gall density were high in this aspect comparing to the north-west aspect.

It can be assumed that the high density of galls might be due to the high density of *A. adenophora* on the south-east aspect but insect breeding may not only depend on the plant density. Table 1 shows that the percent of gall bearing plants per quadrat in the study sites. This percent can also be considered as the infestation rate of the gall fly. As the infestation rate in the south-east facing slope is higher than the north-west facing slope it can be anticipated that the slope aspect is an important abiotic factor affecting the galls of this insect in *A. adenophora*.

The number of galls per plant per quadrat was not significantly different in the two slope aspects. It might be due to less number of branches in the individual plants in the study sites which was seen during the study in the field. Li et al. (2006) studied in the western Panzhihua Prefecture, Sichuan Province, Southwest China and found that the parasitism rate of *P. utilis* is high in the humid habitat and the parasitization rate of branches differs with the age of plants i.e., the seedlings and one-year-old plants are highly infected by the insect than the older plants. Hence, it can be expected that the insect parasitization may depend on geography, local environmental conditions, vegetation of the area and invasion age (time of invasion and age of plants). Therefore, future studies should be conducted considering these factors to understand the effectiveness of *P. utilis* as a biological control agent of *A. adenophora* in different geographical locations.

In conclusion, the slope aspect influences the density of *A. adenophora,* galls formed by *P. utilis* and gall density. It indicates that the slope aspect is one of the abiotic factors affecting the parasitization by *P. utilis* on *A. adenophora.* As the explorations on the effect of abiotic and biotic factors on the parasitization of *P. utilis* in the *A. adenophora* invaded regions are very deficient, future studies should be focused on these factors to understand the effectiveness of *P. utilis* as a biological control agent of *A. adenophora*.

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Variation of Soil Organic Carbon at Glacier Foreland along Succession: a Case Study of Bhimtang Glacier Foreland, Manang, Central Nepal

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Abstract

Glacier forelands are considered as unique field laboratories where one can study succession pattern to ecosystem development. Glacier forelands are highly sensitive space to climate change. It forms space in a chronosequence order, i.e, younger moraine lies nearer to the glacier and older moraine lies farther from the glacier. There will be chronological patterns in biological colonization and nonbiological phenomenon. This present work is attempted to study the variation in soil organic carbon along the succession gradient at Bhimthang glacier foreland, Manang, Central Nepal. We hypothesized that younger moraine builds soil with less organic carbon than at older moraine. Five parallel transects, each representing a particular time period of formation were laid down. The distance of separation between each two transects was made 50 m. A total of 12 plots of 2 m × 2 m each laid at an interval of 30 m along each transect. Transects closer to the glacier terminus were regarded as younger moraine then away from it. About one kg of soil each below 10 cm from the top sampled from the center of each plot by the help of a soil corer. A total of sixty bags of soil samples collected during this study. The soil bulk density, soil organic carbon and altitude of each sample were measured. Soil bulk density found ranged between 0.53 to 1.83 mg/ml and soil organic carbon ranged between 0.73 to 1.18 percent. Present study supported the hypothesis of increasing soil organic carbon with increasing age of the glacier moraine. Accumulation of soil organic carbon may be supported by colonization of organisms and their death and decay.

Keywords: Bulk density, Chronosequence, Colonization, Glacier terminus, Moraine, Vegetation Cover

Introduction

Carbon on the Earth is a quantitative function of three reservoirs: Oceans, Atmosphere and Soil (Kempe, 1979). Each reservoir is in equilibrium within themselves and continuously exchanging and interacting with one other. Hiederer & Kochy, (2011) estimated 2469 Pg of organic soil carbon stored at the top one meter layer of soil globally. This amount of organic soil carbon is nearly three times greater than that of the above ground biomass and approximately two times greater than that of atmospheric carbon (Eswaran et al., 1993). Soil is called as the sink of organic carbon among all three reservoirs. Jenny (1941) explained that soil is a pioneer building block of ecosystem, a mixture of fragmented and partly or wholly weathered rocks and minerals, organic matter, water, air in varying proportions and differentiated into many horizons. It has a definite pattern of color, texture, nutrients and organic carbon in the earth. Formation of soil depends on time since exposure and topography (Darmody et al., 2005). Primary soil formation is clearly seen at glacier foreland. The pedogenic process in glacier foreland is a function of various variables such as temperature and moisture regimes (Hall et al., 1992). Study of soil formation process at glacier foreland gives various opportunities to understand ecosystem development to nutrients and organic carbon accumulation with time.

A glacier moraine is a good site to visualize natural chronosequence processes over time. The space formed after deglaciation can be understood via space-by-time substitutions process (Matthew, 1992). Distance of moraine away from glacier tongue is a proxy of age. Thus measurement of soil organic carbon at particular distance of moraine is a direct measure since formation. Chronosequence is a spatial sequence in which environmental factors other than time is considered to be unimportant either because they are invariant or because they are relatively ineffective (Matthew, 1992).

Soil closer to the glacier tongueis considered as younger and farther way is older (Huggett, 1998; Walker et al., 2010). This concept of chronosequence has been systematized by Jenny (1941) and utilized in the Norwegian glacier foreland succession study by Matthew (1992). Later, Huggett (1998) & Walker et al., (2010) and many other shave utilized this concept in each of their study.

Soil organic matter is an important component of the soil system. It is a good indicator of soil productivity. Soil property is characterized by their texture, organic matter, decomposition rate, soil cation exchange capacity, available phosphorus, nitrogen, pH (Stevenson, 1994). During the primary succession, not only the plants but also the soil undergoes remarkable changes such as soil accumulation, organic matter added by the vegetation, increase in water holding capacity, increase in soil aeration and soil porosity, decrease in bulk density, decrease in water runoff and other soil quality development (Singh et al., 2008). Knowledge on soil formation with organic carbon and nutrients accumulation have great potentiality to understand community to ecosystem development. This highly important aspect of plant ecology is less undertaken everywhere. Urgency of glacier foreland study is indispensable in the fragile landscape of Nepal in the face of global warming. Area of glacier foreland is rampantly increasing day to day in Nepal as well. Accessibilities to each of the glacier foreland would one of be constraining factors as all glacier forelands lie at high altitudes (above 3500 m asl). Another reason would be getting chronosequence of glacier foreland formation. Many glacier forelands in Nepal have mixed topographies that confused chronosequence. Thus this study has been initiated at the Bhimthang glacier foreland, Manang, Central Nepal. The glacier foreland formed by Bhimthang glacier has a clear chronosequence of distance. Distance of retreated glacier foreland away from glacier tongue was considered as equivalent to time. The main objective of this study was to discern the pattern of the soil bulk density and soil organic carbon along the Bhimthang glacier foreland, Manang, central Nepal with the hypothesis of increasing pattern of soil organic carbon with increasing distance from the glacier.

Materials and Methods

Study site

This study was carried out in Bhimthang glacier foreland (Figure 1). Bhimthang lies in lower Manang, Central Nepal with the coordinates ranging between 28°27' to 28°46.35' N latitude and 84°10.44' to 84°30' E longitude (Figure 1: a, b & c).

Figure 1: Glimpse of the study site Photo: C.B. Baniya, 2019

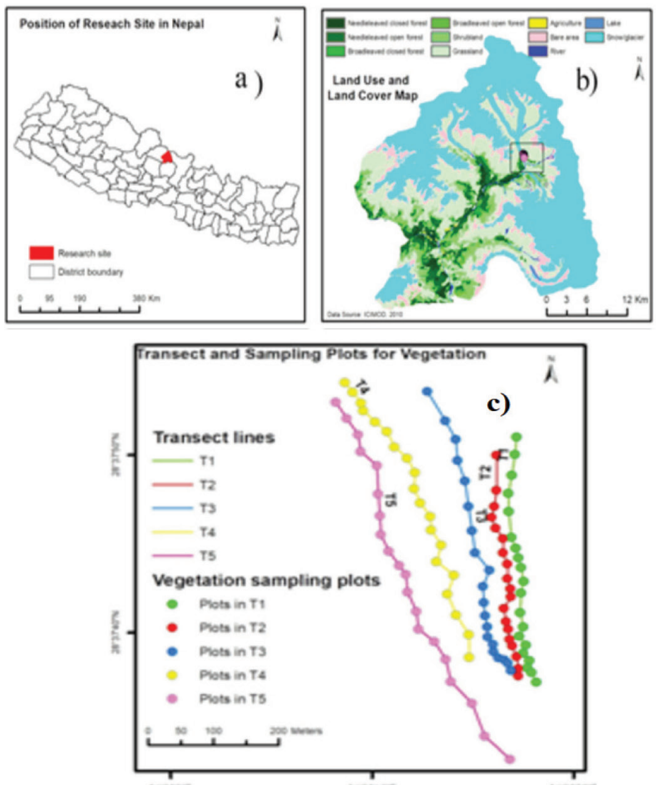

Figure 2: Map of the study area (Bhimthang) (a) Location of Manang district in the map of Nepal (b) Land use and landcover of Manang district and (c) Studied sample plots along each Transect (T1, T2, T3, T4 and T5).

The study area was characterized by high altitude (above 3500 m asl), cold climate, and semi-desert environment with snow fall in winter.

Manang is a unique district in Nepal. Part of this district facing south of the Annapurna range is lower Manang. Bhimthang falls under this class. Part of Manang district facing north of the Annapurna range is upper Manang. Monsoon wind passes through lower Manang to upper Manang after diminishing intensity drastically by the Annapurna range. Moisture decreases from south-east to north-west.South-facing slopes are signiûcantly drier and warmer than north facing slope towards upper Manang. Dense vegetation can be seen in northernslopes of upper Manang and southern slope in lower Manang. Soil moisture is one of determining factors in this phenomenon.

Climate

Meteorological data of Jomsom station nearly at similar altitude of Bhimthang study site was used. Thirty years (1987-2018) climatic data (temperature and precipitation) for Jomsom station was taken from Department of Hydrology and Meteorology, Government of Nepal. According to this record, the average temperature found ranged between -0.78 to 13.39°C during winter and 12.13 to 24.41°C during summer (Figure 3). The mean annual rainfall for the study area was 972.08 mm with the highest monthly rainfall in July (1622.4 mm) and the lowest in November (138.5 mm). November to February was dry months although occasional rainfall occurred throughout the year. These weather conditions have typically been supporting the sub-alpine to alpine vegetation in and around Bhimthang area.

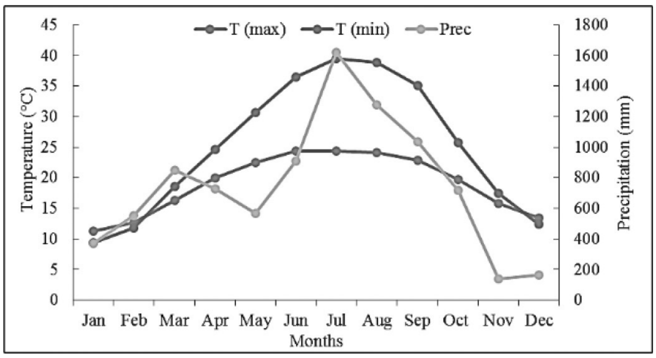

Figure 3: Ombrothermic graph representing the monthly mean maximum and minimum temperature and precipitation trend of Bhimthang, Manang district (Jomsom as meteorological reference point 1987- 2018) (Data Source: Department of Hydrology and Meteorology, Government of Nepal).

Phytogeography and vegetation

The study site is situated inthe lower Manang. Bhimthang is a part of Gyasumdo or lower Manang valley, is a glacially formed U-shaped valley traversed by the Dudhkhola and surrounded by high mountains. It is situated between 3600 m to 3750 m above sea level to wards north-eastern part between Annapurna Conservation Area (ACA) and Manaslu Conservation Area (MCA), Central Nepal.

Vegetation around the studied area are sub-alpine to alpine type. The dominant tree species were *Abies spectabilis* (D.Don) Mirb., *Taxus wallichiana* Zucc., *Tsuga dumosa* (D.Don) Eichler and *Pinus wallichiana* A.B. Jacks. with scattered trees of *Betula utilis* D.Don and *Acer pectinatum* Wall. ex Paxwith patches of *Juniperus* and *Rhododendron* bushes under the open canopy. The dominant shrubby vegetation patches of *Rhododendron lepidotum* Wall. ex G. Don, *Cotoneaster microphyllus* Diels, *Lonicera spinosa* (Decne.) Jacq. ex Walp., *Salix lindleyana* Wall. ex Andersson, *Gaultheria tricophylla* Urb.and *Potentilla fruticosa* Auct.etc were found towards southern slopes.

Data collection

The sampling was done in the south-western aspect of lateral moraine of Bhimthang glacier during June of 2019 and 2020. The moraine was found colonized dominantly by shrub as well as some posts of tree species. Five parallel transects (T1, T2, T3, T4 and T5), each representing a particular time of retreat were laid on the lateral foreland moraine. Each transect located at certain distance away from the glacier tongue, represented a definite time of retreat. The distance between each two transects was made 50 m each. Along each transect, a total of 12 plots of 2 m × 2 m each were laid down at an interval of 30 m each. A total of 60 plots sampled for this study. About one kg of soil sampled from the center each plot. Soil sampled with the help of a soil corer each below 10 depths from the top. Sampled soil collected into a zipper plastic bag with a proper labeling inside it so that will not mix up with other samples. All samples dried first and sieved properly after brought in the laboratory before further analysis. All analysis was performed in the Ecology Laboratory, Central Department of Botany.

Soil Bulk density

Soil Bulk density was determined after following the laboratory procedure given by Gupta (2002).

Soil organic carbon (SOC)

Soil organic carbon was determined by using Walkley-Black Methodgiven by Gupta (2002).

SOC was calculated using following formula:

$$\text{Soil Orgainc Carbon (SOC)} = \frac{N(B - S) \times 0.003 \times 100}{\text{Mass of dry soil (gm)}}$$

Where, N = Normality of ferrous ammonium sulphate (0.5N).

B = Volume of ferrous ammonium sulphate for blank titration (ml).

S = Volume of ferrous ammonium sulphate for sample titration i.e. soil (ml).

Data analysis

Data entered first in the spreadsheet which later imported into R (R Core Team, 2020) and analyzed. Descriptive analysis performed first in the plot-wise data but later utilized to transect-wise data to remove spatial autocorrelation. Each transect was taken as equal status, dummy variable. As position of each transect T1 was the youngest moraine and T5 was the oldest one. Pearson's correlations and simple linear regression were performed after visualizing patterns in pairs plot. Graphics were drawn through R and Map was drawn through QGIS.

Results and Discussion

Descriptive analysis among variables

Transect, altitude, soil organic carbon (SOC) and Bulk density were variables plotted in pairs plot (Figure 4) showed interesting pattern among each other. Transects showed declining pattern with altitude (Figure 4). It meant that younger transects were at the higher altitude and older transects were towards the lower altitudes. This study design justified spatio-temporal design for glacier foreland studies done in Europe such as Matthew, (1992); Huggett, (1998); Walker et al., (2010). Likewise, inclining pattern was observed in between transect and soil organic carbon. All these variables indicated patterns along transect and altitudes.

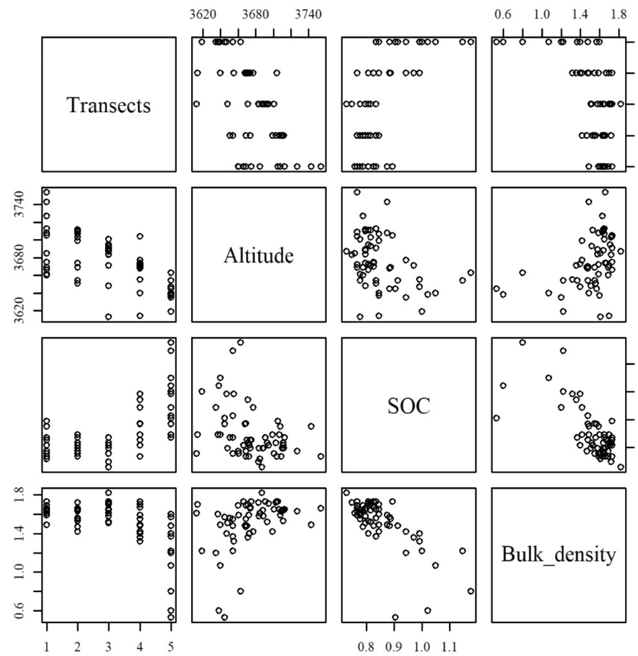

Figure 4: Pairs plot among studied variables along Bhimthang glacier foreland

Correlations among variables

Altitude showed statistically significant negative correlation with soil organic carbon($r = -0.38$, $p < 0.05$) but statistically significant positive correlation with soil bulk density ($r = 0.41$, $p < 0.001$, Figure 5). This study found statistically strong negative relationship between soil bulk density and soil organic carbon ($r = -0.72$, $p < 0.001$, Figure 5).

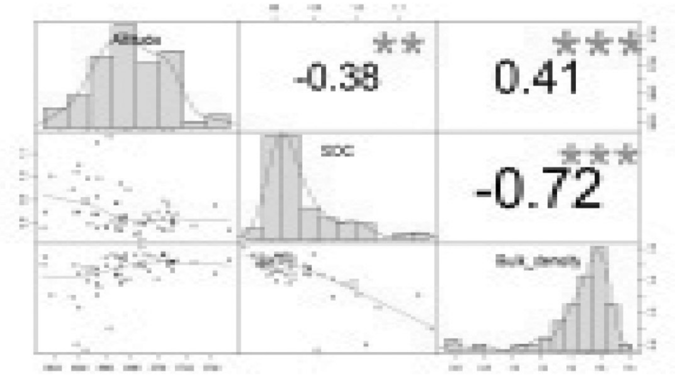

Figure 5: Pearson's correlation coefficient among variables measured during study

Change in soil organic carbon with altitude

Soil organic carbon found a significant linear declining pattern with altitude ($p = 0.02$, $R^2 = 0.15$, Figure 6). This regression coefficient of this model was 0.15. This finding is well supported the conventional and general finding of high content of soil organic carbon found in the old moraine. As moraines are getting older that get longer time to accumulate humus content in soil hence having high amount of soil organic carbon in moraines at lower altitudes. Findings of Elmer et al. (2012), Shakya & Baniya (2019) and Gurung (2012) also supported.

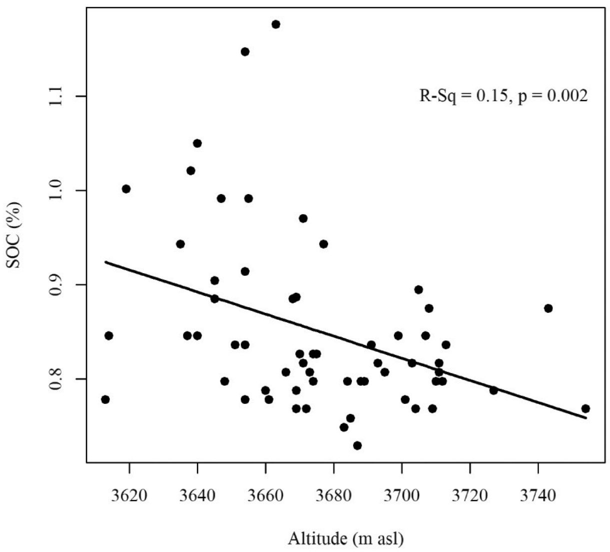

Figure 6: Relationship between soil organic carbon (%) and altitude (m asl). The fitted line is statistically significant first order linear regression model.

Change in soil organic carbon with soil bulk density

The soil organic carbon showed statistically strongly significant declining pattern ($p < 2e\text{-}16$, $R^2 = 0.52$) with soil bulk density (Figure 7). Soil bulk density depends on the compaction, consolidation and organic carbon content in the soil (Morisada et al., 2004). Glacier foreland is a place of harsh environmental condition. No plant propagules were found in the recently deglaciated forelands. Hence very less organic matter will be expected than in older moraine. Decomposition proceeded faster at more developed sites situated at lower altitudes in the glacier foreland (Espersch¨utz et al., 2011).

High altitude range land of Nepal showed relatively higher content of soil organic carbon than lower elevation (Limbu et al., 2013). Probable reason behind of such findings would be low soil temperature and less decomposition. If we applied this interpretation into our glacier foreland, we would expect more soil organic carbon towards younger moraine than at older moraine. To obtain high amount of soil organic content certainly there must have vegetation and their decomposition. But in case of primary succession, the recently deglaciated soil did not get enough time to colonize by living organisms hence very less accumulation of organic matter. Thus, formation time of soil organic matter is crucial. Glacier foreland studies such as Burga et al. (2010), Wietrzyk-Pelka et al. (2020) have found similar pattern of soil organic matter in the glacier foreland. Soil bulk density has almost similar pattern as expected that is negative correlation with soil organic matter. However, Shakya and Baniya, (2019) found no significant relation between soil bulk density and soil organic carbon in the glacier foreland study nearby Bhimthang area. Discrepancy between results would be time since deglaciation. Though these two glaciers lie in the same district but lie completely different topography. Hence our all findings supported the hypothesis of increasing soil organic matter with succession time.

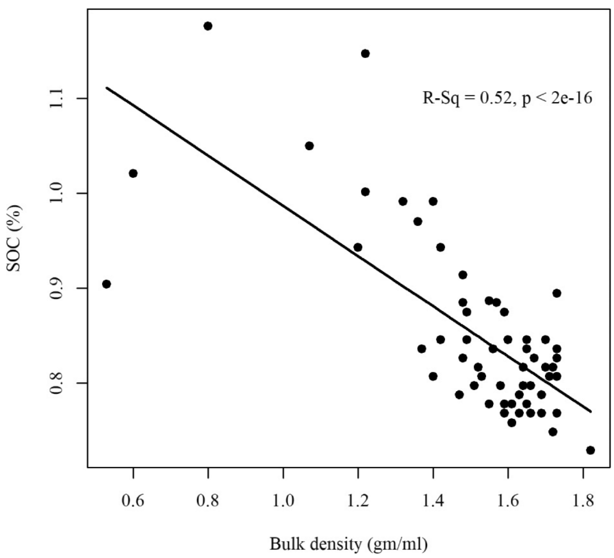

Figure 7: Relationship between soil organic carbon (%) and soil bulk density (gm/l). The fitted line is statistically significant first order linear regression model with R^2-value 0.52 and $p < 2e-16$.

Conclusion

This study concluded that younger glacier moraine lies closer to the glacier terminus, characterized by lesser amount of soil organic matter contents but higher soil bulk density. Similarly, soil organic matter increased linearly with increasing age of soil formation. Formation of soil may be facilitated by time and stochastic factors such as environmental variables.

Author Contributions

The first author did field work, collected data, analyzed data and wrote manuscript.

The last corresponding author designed method, assisted field study, assisted data collection, data analysis and helped to write and revise manuscript.

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Effect of Essential Oils From Two Aromatic Plants Against *Fusarium moniliforme* Sheld. Inoculated In Seeds Of *Oryza sativa* Linn.

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Abstract

The Bakane disease caused by *Fusarium moniliforme* Sheld. is the major disease at seedling stage of rice.The disease is widespread in many rice growing areas in world-wide. Antifungal activity of essential oils of *Eucalyptus citriodora* Hook. and *Cymbopogon citratus* (DC) Stapf. against *Fusarium moniliforme* Sheld. was studied in terms of inhibition percentage using various concentrations of these essential oils. Pure culture of *Fusarium moniliforme* was isolated through blotter test method from infected rice plant, collected from NARC. Sterilized rice seeds were artificially inoculated in conidial suspension of *Fusarium moniliforme* and cultured for 7 days and inhibition percentage was accessed. Each essential oils were extracted through hydro-distillation process using Clevenger oil extracting apparatus and were diluted using 95% ethanol and 1 ml sterile distilled water separately to make the final concentrations 0.04, 0.08, 0.12, 0.16, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4 ml g^{-1} of rice seed. Both essential oils at their various concentration levels were found inhibitory, however, complete inhibition was not observed.The maximum inhibition was achieved at concentration 1.4 ml g^{-1} of *Cymbopogon* as well as *Eucalyptus* oil reaching to the value 90% and 75% respectively. Thus from comparative analysis of both the oils it was concluded that the oil of *Cymbopogon citratus* is more effective than the oil of *Eucalyptus citriodora*.

Keywords: Antifungal activity, Conidial suspension, Hydro-distillation, Inhibition percentage

Introduction

The Bakane disease (also called foolish seedling disease) caused by *Fusarium moniliforme* Sheld. is the major disease of rice at seedling stage. The disease is widespread in many rice growing areas in worldwide but mostly occurring in Asia (Rood, 2004). The disease is reported to affect the host mainly in seedling stage and the associated symptoms are clearly seen in the nursery (Pandey, 2003). Rice plants after transplanting may also be infected, resulting in weak tillering and poor grain filling capacity (Ou, 1985).

Fusarium monoliforme fungi may grow readily on the number of media, producing luxuriant mycelium. The hyphae of *F. moniliforme* is slender, 3-5 μ broad, closely septate and much branched. Each micro-conidium is 1-2 celled, elliptic to ovate or oval in shape and measures 5-12 x 2-4 μ. The macro-conidium is falcate, narrow at both ends 2-5 celled and measure 30-50 x 3 μ. They are formed singly or more often in clusters. The chlamydospores are produced rarely. The perfect stage is reported as *Gibberella fujikuroi* whose perithecia are superficial, globose, dark brown and measuring 270-350 x 240-300 μ. The clavate asci are formed in the perithecia. The asci measure 75-130 x 9-16 μ. The ascospores are long ellipsoid, one-septa and measure 10-20 x 4-9 μ. Each ascus contains 4 or 6 ascospores (Pandey, 2003). The toxins produced by the fungi are fusaric acid, fusarins, gibberellins, moniliformin and fumonisins (Nelson, 1992).

The incidence of *F. moniliforme* infection was reported in different rice varieties of Nepal such as Khumal-9, Khumal-4, Fan-10 etc. with 16.19-72.31%, transmission of disease from seed to seedling (Airee, 2020). Similarly, cultivars like IR50, IR43, and IR841 were also tested against the infection of *F. moniliformae* and found susceptible at varying degrees (Manandhar, 1999). The predominant *Fusarium* species in surface-disinfested seeds with husks were species of the *Gibberella fujikuroi* complex, including *G. fujikuroi* mating population A (anamorph, *Fusarium verticillioides*), *G. fujikuroi* mating population C (anamorph, *Fusarium fujikuroi*), and *G. fujikuroi* mating population D (anamorph, *Fusarium proliferatum*) (Desjardins et al., 2000). The finding of different studied indicate that Nepalese rice varieties are vulnerable to the bakanea disease caused by *Fusarium moniliformae* and studies in this line is highly relevant.

Two easily available aromatic plants, *Eucalyptus citriodora* and *Cymbopogon citratus* were taken in experiments. These aromatic plants are very good source of essential oils which may be extracted by steam or hydro distillation method. Major Chemical constituents of *Cymbopogon citratus* are Citral, Cymbopogone and Cymbopogonal and others are Linalool, Citronellol, Linalyl acetate, Geranyl acetate, Elemol, Neral, Geranial, Myrcene, Borneol, Camphor etc. Indian Council of Medical Research (ICMR, 2012). Similarly major components from *Eucalyptus citriodora* are Citronnellal-66%, Citronnellol-12%, Citronnellyl acetate-4%, Isopulegol-3% from 86% oxygenated compound (Fandohan et al, 2004). In this experiment, the natural essential oils are used as an alternative of chemical fungicides to analyze their antifungal activity against the growth of *Fusarium moniliforme* from rice.

Materials and Methods

Extraction of essential oils

The essential oils of *Eucalyptus citriodora* and Cymbopogon *citratus* were extracted from their leaves by hydrodistillation method using Clevenger's oil extracting apparatus. The collected oil was then dehydrated over anhydrous sodium sulphate and stored at 10°C.

Media preparation

Potato Agar Dextrose (PDA) medium was prepared for culture of fungal pathogen.

Obtaining pure culture of test pathogen

The strain of fungus *Fusarium moniliforme* was isolated from infected leaves of rice through Blotter Test Method. The pathogen was then identified by seeing and comparing their morphological and microscopic characters using the standard literature (Booth, 1971). The pathogen from sample was then taken and inoculated into Petridishes containing PDA medium and was incubated at 25°C with 12 hours of photoperiod. The pure culture of pathogen was thus obtained after 7 days.

Experiment

In the experiment two hundred and sixty rice grains were autoclaved (at temp121^{0}C, duration-10 minute and pressure- 15psi) and were artificially inoculated with 2 ml of conidial suspension of *Fusarium moniliforme.* The conidial suspension was prepared by adding 5 ml of sterile distilled water with seventh day old culture of test pathogen. The culture was superficially scraped to free the conidia from conidiophores and conidial suspension was filtered through muslin cloth. The inoculated rice grains were then treated with oils from *Cymbopogon citratus* and *Eucalyptus citriodora* at their different concentrations obtained by diluting 20, 40, 60, 80, 100, 200, 300, 400, 500, 600 and 700 µl of each oil with 100 µl of 95% ethanol and 1 ml sterile distilled water separately. Twenty rice seeds (0.5g) were allowed to soak in each concentration of each oil for 20 minutes and then dried for 10 minutes and plated into Petridishes containing PDA medium. The concentration range of each oil per rice seed was therefore 0.04, 0.08, 0.12, 0.16, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2 and 1.4 ml g^{-1}. Ten grains were plotted in each Petridish making two replica for each concentration. The Petridishes were incubated at 25° C. Antifungal activity of oil was assessed after 7 days by counting the number of infected and non-infected rice seeds in each Petridish and calculating the healthy grain percentage (*i.e.* of noninfected grain per oil concentration). There were two controls: one –rice grain inoculated with *Fusarium moniliforme* and treated with a solution of 100 µl of 95% ethanol plus 1ml of sterile distilled water and second-rice grain inoculated with *Fusarium moniliforme* with no further treatment.

Results and Discussion

Infected and non infected rice seeds were calculated after the treatment of essential oils from *E. citriodora* and *C. citratus* at their different concentrations ranging from 0.00, 0.04, 0.08, 0.12, 0.16, 0.2, 0.4, 0.6, 0.8, 1.0, 1.2, and 1.4 ml g^{-1}. Different concentrations of both oils could not completely inhibit the fungal contamination on the rice seeds. However, the maximum inhibition was achieved at concentration 1.4 ml g^{-1} of *Cymbopogon* as well as *Eucalyptus* oil reaching to the value 90% (Table-2 and Photoplate-V) and 75% (Table-1 and Photoplate-III) respectively. The table-1 and 2 and corresponding graph (Figure 1) show the effects of both essential oils on inhibition % of fungal contamination on the oil treated rice seeds. Essential oils from *E. citriodora* and *C. citratus* have antifungal properties. The Eucalyptus oil at 1 ml g^{-1} and Lemon grass oil at 0.6 ml g^{-1} concentration showed inhibition effect and gradually increased inhibition percentage with increased in oil concentration in rice seeds at laboratory conditions.

Khanal et.al. (2017) analysed the effectiveness of *E. citriodora* and *C. citratus* oils against *F. moniliforme* by calculating minimum inhibitory concentration. Minimum inhibitory concentration for *E. citriodora* is 6.2 µl ml^{-1} and for *C. citratus* is 4.9 µl ml^{-1}. These essential oils were significant to inhibit the mycelial growth of the fungus irrespective of their sources with $p < 0.05$ (Figure 2). The concentration response found as 12.4 µlml^{-1} = 6.2 µlml^{-1}> 4.9 µlml^{-1}> 3.7 µlml^{-1}> 2.5 µlml^{-1}> 1.2 µlml^{-1}> 0 µlml^{-1} with LSD value 5.42 which indicates that increase in concentrations of essential oils, there is gradual decrease in average colony size of *F. moniliforme* under laboratory conditions. Comparing with this result it was found that the low concentrations of these essential oils are highly effective to inhibit the mycelial growth completely from pure culture disc of *Fusarium moniliforme*. However, *F. moniliforme* inoculated rice seeds require high concentrations to arrest the mycelial growth of the same pathogen in laboratory conditions.

Fandohan et al. (2004) also found that the *Cymbopogon citratus* oil was effective *in in vitro* which completely inhibit the growth of fungi over 21 days of incubation and reduced the incidence of pathogen in corn and totally inhibited fungal growth at concentration of 8.0 µl ml^{-1}. Nguefack et al. (2004) reported that the essential oils from *Ocimum gratissimum*, *Thymus vulgaris, Cymbopogon* citrates had effectively prevented conidial germination and the growth of *Fusarium moniliforme, Aspergillus flavus* and *Aspergillus fumigatus* on corn meal agar at 800, 1000 and 1200ppm respectively. Baruah et al. (1996) studied effect of essential oils against *Fusarium verticilliodes*. They also observed that oil from *Eucalyptus citriodora* was less effective in its antifungal activity than that of the oil from *Cymbopogon* spp.

Table1: Infection of test fungus to oil (*E. citriodora*) treated rice seeds on 7th day of incubation.

S.N.	Concentration of oil (ml g^{-1})	Total no. of seeds	Infected seeds	Non nfected seeds	Inhibition (In %)
1	0	20	20	0	0
2	0.04	20	20	0	0
3	0.08	20	20	0	0
4	0.12	20	20	0	0
5	0.16	20	20	0	0
6	0.2	20	20	0	0
7	0.4	20	20	0	0
8	0.6	20	20	0	0
9	0.8	20	20	0	0
10	1	20	14	6	30
11	1.2	20	10	10	50
12	1.4	20	5	15	75

Table2: Infection of test fungus to oil ((*C. citratus)* treated rice seeds on 7th day of incubation.

S. N.	Concentration of oil (mlg^{-1})	Total no. of seeds	Infected seeds	Non nfected seeds	Inhibition (In %)
1	0	20	20	0	0
2	0.04	20	20	0	0
3	0.08	20	20	0	0
4	0.12	20	20	0	0
5	0.16	20	20	0	0
6	0.2	20	20	0	0
7	0.4	20	20	0	0
8	0.6	20	13	7	35
9	0.8	20	12	8	40
10	1	20	7	13	65
11	1.2	20	5	15	75
12	1.4	20	2	18	90

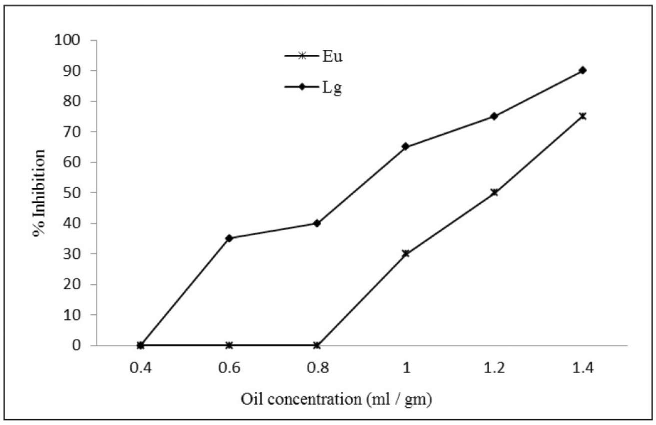

Figure 1: Effect of essential oils on *Fusarium moniliforme* contamination of rice seeds.

P <0.05, LSD = 5.42

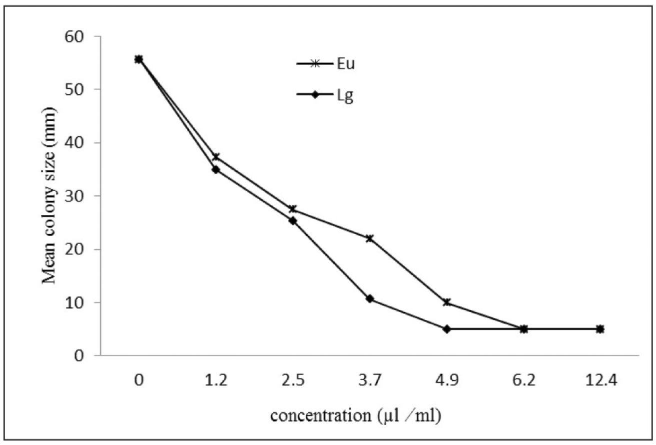

Figure 2: Effect of different concentration of two different oils on the colony size of *Fusarium moniliforme*.(Khanal et al., 2017)

Conclusion

The overall study can be concluded as that the essential oils extracted from *Eucalyptus citriodora* and *Cymbopogon citratus* shows antifungal activity against *Fusarium moniliforme*. The maximum inhibition (90%) for *Cymbopogon citratus* and maximum inhibition (75%) for *Eucalyptus citriodora* was achieved at concentration 1.4 ml g-1.

From comparative analysis of both the oils, it can be concluded that the *Cymbopogon citratus* oil is more effective than that of *Eucalyptus citriodora* oil for inhibiting the growth of *Fusarium moniliforme* in laboratory condition. These essential oils might be used as bio fungicides but this research work has strictly done in *invitro* conditions. So their field trial is recommended to carry out.

Author Contributions

All the authors were involved in concept development, research designing, and literature review. C.Khanal did the laboratory experiments, collected data and prepared manuscript. V.R. Paudel analyzed the data, reviewed and edited the manuscript. Dr. Usha Budathoki had supervised during the experiment.

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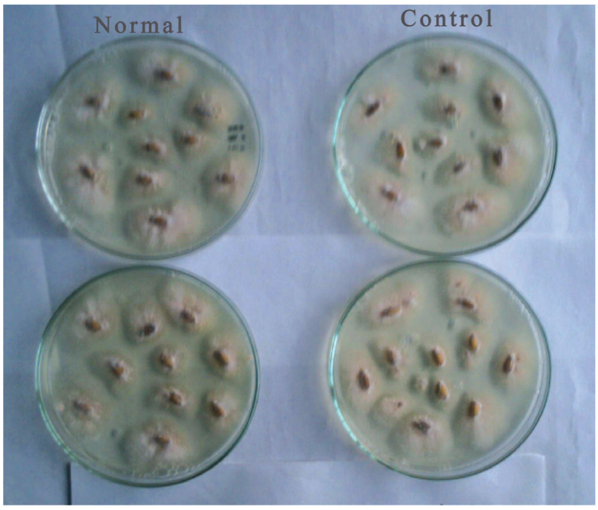

Plate I: Contamination of *Fusarium moniliforme* in rice seeds at Normal and control groups at 7th day of incubation.

Time: at 7th day of incubation

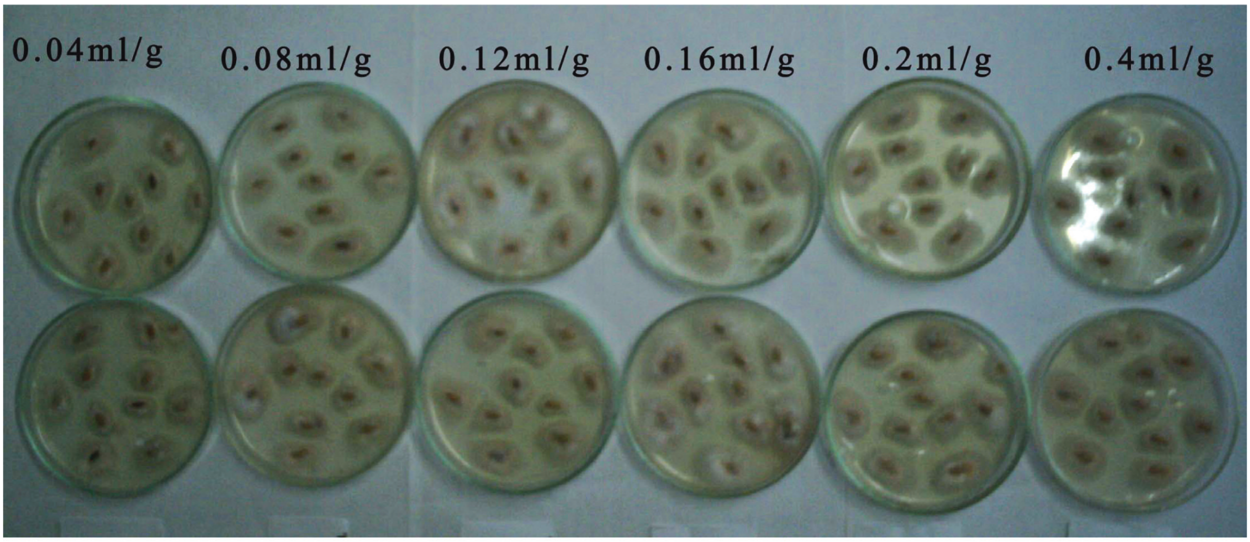

Plate II: Effect of Eucalyptus oil at varying concentrations (0.04 - 0.4 ml /g) on rice seed contamination by *Fusarium moniliforme.*

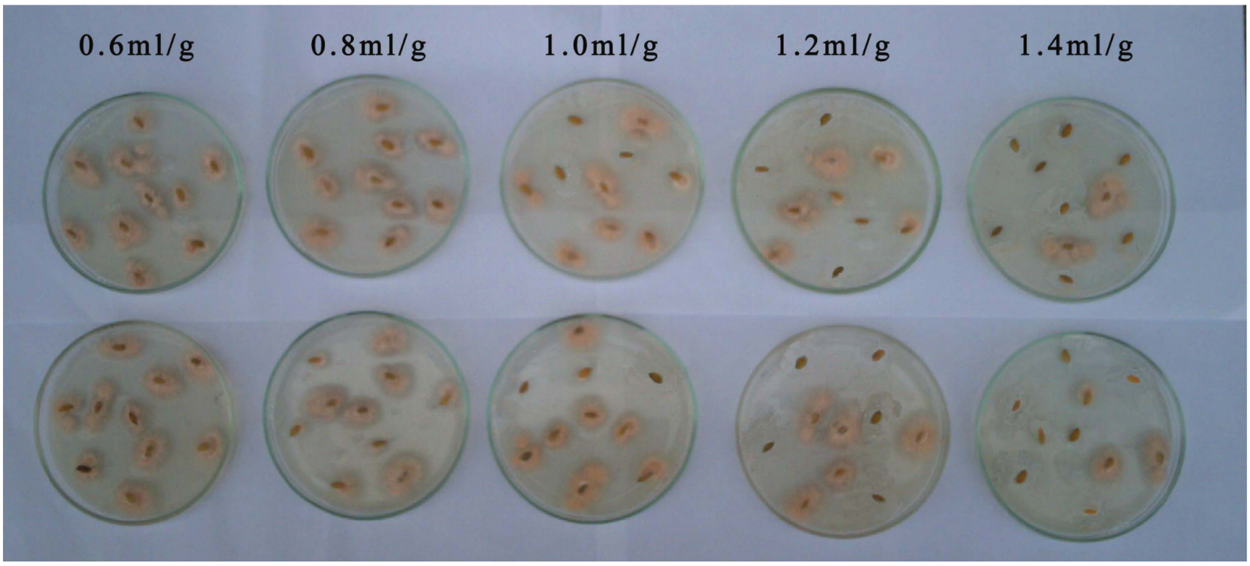

Plate III: Effect of Eucalyptus oil at varying concentrations (0.6 - 1.4 ml /g) on seed contamination by *Fusarium moniliforme.*

Time: at 7th day of incubation

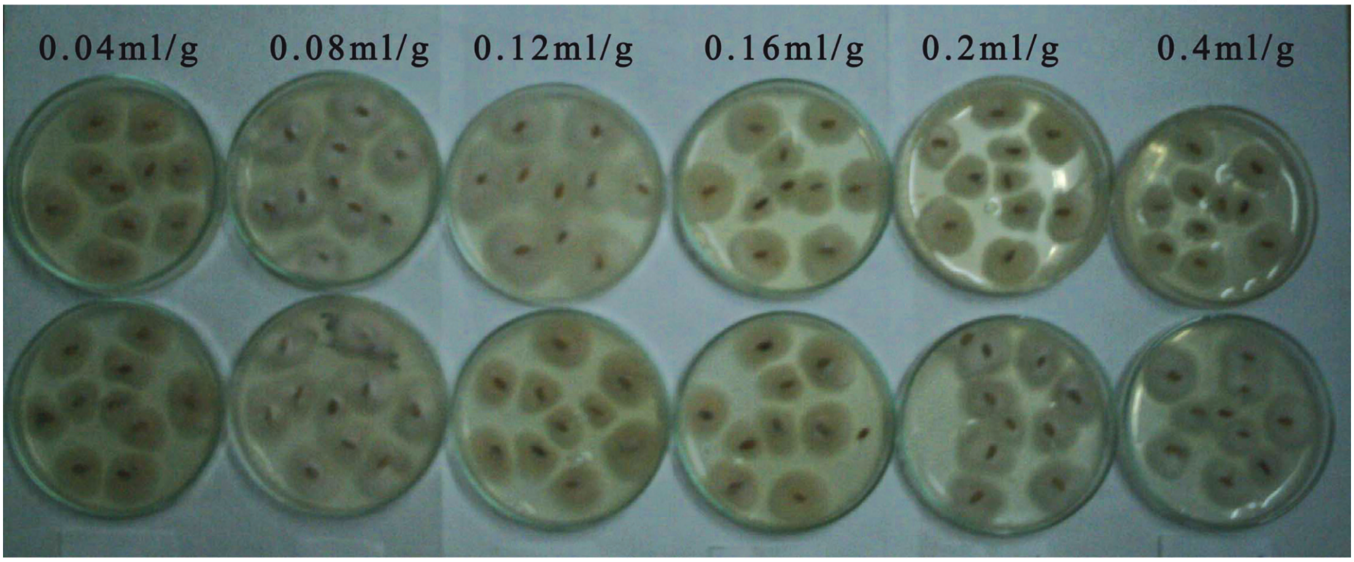

Plate IV: Effect of Lemon grass oil at varying concentrations (0.04 - 0.4ml /g) on rice seed contamination by *Fusarium moniliforme.*

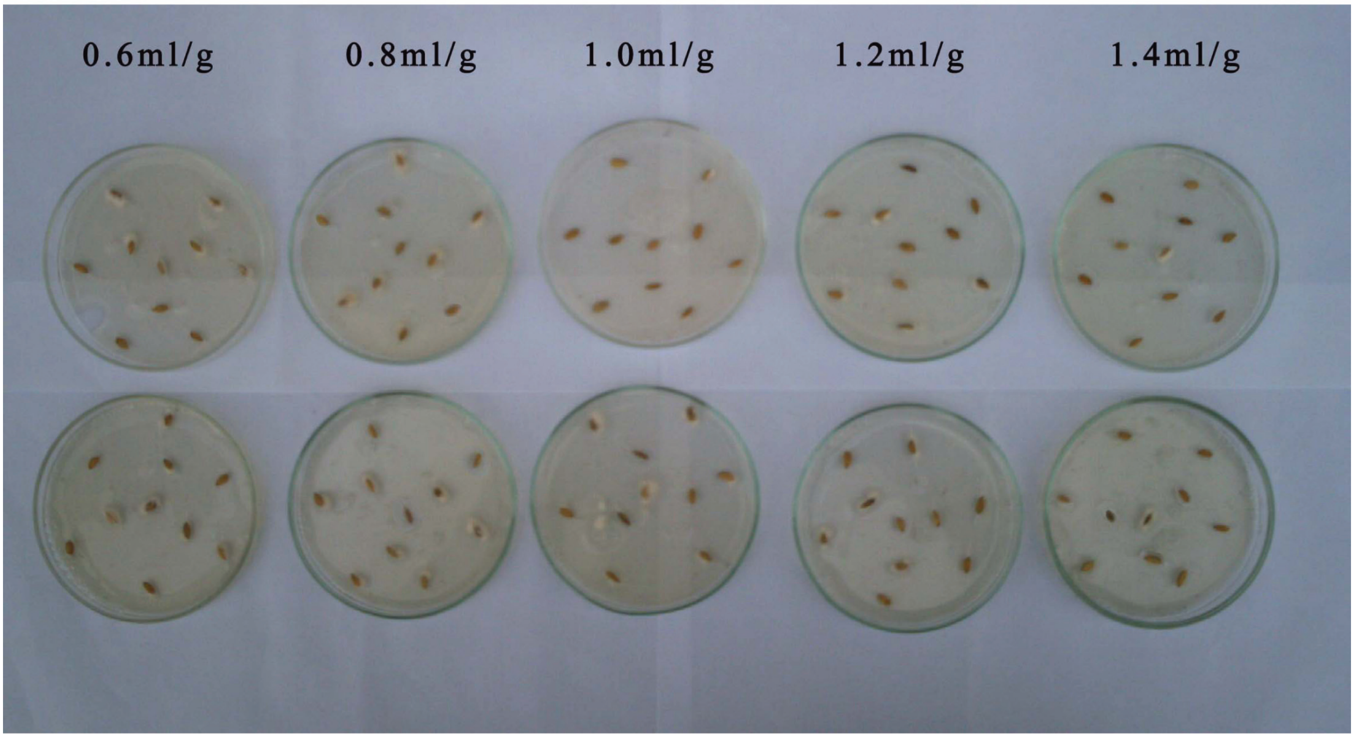

Plate V: Effect of Lemon grass oil at varying concentrations (0.6 - 1.4ml /g) on rice seed contamination by *Fusarium moniliforme.*

Quantitative Estimation of Phytochemicals Present in Selected Weeds and Their Allelopathic Effect on Wheat (*Triticum aestivum* L.) Seedlings at Paklihawa, Nepal

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Abstract

Leaves extracts of the selected weeds (*Parthenium hysterophorus, Lantana camara, Artemesia vulgaris* and *Achyranthes aspera*) were screened quantitatively for their phytochemical constituents and their allelopathic potential against the germination and seedling growth of wheat at Paklihawa campus. Alkaloids, flavonoids and saponins content were determined quantitatively using gravimetric method. The results showed highest alkaloid in *Lantana* (18.01%), flavonoid content in *Parthenium* (13.63%) and saponin content in *Artimisia* (16.23). Allelopathic effects of extract on germination, coleoptile length, shoot and root length, weight of biomass and root shoot ratios were studied. Laboratory based experiment showed that with the increasing concentration of selected botanicals, the germination percentage, seedling length and seedling weight of wheat were significantly decreased while mild concentration of *Achyranthes aspera* leaf extract enhance the seedling growth.

Keywords: Allelopathic, Gravimetric, Screening, Weeds

Introduction

Nepal is an agrarian country serving the livelihood of 65.6% of total Nepalese population. Agriculture sector contributes 27% to the national GDP (MOALD, 2021). Wheat (1,736,849 Mt.) is the third most important cereal after rice (4,299,079 Mt.) and maize (2,231,517 Mt.), contributing 20% of the total cereal production in Nepal (MOAD, 2017). Wheat yields suffer from some factors such as lack of reliable irrigation, unsuitable weather, incidence of disease, various weeds and lack of improved technology (NWRP, 2011). Agricultural researchers have found that weeds cause 17-25% losses in wheat annually due to their competitive and allopathic nature (Shad, 1987). Phytochemicals are naturally occurring compounds found in vegetables, fruits, medicinal plants, aromatic plants, leaves, flowers and roots, and are grouped as primary (Carbohydrates, proteins and lipids) and secondary (polyphenols, steroids, alkaloids etc.,) metabolites based on their function in plant metabolism (Bargah, 2017). Secondary metabolites have no direct role in the growth and development of plant but have evolved in the defense against biotic and abiotic stresses. Their distributions vary both qualitatively and quantitatively depending on age and developmental stage of plants (Harbone, 1972).

A large number of allelochemicals, which are released by plants are stimulatory or have inhibitory effects with the interactions of weeds and crops (Burhan & Shaukat, 2000). Allelochemicals released from leaves, stem roots and other plant parts have capacity to control various weeds (Nasrine, 2011). Nevertheless, leaves seem to be the most consistent sources of chemicals involved in phytotoxicity (Reinhardt & Bezuuidenhout, 2001). As the leaf is the most metabolically active plant body, it is reasonable to believe that it introduces a greater diversity of allelochemicals and, hence, greater allelopathic effects (Riberio et.al., 2009).

Any direct or indirect, harmful or beneficial effect of one plant as a donor plant on another as a recipient plant through the production of chemical compounds that escape into the environment is called allelopathy. Allelopathy and autotoxicity can play significant roles under both natural and manipulated ecosystems, mainly by adversely affecting seed germination and seedling growth (Rice, 1984) whereas one of the main advantages of allelochemicals is the discovery of new modes of action for the development of bio-herbicides (Macías, et al., 2003). Therefore, a better weed management is required, where allelopathy can play an effective role in the crop field system.

The present study was done to quantify alkaloids, flavonoids and saponins present in *Parthenium hysterophorus, Lantana camara, Artemesia vulgaris* and *Achyaranthus aspera* and assess their allelopathic effect in germination and seedling growth of wheat at Paklihawa condition.

Materials and Methods

Quantitative phytochemicals screening and allelopathic effect of *Parthenium hysterophorus, Lantana camara, Artemisia vulgaris* and *Achyranthus aspera* extracts upon the seed germination and seedling growth of wheat cultivar were conducted at Institute of Agriculture and Animal science, Paklihawa Campus. Sample plants were collected around the vicinity of campus. Leaves and tender stem were separated from other parts of plants and were thoroughly cleaned and spread in open area for shade drying for few hours followed by air drying at room temperature (25±5^{o}C) for 8-10 days. The dried plant parts were then grinded using electrical mixture into fine powder form.

Quantitative phytochemical analysis

The powdered part was then used to quantify the presence of alkaloids, flavonoids and saponins as discussed below.

Quantitative estimation of alkaloid: Alkaline precipitation gravimetric method based on Harbone (1972) was used for the determination of alkaloid content. 5gm of dried sample was weighed and wetted with 50 ml of 10% acetic acid solution and allowed to stand for 4 hours after thoroughly shaking. The mixture was then filtered through Whatman No. 42 filter paper. Filtrate was evaporated by using water bath until the volume reduces to one quarter of its original. By drop wise addition of Ammonium Hydroxide (NH_4OH), alkaloid in the extract was precipitated. Precipitate was recovered by filtration using a pre weighed wetted filter paper and washed with 1% NH_4OH.It was dried in the oven at 80oC for an hour which was cooled in desiccator and reweighed.

Weight of alkaloid was determined by using formula (Harbone, 1972).

Alkaloid % = W2-W1/W1 × 100
Where,
W= weight of sample
W1= weight of empty filter paper
W2= weight of paper + alkaloid precipitate

Quantitative estimation of saponin: Double solvent extraction ravimetric method as explained by (Harbone, 1984) was used to determine the saponin content of sample. Five grams (5gm) of powered sample was weighed and mixed with 50 ml of 20% aqueous ethanol solution. The mixture was heated with periodic agitation in water bath for 90 minutes at 55°C. It was filtered through Whatman No. 42 filter paper. The residue was extracted with 50ml of the 20% ethanol and both extracts were pooled together. The combined extract was reduced to about 40mls at 90°C and transferred to a separating funnel where 40ml of diethyl ether was added and shaken vigorously. Separation was done by partition during which the ether layer was discarded and the aqueous layer reserved. Re-extraction by partition was done repeatedly until the aqueous layer become clear in colour. The saponins were extracted with 60ml of normal butanol. The combined extracts were washed twice with 10ml of 5% aqueous NaCl solution and evaporated to dryness in a pre-weighed evaporating dish. The saponin content was determined using the following formula given by (Harbone, 1972).

% of saponin = W2-W1/W ×100
W = Weight of sample
W1 = Weight of empty evaporating dish
W2 = Weight of dish + saponin content

Quantitative estimation of flavonoid: Flavonoid determination was by the method reported by Ejikeme, et al., 2014 and Boham & Kocipai-Abyazan, 1974. Exactly 50 cm^3 of 80% aqueous methanol added was added to 2.50 g of sample in a 250 cm^3 beaker, covered, and allowed to stand for 24 hours at room temperature. After discarding the supernatant, the residue was reextracted (three times) with the same volume of ethanol. Whatman filter paper number 42 (125 mm) was used to filter whole solution of each wood sample. Each wood sample filtrate was later transferred into a crucible and evaporated to dryness over a water bath. The content in the crucible was cooled in a desiccator and weighed until constant weight was obtained.

Flavonoid %= Weight of flavonoid/weight of sample x 100.

Allelopathic test

50 grams of crude powder of each collected samples (*Artemisia vulgaris*, *Parthenium hysterophorus*, *Lantana camera*, *Achyranthus aspera*) were soaked in 250 ml of distilled water separately and macerated overnight (12 hrs) in percolator. Mixture was then filtered through Whatman filter paper no. 42. The filtrate was boiled for five minutes in a heating mantle then allowed to cool by keeping in desiccator. The solution was kept in deep freezer at 4^{o}C for future use. This solution was regarded as stock solution.

Wheat was taken as a sample plant to observe the allelopathic effect of extracts of four plants. Wheat seeds were collected from the Lumbini Agro-vet Bhairahwa, Rupandehi. The aqueous extracts of *Parthenium*, *Artmisia*, *Lantana*, and *Achyranthus* at different concentrations were prepared to observe allelopathic effect.

The surface was sterilized by ethanol (70% alcohol). Two seeds were placed on each polybag containing soil collected from Horticulture farm of the campus. Similar setup was done by (Goda, 1987). Altogether 13 treatments were made and distilled water as control. Each treatment was maintained as stock solution, 10% and 25% of prepared stock solution. The setup was replicated thrice. Experiment was set on 22 November 2019 in Completely Randomized Design (CRD). Each polybag was irrigated with 20 ml botanical extract up to 15 days in alternate days. The numbers of germinated seeds were recorded in a day interval. Shoot and coleoptile length were measured after 5 and 9 days of experimental setup respectively in a day interval up to 15 days. The data means were then accordingly subjected to Analysis of Variance (ANOVA) individually using R-stat and means were separated by DMRT (Duncan's Multiple Range Test) to identify significant differences.

T1	T13	T4
T2	T12	T13
T3	T11	T5
T4	T10	T12
T5	T9	T10
T6	T8	T9
T7	T7	T1
T8	T6	T6
T9	T5	T3
T10	T4	T11
T11	T3	T2
T12	T2	T7
T13	T1	T8

Figure 2: Research design

Notation of Treatments**:**
Stock solution of *Parthenium* -T1
10% of stock solution of *Parthenium*-T2
25% of stock solution of *Parthenium*-T3
Stock solution of *Lantana*-T4
10% of stock solution of *Lantana*-T5
25% of stock solution of *Lantana*-T6
Stock solution of *Artimisia vulgaris*-T7
10% of stock solution of *Artimisia vulgaris*-T8
25% of stock solution of *Artimisia vulgaris*-T9
Stock solution of *Achyranthes aspera*-T10
10% of stock solution of *A. aspera*-T11
25% of stock solution of *A. aspera*-T12
Control/Distilled water-T13

Results and Discussions

Quantitative Estimation of Secondary Metabolites

Quantitative analysis of phytochemicals was carried out by using gravimetric method which revealed that *L. camara* contained highest percentage of alkaloid (18.01) among all the tested botanicals. The result was quite similar to observations of (Bhuvaneswari and Giri, 2018).

Table 1: Quantitative estimation of alkaloid, flavonoid and saponin present in weeds collected at Paklihawa Campus, 2019

Plant Extract	Alkaloid%	Flavonoid%	Saponin%
P. hysterophorus	17.78[a]	13.63[a]	5.76[d]
L. camara	18.01[a]	7.51[b]	13.65[b]
A. vulgaris	6.78[c]	2.85[d]	16.29[a]
A. aspera	16.71[b]	5.89[c]	11.55[c]
Grand mean	14.82	7.47	11.81
CV	3.30	6.03	6.04
SEM	1.41	1.19	1.18
LSD	0.92***	0.84***	1.34***

Note: LSD: Least significant difference, CV: Coefficient variation, SEM: Standard error of mean
Different alphabets signify significant difference between the treatments.
*Significant at 5% level of significance
**Significant at 1% level of significance
***Significant at 0.1% level of significance

Similarly, flavonoid content was found to be highest in *P. hysterophorous* (13.63) and lowest in *A. vulgaris* (3.85). Pradhan and Sarangdevot (2020) reported that *P. hysterophorus* contain 5.25% flavonoids. Such variation in the quantity of metabolites may be due to ecological or geographical differences, plant parts used, plant age, solvent used and other unseen factors (Bourgaud et al., 2001).

Similarly, quantitative test of tested botanicals for Saponin content revealed that *A. vulgaris* contained highest percentage of saponin (16.29) followed by *Lantana camara* and *A. aspera* respectively but *P. hysterophorus* contained very trace amount of saponin (5.75). Not all the phytochemicals were present in all plant parts and that percent occur in different degree based on type of extracting solvent used (Tijjani, et al., 2009). There were only limited researches have been done for the quantitative determination of metabolites for other tested botanicals.

Allelopathic effect of Parthenium, Lantana, A. vulgaris & A. aspera on wheat seedlings

While analyzing the effect of different botanical extract on seed germination of wheat, average seed germination at 4 and 5 days after treatment setup were 1.13 and 1.15 respectively. Maximum seed germination was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 2 which was at par with all other treatments except T1, T2, T4, T6, & T7. Though, the effect on seed germination was found to be significantly different with each other. Detail is shown in table 2 below.

Table 2: Effect of extracts in seed germination of wheat

Treatment	No. of seed germination 4 DAT	No. of seed germination 5 DAT
T_1	0.00[d]	0.00[c]
T_2	0.33[cd]	0.67[bc]
T_3	1.33[abc]	1.67[ab]
T_4	0.67[bcd]	0.67[bc]
T_5	1.00[abcd]	1.00[abc]
T_6	0.67[bcd]	0.67[bc]
T_7	0.67[bcd]	0.67[bc]
T_8	1.67[ab]	1.33[ab]
T_9	1.33[abc]	1.33[ab]
T_{10}	1.67[ab]	1.67[ab]
T_{11}	1.67[ab]	1.67[ab]
T_{12}	2[a]	2.00[a]
T_{13}	1.67[ab]	1.67[ab]
Grand mean	1.13	1.15
CV	51.17	50.67
SEM	0.12	0.12
LSD	0.97**	0.97**

Note: ns: non-significant, LSD: Lower significant difference, DAT: Days after treatment, different alphabets signify significant difference between the treatments
*Significant at 5% level of significance
**significant at 1% level of significance
***significant at 0.1% level of significance

Among all the sample of botanicals, stock solution of *P. hysterophorus* possess higher negative allelopathic effect on germination of wheat seed where as 25% of stock solution of *A. aspera* promoted the seed germination. (Maharjan, et al., 2007) also reported the inhibitory effect of *P. hysterophorus* on germination of many crops such as wheat, barley, maize etc. Inhibitory effect was found to be higher with increasing concentration with plant extract.

While analyzing the effect of different botanical extract on coleoptile length of wheat seedlings, average coleoptile length at 9 days after treatment setup was 2.98cm. Maximum length was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 3.5cm which was at par with all other treatments except T7 & T4 where coleoptile length was only 2.37cm & 2.63cm respectively (Table 3). Though, the effect on coleoptile length was not found to be significantly different with each other.

Average coleoptile length at 11 days after treatment setup was 3.12cm. Maximum length was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 3.67cm which was at par with all other treatment except T6 & T7 where coleoptile length was only 2.70cm & 2.33cm respectively. The effect of different botanicals extracts on coleoptile length at 11 days after treatment setup was found to be significant at 5% level of significance (Table 3).

Table 3: Effects of extracts in coleoptile length of wheat seedlings

Treatment	Coleoptile length 9 DAT	Coleoptile length 11 DAT	Coleoptile length 13 DAT
T_1	2.93^{ab}	3.06^{abc}	3.10^{ab}
T_2	3.00^{ab}	3.47^{ab}	3.53^{ab}
T_3	3.0^{abc}	3.03^{abc}	3.17^{ab}
T_4	2.63^{ab}	3.17^{abc}	3.17^{ab}
T_5	2.83^{ab}	2.87^{abc}	2.87^{bc}
T_6	2.83^{ab}	2.70^{bc}	2.83^{bc}
T_7	2.37^{b}	2.33^{c}	2.33^{c}
T_8	2.97^{ab}	3.07^{abc}	3.10^{ab}
T_9	3.13^{ab}	3.23^{ab}	3.33^{ab}
T_{10}	3.27^{a}	3.33^{ab}	3.33^{ab}
T_{11}	3.03^{ab}	3.10^{abc}	3.10^{ab}
T_{12}	3.43^{a}	3.67^{a}	3.67^{a}
T_{13}	3.17^{ab}	3.53^{ab}	3.53^{ab}
Grand mean	2.98	3.12	3.15
CV	14.23	14.59	12.41
SEM	0.07	0.08	0.08
LSD	0.71^{ns}	0.77^{*}	0.66^{*}

Note: ns: non-significant, LSD: Lower significant difference, DAT: Days after treatment, different alphabets signify significant difference between the treatments
*Significant at 5% level of significance
**significant at 1% level of significance
***significant at 0.1% level of significance

Average coleoptile length at 13 days after treatment setup was 3.14cm. Maximum length was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 3.67cm which was at par with all others treatment except T5, T6 &T7 where coleoptile length was only 2.87cm, 2.83cm & 2.33cm respectively. The effect of different botanicals extracts on coleoptile length at 12 days after treatment setup was found to be significant at 5% level of significance.

Above result showed that stock solution of *A. vulgaris* had strong inhibitory effect on coleoptile of wheat than other tested plant extracts. The result was also supported by findings of (Eom et.al., 2006) which revealed that the volatiles are potent inhibitors of seedlings growth and germination. Higher concentrations of aqueous extract of *A. vulgaris* not only inhibit wheat germination but also their shoot and root growth (El-Fattah, 2011). Low concentration of *A.aspera* extract promotes the coleoptile length of wheat which corresponded with the experimental result of (Khan & Shaukat, 2006).

While analyzing the effect of different botanical extracts on shoot length of wheat seedlings, average shoot length at 5 days after treatment setup was 4.62cm. Maximum length was observed at T13 (i.e., control/distilled water) as 5.77cm which was at par with all others treatments except T1 (i.e. stock solution of Parthenium), T5 (i.e. 10% stock solution of Lantana) and T7 (i.e. stock solution of Artimisia vulgaris) where shoot length was observed only 0.75cm, 4.20cm and 3.12cm respectively. The effect of different botanicals extracts on shoot length at 5 days after treatment setup was found to be significant at 0.1% level of significance.

Average length at 7 days after treatment setup was 11.88cm. Maximum length was observed at T12 (i.e., 25% stock solution of Artimisia vulgaris) as 14.00cm which was at par with all others treatments except T1 (i.e., stock solution of Parthenium), T5 (i.e., 10% stock solution of Lantana) and T7 (i.e., stock solution of Artimisia vulgaris) where shoot length was observed only 2.93cm,10.47cm & 10.37cm respectively. Though, the effect on shoot length at 7 days after treatment setup was found to be significant at 0.1% level of significance.

Table 4: Effect of extracts in shoot length of wheat seedlings

Treatment	Shoot length 5 DAT	Shoot length 7 DAT	Shoot length 9 DAT	Shoot length11 DAT	Shoot length13 DAT	Shoot length15 DAT
T_{1}	0.75^{d}	2.93^{d}	7.70^{b}	11.53^{b}	13.10^{b}	16.63^{b}
T_{2}	5.37^{ab}	12.93^{abc}	19.80^{a}	22.93^{a}	23.13^{a}	25.37^{a}
T_{3}	5.20^{ab}	12.83^{abc}	19.27^{a}	22.20^{a}	23.10^{a}	26.37^{a}
T_{4}	5.10^{ab}	12.73^{abc}	19.70^{a}	23.20^{a}	23.77^{a}	24.53^{ab}
T_{5}	4.20^{bc}	10.47^{bc}	16.40^{a}	18.13^{a}	18.20^{ab}	19.80^{ab}
T_{6}	4.50^{ab}	11.67^{abc}	17.33^{a}	18.0^{a}	18.27^{ab}	19.47^{ab}
T_{7}	3.12^{c}	10.37^{c}	17.00^{a}	20.1^{a}	20.17^{a}	22.57^{ab}
T_{8}	4.97^{ab}	12.93^{abc}	19.73^{a}	22.3^{a}	22.30^{a}	24.17^{a}
T_{9}	5.23^{ab}	13.17^{abc}	17.80^{a}	21.27^{a}	21.27^{a}	22.93^{ab}
T_{10}	4.90^{ab}	13.03^{abc}	19.77^{a}	22.77^{a}	22.87^{a}	24.53^{a}
T_{11}	5.27^{ab}	13.53^{ab}	20.67^{a}	23.3^{a}	23.30^{a}	24.10^{a}
T_{12}	5.67^{a}	14.00^{a}	21.33^{a}	24.57^{a}	24.57^{a}	25.43^{a}
T_{13}	5.77^{a}	13.90^{a}	21.27^{a}	24.13^{a}	24.23^{a}	25.03^{a}
Grand mean	4.62	11.88	18.29	21.11	21.40	23.15
CV	15.69	13.33	15.26	17.11	16.35	15.50
SEM	0.23	0.12	0.67	0.56	0.69	0.78
LSD	1.22***	2.66***	4.71***	6.08*	5.89*	6.05*

Note: ns: non-significant, LSD: Lower significant difference, DAT: Days after treatment, different alphabets signify significant difference between the treatments
*Significant at 5% level of significance
**significant at 1% level of significance
***significant at 0.1% level of significance

Average length at 9 days after treatment setup was 18.29cm. Maximum length was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 21.33cm which was at par with all others treatments except T1 (i.e. stock solution of *Parthenium*) where shoot length was observed only 7.70cm. Though, the effect on shoot length at 9 days after treatment setup was found to be significant at 0.1% level of significance.

Average length at 11 days after treatment setup was 21.11cm. Maximum length was observed at T12 (i.e. 25% stock solution of *Achyranthes aspera*) as 24.57cm which was at par with all others treatments except T1 (i.e. stock solution of *Parthenium*) where shoot length was observed only 11.53cm. Though, the effect on shoot length at 11 days after treatment setup was found to be significant at 5% level of significance.

Average length at 13 days after treatment setup was 21.40cm. Maximum length was observed at T12 (i.e., 25% stock solution of *Achyranthes aspera*) as 24.57cm which was at par with all others treatments except T1 (i.e., stock solution of *Parthenium*) where shoot length was observed only 13.10cm. Though, the effect on shoot length at 12 days after treatment setup was found to be significant at 5% level of significance.

Average length at 15 days after treatment setup was 23.15cm. Maximum length was observed at T12 (i.e., 25% stock solution of *Achyranthes aspera*) as 25.43cm which was at par with all others treatments except T1 (i.e., stock solution of *Parthenium*) where shoot length was observed only 16.63cm. Though, the effect on shoot length at 16 days after treatment setup was found to be significant at 5% level of significance.

Leaf extract of *P. hysterophorus* had strong inhibitory effect on shoot length of wheat as compared to other treatment. Similar result was also found by (Khan et.al., 2005) in inhibition of shoot and root growth by allelochemicals released from *P. hysterophorus.* Likewise, shoot length was promoted by 25% of stock solution of *A. aspera* which is in accordance with research of Khan and Shaukat (2006).

Table 5: Effect of extracts in root length. Root shoot ratio and change in weight

Treatment	Root length 15 DAT	Change in weight	Root Shoot ratio 15 DAT
T_1	5.47^{b}	0.22^{ab}	0.34^{a}
T_2	10.37^{ab}	0.29^{ab}	0.41^{a}
T_3	9.80^{ab}	0.27^{ab}	0.37^{a}
T_4	6.43^{ab}	0.29^{ab}	0.25^{a}
T_5	7.57^{ab}	0.24^{ab}	0.38^{a}
T_6	7.50^{ab}	0.17^{b}	0.38^{a}
T_7	7.03^{ab}	0.27^{ab}	0.31^{a}
T_8	8.93^{ab}	0.33^{a}	0.37^{a}
T_9	6.50^{ab}	0.30^{ab}	0.29^{a}
T_{10}	11.33^{a}	0.27^{ab}	0.46^{a}
T_{11}	9.40^{ab}	0.32^{a}	0.39^{a}
T_{12}	8.63^{ab}	0.32^{a}	0.34^{a}
T_{13}	8.37^{ab}	0.19^{ab}	0.33^{a}
Grand mean	8.25	0.27	0.36
CV	34.24	26.15	31.88
SEM	0.45	0.01	0.01
LSD	4.76^{ns}	0.12^{ns}	0.19^{ns}

Note: ns: non-significant, LSD: Lower significant difference, DAT: Days after treatment, different alphabets signify significant difference between the treatments
*Significant at 5% level of significance
**significant at 1% level of significance
***significant at 0.1% level of significance

On analyzing the effects of different botanical extracts on root length of wheat seedlings, average root length at 15 days after treatment setup was found to be 8.25. Maximum root length was observed at T10 (i.e. stock solution of *Achyranthes aspera*) as 11.33cm which was at par with all others treatments except T1 (i.e. stock solution of *Parthenium*) where the root length was observed only 5.47 cm. Though, the effect on root length was not found to be significantly different with each other.

Similarly, average change in weight on fresh weight of biomass with dry weight of biomass after the experimental setup was found to be 0.27g. Maximum weight was observed at T8 (i.e.10% stock solution of *Artimisia vulgaris*) as 0.33g which was at par with all other treatments except T6 (i.e. 25% stock solution of *Lantana*) where the weight was found only to be 0.17g. However, the effect of botanicals on weight of wheat seedlings was not found to be significantly different with each other.

Likewise, the average root shoot ratio after the cessation of experimental setup was 0.36. Maximum ratio was observed at T10 (i.e. stock solution of *Achyranthes aspera*) as 0.46 whereas minimum root shoot ratio was observed at T9 (25% stock solution) as 0.29. Though, the effect of botanical extract on root shoot ratio was not found to be significantly different with each other.

Root length of wheat was strongly inhibited by the aqueous extract of *P. hysterophorus* which coincided with the findings of (Rashid, et al., 2008). Likewise, change in weight was relatively decreased by the leaf powder of *L. camara* while it was increased by *A.vulgaris* extract. Root shoot ratio was lowered by leaf extract of *L. camara* and higher was found by leaf extract of *A. vulgaris.*

Conclusion

Quantitative test of phytochemical screening done at Paklihawa Campus revealed that alkaloid content was highest in *Lantana camera* (18.01%), flavonoid content in *Parthenium* (13.63%) and saponin content in *Artimisia* (16.23%). Diluted concentration (25% of stock solution) of *Achyranthes aspera* leaf extract showed the potentiality of being a growth promoter for wheat or as in other crops of same family as germination percentage was seen maximum. Similarly, application of *Parthenium* extract shows the highest inhibitory effect against the shoot and root length in wheat seedling. *L. camara* greatly reduced the coleoptile length of wheat seedlings so it can be said that these plants around agricultural field may affect growth parameter of wheat. Further studies on characterization of phytochemicals and their specific role in different agricultural crops is important. In this regard, a further study on characterization of phytochemicals and their specific role in different agricultural crops is to be prioritized.

Author Contributions

All the authors were involved in developing the concepts, research design and reviewing of relevant literatures. Pravin Budhathoki, Manoj Mandal and Amita Gyawali collected the plants, performed the research and prepared the initial manuscript. Subodh Khanal generated and provided the conceptual framework, analyzed the data and prepared the final manuscript.

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Phytochemical Evaluation and Antimicrobial Activity of Stem of *Tinospora sinensis* (Lour.) Merr.

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Abstract

The Magars in Bulingtar rural municipality, Nawalpur district, Gandaki province have been using *Tinospora sinensis* for the treatment of urinary tract infection (UTI). Phytoconstituents present in 70% methanolic extract and hexane extract of stem of the species were evaluated by phytochemical screening, and gas chromatography and mass spectrometry(GC-MS) analysis. Antimicrobial activitiy screenings of the extracts were carried out against *Escherichia coli, Enterococcus faecalis, Pseudomonas aeruginosa* which are UTI causing bacteria along with *Staphylococcus aureus*, *Bacillus subtilis*, *Salmonella enterica* sub-sp. *enterica* serovar Typhi and *Klebsiella pneumoniae*. Antibiotics such as ampicillin and gentamicin were used as positive controls. A total of 35 compounds were identified in the extracts with high percentage of steroids, fatty acids along with triterpene, vitamins etc by GC-MS analysis. The extracts showed antimicrobial activities against *E. coli, P. aeruginosa, B. subtilis* and *S.* Typhi. The extracts showed moderate to weak antimicrobial activity against UTI causing bacterial species supporting the local use. The antimicrobial activity may be due to the presence of phytoconstituents such as: 3,5-dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one; 2-methoxy-4-vinylphenol;hexadecanoic acid, methyl ester; octadecanoic acid; stigmasterol and vitamin E.

Keywords: Bacteria, GC-MS analysis, Magars, Phytoconstituents, Urinary tract infection

Introduction

Tinospora sinensis (Lour.) Merr. is known as Malabar gulbel (English name), Gurjo-ko-laharaa (Nepali), chini lahara (Magar) and Amrta (Sanskrit). *T. sinensis* has been used in Ayurvedic and Homeopathic medicines, particularly in jaundice, fever, rheumatism, gonorrhea, diabetes and several other ailments as an alternative drug for *Tinospora cordifolia* (Willd.) Miers (Hegde & Jayaraj, 2016). Traditionally, the stem is used to treat debility, dyspepsia, fever, inflammation, ulcer, jaundice, urinary disease andliver disease (Akhtar et al., 2000; Devi et al., 2014). Leaves, roots and shoots are used by the Tharus of Nawalparasi district for urinary complaints, dysentery, gastric, stone, fracture and sprain (Ghimire, 2000). Stem is used for stomach problem (Joshi et al., 2011; Manandhar, 2002),whereas leaves are used for stomach problem by the Darai tribe of Chitwan distrct (Dangol & Gurung, 2000). In traditional Chinese medicine, *T. sinensis* is used for relieving rigidity of muscles and activating collaterals (Lam et al., 2018). Compounds from stem of *T. sinensis* were purified and examined for inhibition of superoxide anion generation and elastase release, thereby evaluating their in vitro anti-inflammatory potentials. From the experiment it was concluded that the extracts and purified compounds of the stems of *T. sinensis* have the potential to be developed as novel anti-inflammatory lead drugs or health foods (Lam et al., 2018).

Antimicrobial activity of *T. sinensis* was reported previously. Its roots and leaves exhibit marked antimicrobial activity against *Staphylococcus aureus* (Sandhyarani & Praveen, 2014; Hegde & Jayaraj, 2016). Devi et al. (2014) evaluated antimicrobial activities of ethanolic, methanolic, aqueous and chloroform extracts of the leaves, stems and flowers against Gram-negative as well as Gram-positive bacteria.

During our ethnobotanical survey, we came to know that the juice of the stem of *T. sinensis* has been used for the treatment of urinary tract infection (UTI) by the Magar community in Nawalpur district, Gandaki province, Nepal. To validate the ethnomedicinal knowledge, the present research was focused on evaluation of antibacterial activities of stem extracts of *T. sinensis*. The phytochemicals present in the plant material were also investigated by chemical tests and gas chromatography and mass spectrometry (GC-MS) analysis to identify the biologically active phytochemicals.

Materials and Methods

Sampling site

The study site, Bulingtar rural municipality of Nawalpur district, Gandaki Province, Nepal, was visited in April 2016. Ethnomedicinal data of *T. sinensis* in the Magar community was collected through questionnaires, structured and un-structured interviews among healers and knowledgeable people. The plant sample was collected keeping in mind the conservation of local genetic diversity. Voucher specimen was identified by Prof. Dr. Ila Shrestha, Patan Multiple Campus Patan Dhoka, Lalitpur.

Preparation of the extracts

The collected plant samples were dried in shade at room temperature. Air dried samples were ground and successively extracted with hexane and 70% methanol in water using a Soxhlet extractor until a clean solution was noticed. The extracts were concentrated using a rotary evaporator and vacuum dried. The dried extract was stored in a refrigerator at 4^{o}C for further use.

Phytochemical screening

Phytoconstituents present in the stem extracts were analyzed using different specific reagents. Braymer, Dragendorff, Shinoda, Liebermann-Burchard, Salkowski andfroth tests were carried out to detect polyphenols, alkaloid, flavonoids, steroids, terpenoids and saponins respectively.

Gas chromatography-mass spectrometry (GC-MS)

GC-MS analyses of the hexane and 70% methanolic extracts of *T. sinensis* were performed using an Agilent 7890A GC system coupled with an Agilent 5975 C mass selective detector, equipped with a HP-5MS GC column (5% phenyl methyl siloxane, Agilent 19091S- 433, 30 m × 250 µm internal diameter, 0.25 µm film thickness). Helium was used as a carrier gas at flow rate of 1.21 mL/min. The instrument was operated in the electron impact (EI) mode at 70 eV and ion source temperature 230°C in the scan range of 50-500 m/z. The initial column temperature was set at 40°C held for 2 min, ramped at a rate of 4°C/min to 270°C and held for 5.5 min (total run time 65 min). Dilute sample solutions of the extracts were prepared in HPLC grade hexane or methanol, and a volume of 2 µL was injected. The constituents were identified by comparing the mass spectra available in a MS database of National Institute Standard and Technology (NIST 08).

Antibacterial susceptibility assay

Leading etiological agents of UTIs include *Escherichia coli, Enterococcus faecalis, Pseudomonas. aeruginosa* (Svanborg & Godaly, 1997; Shankar, et al., 2001). Hence, the bacterial strains *Esherichia coli* (ATCC 25922), *Enterococcus faecalis* (ATCC 29212), *Pseudomonas aeruginosa* (ATCC 27263) along with *Staphylococcus aureus* (ATCC 25923), *Bacillus subtilis* (ATCC 6051), *Salmonella enterica* subsp. *enterica*serovar Typhi (Clinical isolate) and *Klebsiella pneumoniae* (ATCC 700603) were used for antimicrobial assays.The cultures of *Pseudomonas aeruginosa*, *Staphylococcus aureus*, *Escherichia coli* and *K. pneumoniae* were collected from Shukraraaj Tropical and Infectious Disease Hospital (STIDH), while those of *Enterococcus faecalis*, *B. subtilis* and *Salmonella enterica* subsp. *enteric* serovar Typhi were collected from Department of Plant Resources, Thapathali Kathmandu, Nepal. These bacteria were sub-cultured in sterile Mueller-Hinton agar (MHA) media.

Agar well diffusion assay: Inoculum was prepared by suspending 3-4 isolated colonies in 5 ml of sterile Mueller-Hinton broth (MHB) and standardized by comparing with McFarland 0.5 standard. Thus preparedinoculums were swabbed on sterile Mueller-Hinton agar (MHA) plates. The hexane and 70% methanolic extracts weredissolved in dimethyl sulfoxide (DMSO) to prepare sample solutionsof 0.1 g/mL concentration. Wells were bored on the MHA plates with of 6 mm diameter cork borer. The wells were loaded with 50 µL of the samples prepared.Ampicillin and gentamicin (Mast Diagnostics) discs of 10 µg/disc wereused as standards. For negative control DMSO was used. The loaded plates were incubated at 37°C for 18–24 hours following Clinical and Laboratory Standards Institute (2012). Zone of inhibition (ZOI) was measured in mm.

Determination of minimum inhibitory concentration (MIC) and minimum bactericidal concentration (MBC)

50 µL of the prepared extract solutions of 0.1 g/mL concentration were mixed with Mueller-Hinton broth (MHB) (50 µL) and then the content was serially double diluted in wells of 96 well microplate. The standardized suspension was further diluted to 1:100 using MHB and then 50 µL of the suspension was inoculated. Thus prepared microplate was incubated for 24 h at 37°C. The minimum inhibitory concentration (MIC) value was taken as the lowest concentration at which there was no turbidity seen by naked eye. Minimum bactericidal concentration (MBC) values were then determined as no colony growth (or growth by 10^{-1}%) by direct streaking the content of the wells inhibiting bacterial growth (MIC and concentrations higherthan the MIC value) on sterile MHA plates.

Statistical analysis

Statistical analysis was done using Microsoft Excel. Experiments were performed in triplicates (n = 3) and the results are presented as mean ± standard error of mean (SEM).

Results and Discussion

Phytoconstituents

Successive Soxhlet extractions of the stem of *Tinospora sinensis* (100 g) yielded hexane extract (0.5g, 0.5%, greenish color) and 70% methanolic extract (9.7g, 9.7 %, dark brown). Phytochemical screening of the extracts revealed that the stem of *T. sinensis* constituted terpenoids, polyphenols, alkaloids, steroids and saponins. Similarly alkaloids, phenolics, steroids, tannins and saponins were reported from various extracts of leaves and stem of *T. sinensis* on preliminary phytochemical screening (Jain et al., 2010; Vijaya & Aruna, 2014; Hegde et al., 2015a; Hegde et al., 2015b; Khandelwal, 2000).

Table 1: Phytoconstituents identified from 70% methanolic extract of *Tinospora sinensis* stem

S. N.	R. T.	Compound	Peak area %	Compound nature
1	15.229	2,3-dihydro-3,5-dihydroxy-6-methyl-4H-pyran-4-one	1.41	Flavonoid fraction
2	21.099	2-Methoxy-4-vinylphenol	3.17	Phenol
3	22.359	2,6-dimethoxy phenol	1.13	Phenol
4	23.859	Vanillin	2.11	Aldehyde
5	27.727	Dodecanoic acid, methyl ester	2.21	Fatty acid
6	32.697	2,6-dimethoxy-4-(propenyl)phenol	1.54	Phenol
7	33.662	4-(1E)-3-Hydroxy-1-propenyl -2-methoxyphenol	9.17	Phenol
8	36.985	1,2-Benzenedicarboxylic acid, diphenyl ester	1.39	Ester
9	38.430	Hexadecanoic acid, methyl ester	4.49	Fatty acid
10	39.319	n-Hexadecanoic acid	10.04	Fatty acid
11	42.331	9, 12-Octadecadienoic acid (Z,Z)-, methyl ester	4.28	Fatty acid
12	42.478	9-Octadecenoic acid-, methyl ester, (Z)-	5.56	Fatty acid
13	43.089	Octadecanoic acid, methyl ester	1.69	Fatty acid
14	43.215	9,12-Octadecadienoic acid, (Z,Z)-	6.51	Fatty acid
15	43.345	Oleic acid	15.50	Fatty acid
16	43.880	Octadecanoic acid	2.72	Fatty acid
		Total	72.92	

The only alkaloid detected in the stems of *T. sinensis* is palmatine (Bisset & Nwaiwu, 1983).

Next, the extracts were used for the GC-MS analyses. Total of 35 compounds were identified from the extracts of *T. sinensis* stem. Sixteen compounds, accounting for 72.92%, were identified in the 70% methanolic extract of the stem of *T. sinensis* by GC-MS analysis (Table 1). As a flavonoid fragment, the extract constituted of 3,5-dihydroxy-6-methyl-2,3-dihydro-4H-pyran-4-one, which was reported as an antimicrobial and anti-inflammatory agent (Kumar et al., 2010). 2-Methoxy-4-vinylphenol exhibits antioxidant, antimicrobial and anti-inflammatory activities (Al-Marzoqi et al., 2016). Oleic acid is reported as anti-inflammatory, anti-androgenic, cancer preventive, etc. (Alagammal et al., 2011). Hexadecanoic acid, methyl ester (Rukshana et al., 2017) and octadecanoic acid was reported to be antimicrobial (Mujeeb et al., 2014).

Phytoconstituents identified in the hexane extract by GC-MS analysis are presented in Table 2. Nineteen compounds (accounting for 93%) were identified in the hexane extract with a higher percentage of steroids (42.23%) and then fatty acids (33.46%) followed by hydrocarbons (11.55%), triterpene (3.35%), vitamin (1.69%), ketone (0.46%) and alcohol (0.26%). Steroids such as stigmasterol are reported as antioxidant, antibacterial, anti-inflammatory, antiarthritic, antiasthma and diuretic (Tyagi & Agarwal, 2017). Sitosterol exhibits strong antifungal, antibacterial and anti-angiogenic activities (Raman et al., 2012). It has been reported that many fatty acids possess antibacterial and antifungal properties (Knapp & Melly, 1986). Vitamin E has beenreported as antioxidant, antimicrobial, analgesic, antidiabetic, anti-inflammatory, antidermatitic, antileukemic, antitumor, anticancer, hepatoprotective and antispasmodic (Mujeeb et al., 2014). Betulin is antiviral, analgesic, anti-inflammatory and antineoplastic agent ("Showing metabocard", n.d.).

Table 2: Phytoconstituents identified from the hexane extract of *T. sinensis*

S. N.	R. T.	Compound name	Peak area %	Compound nature
1	39.368	n-Hexadecanoic acid	10.75	Fatty acid
2	40.061	Hexadecanoic acid, ethyl ester	0.37	Fatty acid
3	42.080	9-Dexadecenoic acid	0.19	Fatty acid
4	42.320	10,13-Octadecadienoic acid, methyl ester	0.26	Fatty acid
5	42.467	6-Octadecenoic acid	0.29	Fatty acid
6	42.740	E-10,13,13-trimethyl-11-tetradecen-1-ol acetate	0.26	Alcohol
7	43.247	9,12-Octadecadienoic acid, (Z,Z)-	5.20	Fatty acid
8	43.389	cis-Vaccenic acid	12.29	Fatty acid
9	43.891	Octadecanoic acid	2.59	Fatty acid
10	43.967	(E)-9-Octadecenoic acid, ethyl ester	0.91	Fatty acid
11	47.961	beta-Sitosterol	32.63	Steroid
12	51.627	3',8,8'-Trimethoxy-3piperidyl-2, 2'-binaphthalene-1,1',4,4'-tetrone	0.46	Ketone
13	52.008	Docosanoic acid	0.61	Fatty acid
14	54.327	Ethyl isoallocholate	0.39	Steroid
15	61.342	17-Pentatriacontene	11.55	Hydrocarbon
16	61.883	Vitamin E	1.69	Vitamin
17	63.465	Betulin	3.35	Triterpene
18	63.579	Campesterol	4.21	Steroid
19	64.397	Stigmasterol	5.00	Steroid
		Total	93.00	

Antimicrobial assays

Results of the antibacterial susceptibility assay of both the hexane and 70% methanolic extracts are given in Table 3 showing Zones of Inhibition (ZOI). The 70% methanolic extract showed antibacterial activity against *Pseudomonas aeruginosa* and *Bacillus subtilis*. The results obtained by using 70% methanolic extract showed antimicrobial activity against *Eshcerichia coli* and a moderate activity against *B. subtilis* and *P. aeruginosa*, and no antimicrobial activity against rest of the tested bacteria. Similarly Shakya et al., (2008) reported antimicrobial activity of 50% ethanolic extract of *Tinospora sinensis* stem against *B. subtilis* and *E. coli* but not against *Salmonella enterica* subsp. *enterica* serovar Typhiand *Staphylococcus aureus*.

Devi et al. (2014) reported methanolic extract of leaf, stem and flower of *T. sinensis* had not shown antibacterial activity against Gram-positive and Gram-negative bacterial strains, but it was found effective against *Candida albicans*.

The antimicrobial activities of 70% methanolic extract may be due to presence of 2,3 dihydro 3,5 dihydroxy 6 methyl 4H pyran 4 one and 2-methoxy-4-vinylphenol The hexane extract was also found effective to inhibit the growth of *B. subtilis*, *E. coli* and *Salmonella enterica* subsp. *enterica* serovar Typhi. Perhaps the antibacterial activity observed was mainly due to the presence of fatty acids.

The result of MIC and MBC of the 70% methanolic extract and hexane extract areshown in table 4. The result showed that 70% methanolic extract was bactericidal against *B. subtilis*, and bacteriostatic against *E. coli* and *P. aeruginosa*. The hexane extract also showed bactericidal activity against *B. subtilis*.

Conclusion

The Magar community of Bulingtar rural municipality, Nawalpur district, Gandaki Province, Nepal uses juice of fresh stem of *Tinospora sinensis* for UTI. The result of antimicrobial assay showed antimicrobial activity against UTI causing bacteria supporting the local use of *T. sinensis* for UTI. But the antimicrobial activity was weak to moderate and the extract killed the bacteria only at high concentrations. The result of GC-MS analysis showed presence of antimicrobial compounds as well as high percentage of steroids which have been

Table 3: Antibacterial activity of the extracts of *Tinospora sinensis* stem

Sample	Diameter of ZOI±SEM (in mm)						
	Gram positive bacteria			Gram negative bacteria			
	Sa	*Bs*	*Ef*	*Ec*	*St*	*Kp*	*Pa*
Hexane extract	-	9±1	-	10.5±0.5	9±1	-	-
70% Methanolic extract	-	11±0	-	8±0	-	-	12±0.48
Ampicillin	32.50±0.50	8.50±0.50	17.75±0.25	25.00±1.00	15.50±0.50	8.50±0.50	–
Gentamicin	16.75±0.25	15.50±0.50	18.5±0.50	17.50±0.50	12.66±0.33	11.33±0.88	14.66±0.33
DMSO	–	–	–	–	–	–	–

Note: *Sa = Staphylococcus aureus, Bs = Bacillus subtilis, Ef = Enterococcus faecalis, Ec = Escherichia coli, St = Salmonella enterica* subsp. *enterica* serovar Typhi*, Kp = Klebsiella pneumoniae, Pa = Pseudomonas aeruginsa*

Table 4: MIC and MBC values of the extracts of *Tinospora sinensis* stem

S.N.	Bacterial strain	Hexane extract		70% Methanolic extract	
		MIC (mg/mL)	MBC (mg/mL)	MIC (mg/mL)	MBC (mg/mL)
1	*Staphylococcus. aureus*	-	-	-	-
2	*Bacillus subtilis*	50	50	25	25
3	*Enterococcus faecalis*	–	–	-	-
4	*Escherichia coli*	50	Na	>50	>50
5	*Salmonella enterica* subsp. *enterica* serovar. Typhi	50	>50	–	–
6	*Klebsiella pneumonia*	–	–	-	-
7	*Pseudomonas aeruginosa*	-	-	12.5	50

reported as showing anti-inflammatory, antiarthritic, antiasthma,diuretic and anti-angiogenic activities. Lam et al. (2018) concluded from their work on *T. sinensis* that the stems of *T. sinensis* have the potential to be developed as novel anti-inflammatory lead drugs or health foods.

Author Contributions

All the authors were involved in the research. C. M. Nemkul visited the study site, collected plant materials, and performed phytochemical screening, GC-MS analysis and antimicrobial assays in the laboratory. G. B. Bajracharya helped in chemical analysis by GC-MS and reviewed the manuscript. I. Shrestha reviewed the ethnobotanical part of the manuscript.

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Rhododendron arboreum: Propagation through Seeds, Cultivation, Diseases and Control Methods

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Abstract

This paper aims to discuss about the seed germination process, problems during cultivation, diseases and control methods of *Rhododendron arboreum*. Germination test was carried out at National Botanical Garden, Godavari from the seeds collected from there. The problems during seedling transplantation and disease appeared were observed in Hupsekot Rural Municipality, Nawalparasi District at elevation of about 1500 m asl. The seed germination period was found more than one year with about eighty percent germination percentage with 90–95% survival rate. It was also found that the *R. arboreum* was acid loving plant. Powdery mildew was the common disease appeared in the field. Some recommendations are proposed for prevention and cure of Rhododendron related diseases.

Keywords: Diseases, Ericaceae, Germination percentage, Precaution

Introduction

The name 'Rhododendron' is derived from the Greek word 'Rhodo' means rose and 'Dendron' means tree. *Rhododendron* is a large genus of woody plants belongs to family Ericaceae and consists of around 1000 species within one genus and 8 sub-genera (Chamberlain et al., 1996). There are 571 and 80 species of *Rhododendron* recorded in China and India respectively (Wu et al., 2005; Bhattacharya & Sanjappa, 2008). 31 species of *Rhododendron* are reported from Nepal, which are distributed from the subtropical region (*R. arboreum*) to the nival region (*R. nivale*) (Poudel et al., 2018). Most of the species have an elevation range of 1000 m asl, but four species (*R. lepidotum, R. anthopogon, R. arboreum,* and *R. setosum*) have a 2000-3000 m asl range of distribution, covering more than one vegetation zone (Noshiro et al., 1995; Watson & Rajbhandari, 2005). Among them, *R. arboreum* is found as low belt *Rhododendron* (1200 m asl in Western Nepal), while *R. nivale* is reported from the nival region near the vegetation limit (5600 m asl). Recently, the emphasis has been given for the conservation of *Rhododendron* species (especially for rare and endangered species) around the globe (Ma et al., 2014). The Government of Nepal has prepared the Rhododendron Conservation and Action Plan (DoFSC, 2019).

This paper has aimed to know the seed germination technique, required precautions during seedling plantation, disease infestation and control methods of *R. arboreum* in Nepal.

Materials and Methods

The experiment was carried out in National Botanical Garden, Godawari, Lalitpur, Nepal. The altitudinal range of this botanical garden is 1515-2000 m asl. The temperature range is 20°C to 30°C during summer and -5°C to 20°C during winter and annual rainfall is approximately 2075mm (Nayava, 1981). Field visit was carried out in the Hupsekot Rural Municipality of Nawalparasi (Bardaghat-Susta East) where the large barren hill area was planted with *Rhododendron arboreum.* Seed germination test was carried out at National Botanical Garden (NBG). Fruit (Capsule) of *R. arboreum* becomes mature from October to December. Mature capsule were collected arbitrarily selected *R. arboreum* trees in December 2017. Then, the capsules were carried to the green house of NBG. All capsules were air dried and stored in the porous cotton bags for 3 months. Seeds were separated from the capsules and 500 robust seeds were selected for germination test. Altogether, the germination was repeated five times. For seed germination, the beds of soil collected from forest area of NBG, sand and cow dung were mixed well and sown in the beds made in wooden box (2ft×1.5ft).The wooden boxes were then kept in shaded area of agro-net house. The watering was done regularly to keep the soil moist. The pH was also noted. Germination percentage, survival rate, seeds germinating time, height of seedlings, number of leaves emerging in a time interval and their length and breadth were also recorded. From the field visit, the survival rate of saplings, problems seen in the field and symptoms of disease were recorded. Discussion with key stake holders was carried out during field observation.

Results and Discussion

The minute seeds of *Rhododendron arboreum* were germinated in the mixture of soil, sand and cow dung (1:1:1) after the 50 weeks of seed sowing, the average height of seedlings was 0.5 cm, average number of leaves was 3, the average length of the leaf was 0.5 cm, and breadth was 0.9 cm after almost one year. The average height of seedlings was measured 1 cm with average number of leaves 5, length and breadth 1.2 cm and 0.8 cm respectively after one year of picking from soil beds to poly bags. Similarly, in next year the average height of seedlings were measured 6.7 cm with average number of leaves 8, length and breadth were 6.5 cm and 2.5 cm respectively (Table 1). The germination percentage was ~ 80%. Survival rate was 90-95%. This finding is similar with previous research (Shen et al., 2015)). The pH measured was 6.2 for the mixture of soil, sand and cow dung.

To know the precautions before cultivation, problems during cultivation of seedlings and problems and disease appeared in seedlings, the cultivation site was visited and some significant points were noticed during the field visit. To study about the problems during cultivation of seedlings and appeared diseases, the plantation site done by others was selected in the Hupsekot area of Nawalapur (previously Nawalaparasi) District.

From our field visit, we recommend following points to be considered before plantation of *Rhododendron.*

- Consultation with expert about right confirmation of the plant species and taxonomical confirmation of the targeted plant species.
- Broad knowledge of the distribution and growth habitat of the target species.
- Environmental factors like temperature and rainfall of plantation area.
- Testing of soil components like Nitrogen, Potassium, Phosphorous, soil pH, Moisture content etc.
- Most important point is Acclimatization/ adaptation of seedlings or saplings.
- From the expert view, It is believed that if we collect saplings with soil root, the chances of survival rate increased by fifty percent.

In case of *Rhododendron*; Acid-loving plants may be applied in late winter or early spring but much manure is not needed as other plants. More fertilizers are harmful sometimes, even whole plant can die. If plants are mulched with materials like fresh sawdust or wood chips, there will be a nitrogen demand caused by the decomposition of these materials, and unless nitrogen fertilizer is added, the plants are likely to show yellowish foliage and poor growth. In this case, an organic nitrogen fertilizer can be added. It is shown that not to use phosphorus (needed for flower buds) fertilizers unless a soil test indicates a deficiency.

Probable diseases in *R. arboreum* around the globe are as follows:

- Powdery mildew: sometimes exhibits the typical white powdery or fuzzy growth, but often takes on a completely different appearance light

Table 1: Average height of seedlings, leaves number, leaves length and leaves breadth in different time interval

S.N.	Average height of seedling (cm)			Average no. of leaves emerging (cm)			Average length of leaves (cm)			Average breadth of leaves (cm)			Remarks
	2018 Aug	2019 Aug	2020 Aug	2018 Aug	2019 Aug	2020 Aug	2018 Aug	2019 Aug	2020 Aug	2018 Aug	2019 Aug	2020 Aug	
1	0.5	1	6.7	3	5	8	0.5	1.2	6.5	0.3	0.8	2.5	

green or yellowish patches on the top of leaves sometimes accompanied by purple-brown areas on the backside of leaves are signs of powdery mildew. These symptoms were seen in our study area.

- Gall: Gullis fruit-like growth in a leaf or flower petal caused by spores of the fungus *Exobasidium*. Fungicide control of the disease generally has not been successful. Removal and disposal of galls before they become white-colored is the most effective means of controlling the disease.
- Petal blight: causes spots in a flower petal to look like they are wet. It is seen after flowering.

Common insect pests in *Rhododendron* are as follows:

- Lace bug: They eat back side of the leaf and leaf started fall down.
- Weevils: Active at night and often eat margin of the leaf.
- Rhododendron Borer: Often seen in big trees. Need to care when plants are big enough.

Problems seen in the seedlings of *Rhododendron* in Rudrapurgadhi Nawalpur can be summarized as follows:

- Water deficiency and struggling with stress.
- Problem of grazing.

Figure 1: Common insects pests seen in Rhododendron. (1) Lace bug, (2) Weevils, and (3) Rhododendron Borer


Figure 2: Stressed plants

- Lack of acclimatization, especially for big seedlings.
- Diseases were seen especially in leaf (powdery mildew) due to stress.
- 3 to 5% plants were died, 15-20% seedlings were struggling for stress or drought, and remaining plants were in good condition.

We have some recommendations to solve the problems seen in the study area:

- Manage water supply as soon as possible.
- Water storage polythene tank can be built to store water for winter.
- To look out the seedlings in the field, manpower should be managed according to the number and area of plantation.
- While replacing the dead seedlings, as far as possible, the seedlings from local area or adjoining forest should prioritize.
- If possible, the seedlings should collect with root soil for plantation.
- Plantation of large seedlings should be avoided.
- Acclimatization of seedlings in the targeted area is also very important. So, the seedlings should acclimatize before plantation.
- Fungicide or insecticide should use for suffered seedlings.
- Awareness program and local participation is seriously needed to conserve the planted or cultivated seedlings in the proposed foot trail or tourist area.

Conclusion

It can be concluded that, *R. arboreum*, national flower of Nepal, can be grown or propagated successfully from seeds; however the germination is slow and takes relatively longer times. The rate of germination is very high (~80%). The survival rate is 90–95%. Powdery mildew, Gall, Petal blight are the common diseases seen in the *Rhododendron* and Lace bugs, Weevils, *Rhododendron* Borer are the common insects which bring trouble after plantation or growing for *Rhododendron*. Selection of small seedlings, collecting of seedlings with root soil, acclimatization of seedlings before plantation and prevent from different diseases are the major precautions and challenges for plantation of *Rhododendron arboreum* in the hilly region of Nepal.

Author Contributions

The first author develop concept, visited field, and finalize Manuscript by the help of second author. Second, third and fourth author did field experiment and taken data.

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Nepalese Medicinal Plants Which Can Develop Immune and Inhibit Viral Growth

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Abstract

This paper aims to review and enumerate the top Nepalese medicinal plants which are helpful to develop immune to the body against viral diseases including SARS-CoV-2 (Covid–19) and prevent viral growth after confirmation. For this, recent research about the title was reviewed. Scientific name, common name, family, distribution or habitat range, parts used, chemical compounds and their role for immune system or inhibit viral growth were enumerated and analyzed . The result shows that including some daily uses spices (Garlic, Onion, Ginger, Turmeric etc), common seasonal fruits (Mango, Papaya, Pomegranate, Sweet orange) to high value medicinal plants are important to develop resistant power and fight with SARS-CoV-2 (Covid–19) after confirmation. Altogether, 41 medicinal plants (belongs to 30 families) to develop immune and to inhibit viral growth after confirmation are recorded through the reviews and analysis. Amaryllidaceae, Fabaceae and Lamiaceae were three larger families with three species in each. Whereas, Combretaceae, Piperaceae, Rutaceae, Solanaceae and Zingiberaceae were found with two useful plants in each family. Other 23 families were reported with single species.

Keywords: Antiviral property, Nepal Himalaya, SARS-CoV-2 (Covid–19)

Introduction

Covid-19, a disease induced by SARS-CoV-2 (Severe Acute Respiratory Syndrome Coronavirus-2), has been the cause of a worldwide pandemic. Though extensive research works have been reported in recent days on the development of effective therapeutics against this global health crisis, there is still no approved therapy against SARS-CoV-2. According to WHO, 213 countries and territories are affected by Corona Virus and 26 million people are died around the world till date; 13 March 2021 (www.worldometers.info/coronavirus), whereas the death number is 3012 out of 275,118 cases in Nepal (till 13 March 2021. Daily confirmed cases and death were increasing few months before (Figure 1 and 2). However, recently the data is in decreasing order. Though, different vaccines are in trial phase recently, this paper will be important for the future to know about useful plants to resist from similar diseases and for future medicine related research belongs to different viral diseases.

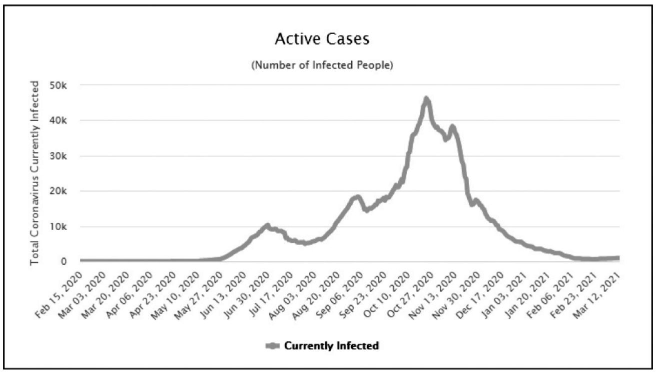

Figure 1: Daily new confirms cases up to March 12, 2021 (Source: https://www.worldometers.info/coronavirus/country/Nepal)

Vaccines still in trial phase yet and people all around the world are still worried. Some countries are already returned at normal daily life and recaptured their previous moment. Specific vaccines against SARS-CoV-2 are also being developed in many laboratories across the world. However, a recent review (Yang et al., 2020) and many others underline the role of traditional Chinese medicine in treating SARS-

CoV-2 patients. The case study with each selected medicinal plants and their positive effect for COVID patient was noted in Bangaladesh too (Azam et al., 2020). Though there are not such comprehensive studies available in Nepal, However, we have a long history of using medicinal plants for treating broad-spectrum diseases since ancient times (References). Recently, some attempts from Ayurveda hospital in Nepal viz. Community Nature cure Hospital Rajahar, Nawalapur (Gandaki Province, Nepal), Ayurveda teaching hospital Kirtipur, Kathmandu) have found more efficient to develop immune system of patients and to cure positive cases without serious symptoms (is it personal communication, references). Some other research also has reported some plants and their compounds used against viral diseases (Taylor et al., 1996; Rajbhandari et al, 2009; Joshi et al 2020).

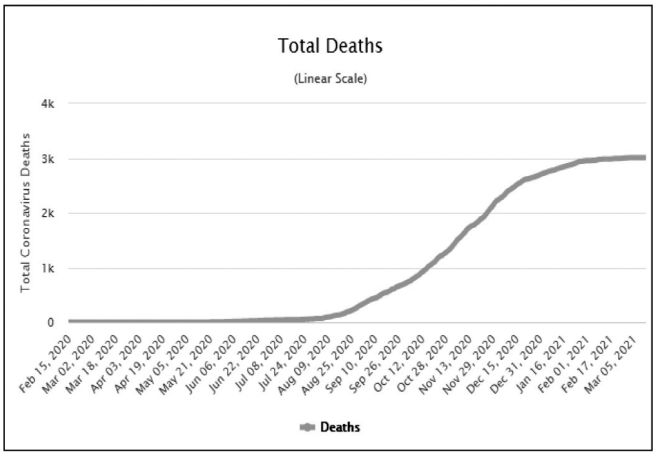

Figure 2: Death cases in Nepal up to March 05, 2021 (Source: worldometers.info/coronavirus/country/Nepal)

In this context, this paper aims to enumerate the plants from Nepal Himalaya (wild as well as cultivated) which develop immune system and used to inhibit viral replication of Covid-19 after positive confirmation. Hope, this review paper will help to enhance similar studies including screening of plants which can be used against viral diseases.

Materials and Methods

The study is based on literature review. For this, the information about medicinal plants was gathered from published books (DPR, 2016), scholar articles, reports and different health blogs using different search engines. The data were organized and analyzed in Microsoft Excel (2010) software and then summarized in to tables and figures. For the taxonomic treatment of the documented plant species, the online botanical databases 'IPNI' (International Plants Name Index), 'The Plant List' (Royal Botanic Gardens, Kew, UK and Missouri Botanical Garden, USA) and 'Tropicos'(Missouri Botanical Garden, USA) and online version of Annotated checklist of the flowering Plants (www. Efloras.org) were used.

Results and Discussion

There is a well said in the society that 'Prevention is better than cure'. So, the Plants or food items used before infection of any diseases are crucial in our daily life. Many common spices and daily used 41 plants are described in this revision work.

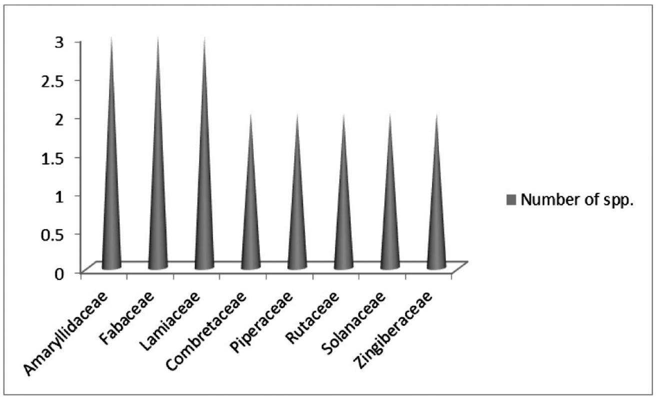

Figure 3: Number of useful species in eight larger families.

Among them, 26 are as preventive and immune system developing plants and other 14 are viral growth inhibiting plants after infection by SARS-CoV-2 (Covid-19). Fabaceae (*Cassia tora, Glycyrrhiza glabra and Psoralea corylifolia*) Amaryllidaceae (*Allium cepa*, *A. sativum* and *Lycoris radiata*) and Lamiaceae (*Ocimum tenuiflorum*, *Origanum vulgare* and *Rosmarinus officinalis*) are larger families with three useful plant species in each (Figure 3). Combretaceae (*Terminalia chebula* and *T. billerica*), Piperaceae (*Piper longum* and *P. nigrum*), Rutaceae (*Citrus aurantifolia* and *Citrus sinensis*) Solanaceae (*Lycium barbarum* and *Withaina somnifera*) and Zingiberaceae (*Curcuma longa* and *Zingiber officinale*) were found with two species in each family. Other 23 plants species were from single species in each family (Table 1 and 2).

Table 1: List of plants which develop immune to resist COVID-19.

S.N.	Name of Plants	Family	English name	Compound	Distribution in Nepal	Parts used	For what (Mode of action)	References
1	**Allium cepa L.*	Amaryllidaceae	Onion	Quercetin, Thiosulfinates and anthocyanins	Cultivated and common as vegetable spice	Bulb	Develop immune system	Harazem et al. 2019
2	**Allium sativum* L.	Amaryllidaceae	Garlic	Diallyl disulphide,allin, Poliphenols proteins	Cultivated and common as vegetable spice	Bulb	Develop immune system	Fani et al. 2007
3	**Aloe vera* L.	Asphodelaceae	Aloe	Amino acids, Anthraquinones, Enzymes, sugar, Vitamins A, B, C, E, B12	Cultivated	Whole plant	Antioxidant, Aniti viral activity	Sahu et al. 2013
4	*Berberis Aristata* DC.	Berberidaceae	Barberry	berberine	1800–3000 CW	Fruit, stem and root	Antioxidant/ antiviral/develo p immune	Dehar et al. 2013
5	**Camellia sinensis* (L) Kuntze	Theaceae	Tea plant	Catechins,quercetin , gallic acid, Theaflavin–3,3'digellate	cultivated	Leaf	antioxidant	Perva-Uzunalić et al. 2006
6	**Carica papaya* L.	Caricaceae	Papaya	Caricaxanthin, Violaxanthin, Zeaxanthin, carpaine	Cultivated terai and hilly region	Leaves Juice, Fresh fruit	Antioxidant and develop immune system in body	Kala 2012
7	* *Citrus* × *limon* (L.) Burm.f.	Rutaceae	Lemon	Polysaccharides, polyphenolic compounds	cultivated	Fresh fruit /peel	Antioxidant/ develop immune	Shen et al. 2017
8	*Lycium barbarum* Lam.	Solanaceae	Wolfberry	Polysaccharides proteins, phenolic compounds	1600 C	Fruit	develop immune	Tang et al. 2012
9	**Mangifera indica* L.	Anacardaceae	Mango	Flavonoides, Phenolic acid	Cultivated terai and mid hills	Bark, leaf, root, flowers	develop immune	Makare et. al. 2001
10	*Moringa oleifera Lam.*	Moringaceae	Drumstick	oleic acid, ascorbic acid- 2, 6-dihexadecanoate, 9-octadecenoic acid, methyl ester-hexadecanoic acid and 9-octadecenamide	Rarely found in marginal land as wild and widely cultivated CE 150-1100	Leaf, fruit	Antioxidant, anti-viral activity and used as super food	Moyo et al. 2011
11	*Morus serrate* Roxb.	Moraceae	Mulberry	Carotene, Vitamin B1, Vita.-D, Folic acid, Folinic acid	WC 1600-2400	Fruit, leaf, root	Develop immune	Bagachi et al. 2013
12	**Nigella sativa* L.	Ranunculaceae	Black cumin	Quinones, alkaloids, saponins	cultivated	Seeds	Immune boosting and antioxidant	Ahmad et al. 2013
13	*Panax pseudo-ginseng* C.A. Mey.	Araliaceae	Ginseng	Ginsenosides and more 40 compounds	Temperate to sub alpine	Root	Immune boosting and antioxidant	Li et al. 2013 Lü et al. 2009

S.N.	Name of Plants	Family	English name	Compound	Distribution in Nepal	Parts used	For what (Mode of action)	References
14	*Piper longum* L.	Piperaceae	Long peeper	piperine	WCE 200-800	Fruit	Antiviral activity	Hamidi et al. 1996 Priya et al. 2017
15	*Piper nigrum* L.	Piperaceae	Black peeper	Chloroform extract	Widely cultivated	fruit	Antiviral activity	Priya et al. 2017
16	*Prunus cerasifera Ehrh.*	Rosaceae	Cherry plum	polysaccharides, Acetonitrile	E 1800	Fruit	Antiviral activity	Stacewicz-Sapuntzakis et al. 2001
17	**Psidium guajava* L.	Myrtaceae	Guava	tannins, guajavins, psidinins and psiguavin	cultivated	Fruits, shoots and leaf	Antiviral activity	Balasubramanian et al. 2007
18	**Punica granatum* L.	Punicaceae	Pomegranate	ellagic acid ellagitannins punicic acid, flavonoids, anthocyanidins, anthocyanins	cultivated	Fruit, seed and bark	Immune boosting and antioxidant	Zhang et al. 1995
19	**Rosmarinus officinalis* L.	Lamiaceae	Rosemary	Rosmanol, Carnosol	cultivated	leaf	Antioxidant and Antiviral activity	e Silva et al. 2020
20	*Tinospora cordifolia* (Willd.) Hook. f. & Thoms	Menispermaceae	Heard leaved moonseed	alkaloids, glycosides, steroids, aliphatic compounds, essential oils, mixture of fatty acid, calcium, phosphorous, protein and polysaccharides	Subtropical to temperate	Stem, leaf	Boost immune	Tiwari et al. 2018
21	**Zingiber officinale* Roscoe	Zingiberaceae	Zinger	Essential oils, crude fiber, proteins, fatty oils and carbohydrates	cultivated	Root	Antiviral activity	Sahoo and Banik 2019
22	*Azadirachta indica* A. JUSS. *Ocimum tenuiflorum* L. *Withaina somnifera* (L.), Dunal *Terminalia Chebula* Retz. *Terminalia bellerica* (Gaertn.) Roxb. *Phyllanthus emblica* (Gaertn.) Kurz, *Curcuma longa* L.	Meliaceae Lamiaceae Solanaceae Combretaceae Combretaceae Euphorbiaceae Zingiberaceae	Neem tree, Holybasil, Awshwagandha, Chebulic Myrobalan, Myrobalan, Indian gooseberry, Tumeric	Flavonoids, alkaloids, glycosides, steroids, eugenol, linalool, apigenin, and ursolic acid, aliphatic compounds, essential oils, mixture of fatty acid, curcuminoids and so on.	Tropical to subtropical	Leaf, root, fruit	Immune body systems, antioxidant, and anti-viral activity	https://pharmeasy.in/blog

Note: * = cultivated; C = Central; W = Western; E = Eastern

Carica papaya (Papaya), *Psidium guajava* (Guava), *Punica granatum* (Pomegranate), *Mangifera indica* (Mango) are common daily used seasonal fruits. From different research it was found that the plants like drumstick (*Moringa oleifera*) and *Camellia sinensis* (as green tea) and spinach and other green vegetables (which are not included in this review work) which have lots of vitamins, minerals and especially antioxidant properties have the sufficient strength to fight against different virus and other infectious diseases like SARS-CoV-2 (Covid-19) and many others (References).

Plants used against Covid–19 after confirmations were found out from different recent research. Many scientists believed that the traditional used plants from ancient time have played very important role to cure from SARS-CoV-2 (Covid-19) in China (Yang et al. 2020). During the finding Nepalese medicinal plants effective for SARS-CoV-2 (Covid-19), three plants were found from family Fabaceae (*Glycyrrhizaglabra, Cassia tora* and *Psoralea corylifolia*). Out of these three, *Glycyrrhiza glabra* and *Cassia tora* are common in Nepal, whereas *Psoralea corylifolia* is reported in online checklist (www.Efloras.org) and might be cultivated. Also, it is found as herbal dietary supplements in the market. *Cassia tora* is common as roadside shrub in terai region. Other important plants which play important role for antiviral activity and even to inhibit the further growth of SARS-CoV-2 (Covid-19) virus in the human body are explained with common name, family, chemical constituents found in the plants, distribution or habitat status and their used parts (Table 2).

Table 2: List of the plants used against Covid–19 after confirmation

S.N.	Name of Plants	Family	English Name	Compound	Distribution in Nepal	Parts used	For what (Mode of action)	References
1	*Glycyrrhiza glabra* L.	Fabaceae	Liquorice	*glycyrrhizin*, glycyrrhetic acid, isoliquiritin, isoflavones	Subtropical to temperate	Root	Inhibiting viral replication	Cinatl et al. 2003
2	*Arabidopsis thaliana* (L.) Heynh.	Brassicaceae	Thale cress	12-oxophytodienoic acid (OPDA) and dinor-oxophytodienoic acid	2300 W	Leaf extracts	Immunogenic activity against the virus.	Gómez et al. 1998
3	*Rheum australe* D.Don	Polygonaceae	Himalayan Rhubarb	anthraquinones, stilbenes, anthrones, oxantrone ethers and esters, chromones, flavonoids, carbohydrate, lignans, phenols and sterols	CW 3200-5200	Root, bark and leaf	ACE2 and S-glycoprotein interaction is blocked	Rokaya et al. 2012 Zargar et al. 2011 Ho et al. 2007
4	*Origanum vulgare* L.	Lamiaceae	Oregano	carvacrol, β-fenchyl alcohol, thymol, and γ-terpinene etc	WC 600-4000	Leaf	Antiviral and antioxidant activity	Zhang et al. 2014
5	*Rauvolfia serpentine* (L.) Benth. ex Kurz	Apocynaceae	serpentine wood	reserpine	CE 100-1000	Root	inhibiting viral replication	Wu et al. 2004
6	**Lonicera japonica* Thunb.	Caprifoliaceae	Japanese honeysuckle	Linalool, hexadecanoic acid, octadecadienoic acid, ethyl palmitate and dihydrocarveol	C 1400, mostly cultivated	flower buds, stems, and leaves	Inhibit viral activity	Shang et al. 2011
7	*Dendrobium nobile* Lindl.	Orchidaceae	*Dendrobium*	Vitamin A Aldehyde; Longifolene; 1-	E 500-1700	Stem, leaf,	Antiviral activity	Song et al. 2013

S.N.	Name of Plants	Family	English Name	Compound	Distribution in Nepal	Parts used	For what (Mode of action)	References
				Heptatriacotanol; Z, Z-6, 28-Heptatriactontadien-2-One and Dendroban-12-One		flower		Yang Y. et al. (2020) Xia et al. 2020
8	*Verbena officinalis* L.	Verbenaceae	common verbena	Verbenin, verbenalin, hastatoside, alpha-sitosterol, ursolic acid, oleanolic acid	WCE 900-2400	Leaf, stem	Antiviral activity	Kubica et al. 2017
9	*Phragmites australis* (Cav.) Trin. ex Steud	Poaceae	common reed	aurantiamide acetate, 2,3-dihydroxy-1-(4-hydroxy-3,5-dimethoxyphenyl)-1-propanone , ferulic acid, p-coumaric acid, syringic acid, vanillic acid , p-hydroxy benzoic acid , p-hydroxybenzaldenhyde, palmitic acid, heptadecanoic acid , β-sitosterol, stigmasterol, α-D-glucose and β-D-glucose	CE 3000–3600	mostly Rhizome	Antiviral activity	Zhu et al. 2017
10	*Cassia tora* (L.) Roxb.	Fabaceae	sickle pod	Anthraquinone glycosides, Naphthopyrone glycosides, Phenolic compounds, Flavonoids	WCE 100-1300	Dried seed	Inhibit growth and replication of SARS-CoV	Wen et al. 2011
11	**Paulownia tomentosa* (Thunb.) Steud.	Paulowniaceae	princess tree/ Empress tree	flavonoids, lignans, phenolic glycosides, quinones, terpenoids, glycerides, phenolic acids	Cultivated	seed	SARS-CoV papain-like protease	Cho et al. 2013
12	**Psoralea corylifolia* L.	Fabaceae	babchi	dioscin and angelicin, Psoralen, terpenophenol	Native of India and Shrilanka, cultivated in Nepal	seed	Crude ethanol extract of the seeds Inhibit viral growth	Alam et al. 2018 Kim et al. 2013
13	**Citrus sinensis* (L.) Osbeck	Rutaceae	Sweet Orange	Polyphenols	cultivated	Fruit	Control replication	Ulasli et al. 2014
14	**Lycoris radiata* (L'Héritier) Herbert	Amaryllidaceae	red spider lily	Lycorine, Crinine, Galanthamine, Tazettine, Narciclasine, Lycorenine, Homolycorine and Montanine	Cultivated	Herbal extract	Control replication in vitro (raw Plant's bulb are poisonous for human and animals)	Li et al. 2005

Note: * = cultivated, WCE = West, Central and East

Among them, *Citrus sinensis* (can be used as fresh fruit), *Cassia tora* (Seeds can be used as coffee; also see the side effect below), *Rauvolfia serpentina* and *Glycyrrhiza glabra* (dried root can be used as green tee) are the common plants (even common people may know) which can be used by the Covid-19 infected not serious patients during isolation period. However, the scientific confirmation is necessary for all mentioned plants. I=f we are not familiar, better to confirm. Some plants like *Lycoris radiata* (Red spider lily) as raw form of plant's parts (bulbs) are poisonous for human being and animals. Similarly, *Senna* (Cassia) poisoning is rarely reported, and its potential for toxicity greatly underestimated. Clinical presentation mimics acute liver failure, which is very difficult toattribute to this seemingly innocuous agent (Ish et al., 2019). Therefore, precaution is necessary and random uses of medicinal plants are also not good.

Conclusion

From this study it can be concluded that the Nepal Himalaya is the worldwide recognized center and rich diversified place for high value medicinal plants including several infectious diseases like SARS-CoV-2 (Covid-19) too. Described 41 plants, are just the initiation not the final list of plants which are effective for viral infectious diseases from Nepal. So, in Nepalese context, the screening and compound isolation of medicinal plants (including reported in this review work) against viral diseases is foremost necessary and baseline for the further compound isolation. However, drugs identification, designing, development and clinical trial are badly needed for future generation.

Recommendations

Though medicinal plants have been used from prehistoric time based on traditional knowledge. In contrast, recently many scientists believe that the use of some medicinal plants as raw form might be side effects and even some chemical compounds are found as carcinogenic and lethal. So, Author highly recommends using plants and their parts after confirmation and consulting with experts and Ayurveda specialists.

Author Contributions

Author first develop the concept and find the different literature about introduction and recent update and prepare first and final draft. Authors second, third, fourth and fifth help to develop Table 1 and 2 with references.

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Uses of Bamboos in Two Ecological Regions of Lumbini Province, Nepal

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Abstract

Bamboos (including nigalo and malingo) are indispensable for mankind. These plants use from womb to tomb since the infinite period that made life comfortable in all regions of Nepal. Also, these plants play a crucial role in alleviating poverty and ensuring food security, among others. The widespread applicability of these plants becomes possible mainly because of affordability, availability, and handling-friendly in daily life. This paper tries to explore the ethnobotany and traditional knowledge of diversity in bamboos use in diverse ethnic communities in two ecological regions (Mid-hills and Terai) of Lumbini province, Nepal. All together 7 distinctive species were identified, 60 more traditional use of bamboos were documented and these uses are categorized into broad groups viz. structural use, consumptive use, religious and cultural use, agricultural use, and other use. Apart from these ethnobotanical use, three principal potential uses are noted viz.;vital source of carbon sequestration for mitigating climate-change and option for carbon trading under different carbon financing mechanism, soil quality indexing, and replacement of mine and wood-based constructional product in more effective, efficient with a low level of technical inputs. These findings and discussions would give insights and explore the widediversity in ethnobotany of bamboos of the regions and its potentiality for multiple uses of these species without jeopardizing the environmental and cultural assets. The findings would be a reference to the other communities inside the country and the global communities for application and replication of bamboos'usufruct for diversifying bamboo-based livelihoods options and beyond.

Keywords: Ethnobotany, Food security, Livelihood option, Traditional knowledge

Introduction

Ethnobotany, is the traditional uses of plants and their parts using knowledge of local culture and people, was firstly coined by John W. Harsberger in 1896, the subject of ethnobotany has become an important matter which also includes health care and conservation programs in different parts of the world (Kunwar & Bussmann, 2008). Using traditional knowledge to a particular species is varying, in which, we demonstrate the case of bamboo in Nepal. The origin of the word 'bamboo' is uncertain, but it probably comes from the Dutch or Portuguese language, which originally borrowed it from Malay or Kannada (Kelchner et al., 2013).

Bamboois a diverse group of evergreen perennial flowering plants in the subfamily Bambusoideae of the grass family Poaceae (Soreng et al., 2015), that human usage has a stronger link to introduce and diversify it (Canavan et al., 2017). The absence of secondary growth wood causes the stems of monocots, including the palms and large bamboos, to be columnar rather than tapering (David, 1984). Bamboo includes some of the fastest-growing plants in the world, are the largest member of the grass family. This rapid growth and tolerance for marginal land make bamboo a good candidate for afforestation, carbon sequestration, and climate change mitigation (Kaminski et al., 2016a; 2016b). Bamboo is of notable economic and cultural significance in South Asia, Southeast Asia, and East Asia, for its multi-facet uses (David, 1984).The most widely distributed species comprises 1662 species in 121 genera, of which 232 (14%) have been introduced beyond their native ranges and a non-random selection of bamboo increase the widespread dispersion of species and multiply the utility (Canavan et al., 2017). In Asia, China contains more than 500 species followed by India, Indonesia, Myanmar, and Malaysia, each with more than a hundred species. In Asian countries, about 84 species are found in Japan, 90 in Myanmar (Barma), 55 in the Philippines, 50 in Thailand, 44 in Malaysia, 31 in Indonesia, 30 in Nepal, and 30 in Srilanka (Nirala et al., 2017).

Bans, nigalo and malingois collectively called bamboo (hereafter 'bamboo') in Nepal (Jackson, 1994). Despite having multi-facet important, limited documentation in Nepal observes. 'Bamboos of Nepal' written by Chris Stapleton reflects their abundance is in the eastern, central, and western parts of Nepal (Shrestha, 1998). In the mid-western region, 48 bamboo species in the far-western region, 31 species recorded (Das & Thapa, 2013). Despite various utilization and aesthetic value of the bamboos, Nepalese people still believe in different taboos, believes, and superstitions regarding bamboos in Nepal (Das & Mitchell, 2005).As Lumbini province, which belongs in the western region, has limited studies in ethnobotany of the bamboo and its uses, the study aims to document the ethnobotany and uses of bamboos available in two different ecological regions of the province, Nepal to contribute to the knowledge of bamboo.

Materials and Methods

Study area

The study was carried out in the Bahigaon village of Chhatradev Rural Municipality and Bodgaon village of Banganga Municipality of Arghakhanchi and Kapilbastu districts from Mid-hills and Terai regions of central Nepal, respectively (Figure 1). These municipalities were selected based on a good number of bamboos and their utilization values compared with the other municipalities of the regions. Also, this region (Lumbini province and the districts) was free from the ethnobotanical study of the bamboo so far realize the researchers to carry a research on the topic for this area. The field visit was conducted in October-November 2019.

Chhatradev Rural Municipality

Chhatradev Rural Municipality lies in 28°00' -28°01' N and 83°13' -83° 34' E at the north-east belt of Arghakhanchi district (Figure 1). The altitude ranges from 720 to 1800 m asl (above sea level). The whole area of this rural municipality falls in the mid-hills region. Major ethnic groups inhabiting the area are Brahmin, Chhetri, Magar, Newar, Kami, Damai, and Sarki. Major vegetation includes the *Schima-Castanopsis* forest with associated species of *Pinus roxburghii, Myrica esculenta, Alnus nepalensis, Ficus*spp., *Madhuca longifolia*. The Chhatradev has a subtropical type of climate. The temperature ranges from 14.9°C to 25.8°C and the average annual rainfall is 1627.7 mm (DHM, 2017).

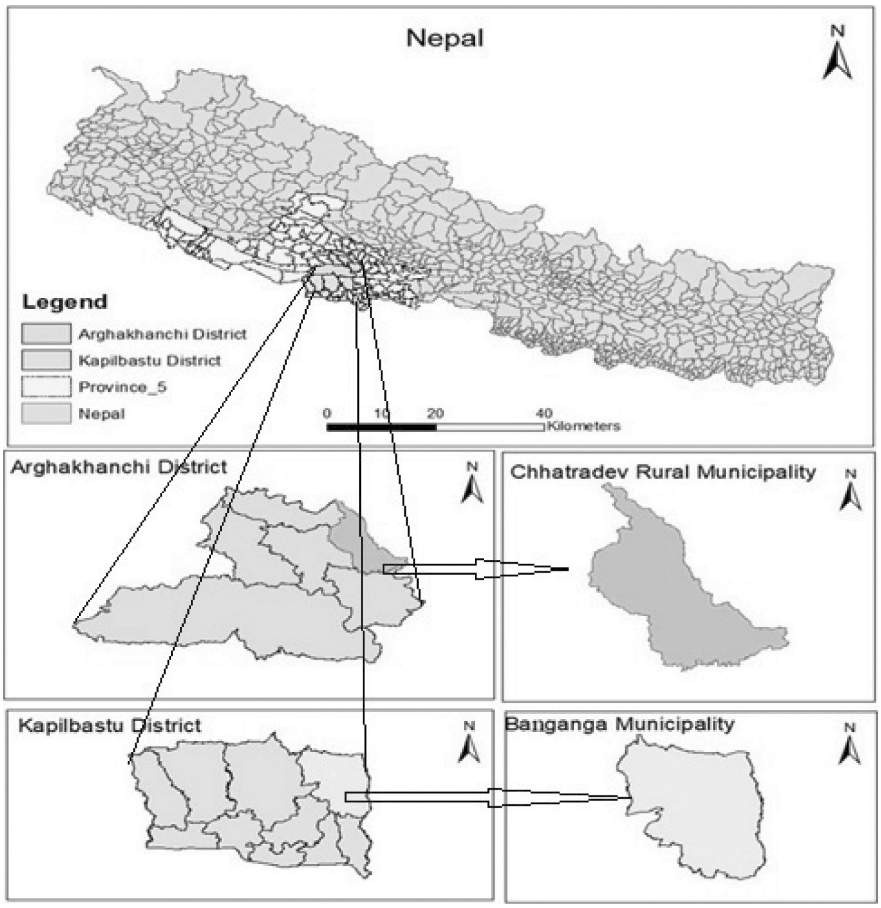

Figure 1: A map showing the study area [top: map of Nepal and an indication of the study area; middle left: Arghakhanchi district; middle right: Chhatradev Rural Municipality; bottom left: Kapilbastu district; bottom right: Banganga Municipality]

Banganga Municipality

The Banganga Municipality lies in 27°35'-27°48' N and 83°03'-83°14' E at the north-east belt of Kapilbastu district. The altitude ranges from 100 to 350 m asl. The area of this municipality belongs to the Terai region. Major ethnic groups residing in the area are Brahmin, Chhetri, Gurung, Magar, and Tharu. The vegetation of the area is dominated by riverine deciduous forest with *Dalbergia sissoo* and *Bombax ceiba* species. Other major tree species include *Shorea robusta, Leucaena leucocephala, Artocarpus lakoocha, Morus alba, Artocarpus heterophyllum.* The Banganga has a hot and humid climate during the summer and cold during the winter. The temperature ranges from 18°C to 30.3°C and, the average annual rainfall is 1532.0 mm (DHM, 2017).

Data collection and presentation

Informal consultation with local people and field observation were the major approaches for data collection for the study in study areas. Age-old people were consulted to document the customary use and ethnobotany of the bamboos of the region. The species of the bamboos were recorded during the field observation in the first-hand sites or the used site of the bamboos products. A total of 50 individuals from 150 and 30 households from 200 were taken from the mid-hills and Terai region, respectively for individual consultation from separate households on a sporadic and random basis without overlapping the same family member of a household. The responses on the utilizations of bamboos were recorded and triangulated.

Results and Discussion

Type of bamboo available in the study area

The following seven types of bamboos were identified in the study area (Table 1). The major dominant species in the hills was *Bambusa balcooa* and Terai was *Dendrocalamus strictus.*

Uses of bamboo

The uses of bamboo traditionally in the study area are summarized in tabular form (Table 2). Figures in the remark column refer to the serial number of Table 1 and corresponding species of bamboos used for that particular purpose but not confined to.

Ethnobotany of bamboos is a site, locality, and culture-specific. This is not unique from other studies reveals in this regard. Jackson (1994), explores a dozen of the traditional use of bamboos in the Midhills of Nepal prevails. But these are very general use explore by that study but the minor and detailed use are presented by this study from the Midhills and the Terai region of Nepal. In recent decades, the growing trend of diversifying household income sources is based on the bamboos for a poor and ultra-poor household in the lowland of Nepal (Jha & Yadav, 2015). This exercise not only would support the protection and reproduction of bamboos in any locality but also diversify the options for households' livelihood. This study further broadens the knowledge on ethnobotanical use of the bamboos and explores the potential use. Bamboos are being used in many aspects of the study area. These species have very important support in rural livelihoods

Table 1: The species of bamboos found in the study area

S.N.	Local Name	Botanical Name	Ecological Region	Remarks
1	Tame bans	*Bambusa nepalensis* Stapleton	Mid-hills	The best clumps consumption
2	Lebans	*Ampelocalamus patellaris* (Gamble) Stapleton	Mid-hills	Relatively medium size
3	Dhanu bans	*Bambusa balcooa* Roxb.	Mid-hills	Better for fodder
4	Mal bans	*Dendrocalamus strictus* (Roxb.) Nees	Terai	Better for structural use
5	Tite-nigalo	*Drepanostachyum falcatum* (Nees.) Keng.	Mid-hills	Relatively the smallest size
6	Thulo-nigalo	*Drepanostachyum intermedium* (Munro) Keng.	Mid-hills	Better for basket weaving
7	Choya Bans	*Dendrocalamus hamiltonii* Gamble	Mid-hills and Terai	Better for basket weaving

Table 2: The ethnobotany of bamboos in the study area

S.N.	Uses	Major Part	Value of Uses	Remark*
1	Rainwater disposal from CGI sheet, slate roof	Stem	Tools accessories	1, 3
2	Ropes making - fiber and slicing	Stem, an early age	Tools and accessories	2, 5, 6
3	Water canal, water tap	Stem	Tools and accessories	1
4	Chair, stools, canket (Khatiya)	Stem	Structural use- Construction	3, 5, 6, 7
5	Soil conservation and fencing, Wall support	Stem	Ecological use - soil conservation Safeguarding use - fencing	1-7
6	Support for climber vegetables	Stem	Farm-field	3, 5, 7
7	Decorative use	Rhizomes	Ethical/cultural value	3
8	Vegetable - new shoots/culms and pickle	Clumps	Consumptive value	1
9	Souvenir, handcrafts, gifts articles	Rhizomes, stems, branches, leafs	Consumptive value	3, 7
10	Scales for fueling	Scales, branches	Consumptive value	1-7
11	Fuel wood	stem	Consumptive value	1-7
12	Fodder	leaves	Consumptive	1, 2, 3, 5, 6
13	Stick and support	Stem, branches	Tools and accessories	2, 3, 4, 7
14	Bow and arrow	stem	Decorative/recreational value	3
15	Cradle and rope	stem	Tools and accessory	2, 5, 6, 7
16	Swinging	stem	Recreational	3, 4, 7
17	Nesting and resting places for birds and bats	Nodes, stems, rhizomes	Ecological value	1, 3, 4, 7
18	Stick for bells	Stem, branches	Consumptive	3, 4
19	Hut construction	Stems	Structural	2-7
20	Hut for hey and dry grass storage	Stems	Structural value	3, 4
21	Furniture and construction wood	Stems	Tools and accessories	5, 6
22	Cooking pot (Dhungre-khaja)	Stems	Recreational	3
23	Hooking instruments	Stems	Tools and accessories	2, 3, 4
24	Plowing main beam, shaft, and support	Branches, stem	Tools and accessories	3, 4, 7
25	The fixed peg for fixing domestic animals	Stems, branches	Tools and accessories	3, 4
26	Scaffolding	Stem	Structural value	3, 4
27	Bedding materials	Leaves	Tools and accessories	1-7
28	Flute making	Stem/branch	Recreational	1
29	Ladder making	Stems	Structural value	3, 4, 7
30	Flooring and ceiling	Stems	Structural value	3, 4, 7
31	Goat cage, cowshed	Stems	Structural value	3, 4, 7
32	Weaving for Doko, dalo, soli, phugo, store-grain, basket, cage, umbrella (Siu)	Stems	Tools and accessories	5, 6
33	Religious use - during marriage and other God offering ceremonies in Hinduism, god effigy	Stems	Religious/cultural value	1, 4
34	Bow and arrow as a symbol of dignity	Stems	Cultural value	4
35	Electrification - electric poles in rural areas	Stems	Structural value	3, 4
36	Maize and hay storing structure	Stems	Structural value	3, 4
37	Funeral time -dead body tying and carrying to the burning or burying sites	Stems	Cultural value	3, 4, 7
38	Liquid carrier, carrying vegetable for selling or fetching from farm - hanger	Stems	Structural value	3, 4
39	Nest for birds	Leaves	Structural value	1, 3, 4, 7
40	Kids playing things -dandibigo	Stems	Recreational value	3
41	Fixing/joining the drinking water pipes in steeped terrains	Stems	Structural value	2

S.N.	Uses	Major Part	Value of Uses	Remark*
42	Religious value - symbols of god and goddess in worshiping grandeur	Whole parts	Cultural value	3
43	Pens and pencils using for painting and writing - horoscope	Stems	Study purpose	5, 6
44	Teeth brushing and Comb	Stems	Personal uses and health care	3, 5, 6
45	Key for making a traditional mattress	Stems	Structural value	3
46	Lingo in Falgu Purnima (Holy)	Stems	Cultural and recreational value	1, 4
47	Bamboo gardening	Whole plant	Decorative purpose	5, 6
48	Swinging for kids/ Fixing a rope for a swing	Stems	Recreational purpose	3, 7
49	Hand fans	Stems	Personal use	2, 5, 6
50	Pulping for paper	Whole plant	Industrial purposes	4, 7
51	Water source protection/CO2 sequestration (13% faster than woody trees)	Whole plant	Environment conservation	1-7
52	Winnows and sieves for cleaning grains	Stems	Agricultural uses	5, 6
53	welcoming gate (both live-permanent and felled-temporary)	Stems	Decorative and structural value	3, 5, 6
54	Rhizomes for making a pot to put ambrosia during the offering	Rhizome	Religious	3
55	Landslides and stream bank protection	Rhizome	Environment conservation	1-7
56	Effigy (lingo) making in Tulasi (Ocimum) marriage ceremony	Stem	Cultural use	2, 4
57	Raft making	Stem	Structural use	4, 7
58	Nailing	Sawn stem	Structural use	1, 5, 7
59	Bridge/culvert	Stem	Structural use	3, 4
60	Tying material	Split stem / rhizome's hairs	Other use	5, 6
61	Thatch supporting/lattice	Split stem	Structural use	2, 3, 7

and facilitate income generation activities in many instances to the rural dwellers. These are the sources of income in rural areas in the study areas.

Due to the fastest growth rate and has acclimatize to diverse climates; these plants are widely adapted in the regions. These plants are useful for several purposes so that rural people can accept these plants as a source of income. Replications, application, and use of ethnobotany of bamboos would be very crucial to diversify livelihood options in the regions where these plants are available and make available. These utilitarian values of the bamboos in these regions give insight and explore the wide diversity in ethnobotany of bamboos of the regions. This knowledge would be a reference to the other communities inside the country and to the global communities for application and replication of bamboos' usufruct for diversifying bamboo-based livelihoods options. In other words, the potential diversified use of bamboos in changing context without jeopardizing the traditional indigenous knowledge would be a great asset for a nation.

Despite bamboos have many ethnobotanical values in the locality; they have high carbon sequestration and storage potentiality. This invites international attention for mitigating global environmental problems through local action by simply the management of bamboos, and become a means of carbon trading. This is highlighted by different studies as well. A study in India indicates that mean carbon storage and sequestration rate in woody bamboos range from 30–121 Mg ha^{-1} and 6–13 Mg ha^{-1} yr^{-1}, respectively. Bamboo has vigorous growth, with completion of the growth cycle between 120 and 150 days. Because of its rapid biomass accumulation and effective fixation of CO_2, it has a high carbon sequestration capacity. Over and above the high biomass carbon storage, bamboo also has a high net primary productivity (12–26 Mg ha^{-1} yr^{-1}) even with regular selective harvesting, thus making it a standing carbon stock and a living ecosystem that continues to grow (Nath et al., 2015a). Such potentiality also poses in the study area as well and can be a great source of carbon sink in the area in a very short period as compared to the similar sink by trees.

Bamboos have become an indicator for soil quality indexing (SQI) in the modern context. A study reveals that Farmers' hierarchal folk soil classification was consistent with the laboratory scientific analysis in Assam, India. Culm production was the highest (27 culms clump^{-1}) in kalo mato (black soil) and the lowest (19 culms clump^{-1}) in *balaute mati* (sandy soil). Development of SQI from ten relevant soil quality parameters and its correlation with bamboo productivity explained the 64% of the variation suggests SQI as the best determinant of bamboo yield. Data presented indicate that the *kalo mati* (black soil) is sustainable or sustainable with high input. However, the other three folk soil types (red, stony and sandy soil) are also sustainable but for other land use (Nath et al., 2015b). Such soil quality indexing assessment is not the scope of this study but opensa new area for the given sites to the researcher in this field using this species without jeopardizing the ethnobotany of bamboos, as noted.

Apart from minor constructional, ethnopedological, ethnobotanical, and carbon sequestration use, bamboo could be a replacement material for many mine-based structural materials and replacement of timber (tree-based), as noted in this study. Other researchers are consistent with our assumption that bamboo units had strengths in heat storage and vapor resistance but weakness in heat transport performance, which varied with climate condition, building function, and construction type. Bamboos have advantages in full bamboo/timber constructions in hot and temperate regions (Huang et al., 2017). Moreover, the status of wood as a sustainable construction material has been reflected upon concerning different features such as environmental friendliness, durability, waste disposal, and recycling, is bamboo for structural and constructional relatively good properties (Asif, 2009).

The construction groups with bamboo particleboard as interior or (thickened) interlayer boards show overall better hygrothermal performance than those with timber units given the same construction and space size. For example, the annual total cooling demand and cooling peak are reduced by up to 14%, respectively. Moreover, the combination of bamboo mat board and bamboo particleboard in bamboo groups shows better performance in most indicators than the combination of other substance-based materials and Spruce in timber groups. These advantages of bamboos in addition to lower cost and technical requirements, bamboo particleboard and bamboo mat board have the potential to be local climate adaptive building materials and are competitive compared with the corresponding timber products (Huang & Sun, 2021). Furthermore, the multi-level comparison between bamboo and timber units demonstrates the feasibility to 'substitute timber with bamboo' in terms of hygrothermal performance, identifies the dominant bamboo variants, and offers suggestions on its market competition with timber (Huang & Sun, 2021).

The utilization of bamboo (including nigalo, *Drepanostachyum falcatum* (Nees) Keng, which is commonly known as Himalayan bamboo) grows naturally as well as planted artificially in community and state-owned forests, and is also cultivated in people's backyards. The stem of bamboos is collected and traded for manufacturing household items such as doko (big basket), dalo (small basket), suppa (tray), chakaties (small mats), and matta (sleeping mats) (ICIMOD, 2020).Also, bamboo growing is strongly associated with farm size (landholding), wealth, household size, food sufficiency, irrigation facility, livestock owned, land tenure, household off-farm and on-farm incomes, physiography of the land, and access to forests. Landholding is the most important socioeconomic factor that influences households' decision to grow bamboos (Das, 1998).

Increasing concern of bamboos and networking (eg. INBAR - International Network on Bamboos and Rattan) of the country with international communities regarding bamboos growing the opportunities to explore the multiple uses of bamboos in upcoming days. As the climate and diverse species favor in the Nepalese climate for bamboos (Jackson, 1994), this species could be one of the best fast-growing plant species for socio-economic as well as environmental transformation for livelihood support as well as industrializing the product's base on bamboos in Nepal without compromising environmental and ecological integrity. As result suggested, the government policy is required to shape accordingly and bamboos-based infrastructure is required for materializing the policy for the prosperity of the country. This lesson could be learned by other countries where the bamboos are distributed naturally and/or artificially.

Conclusion

All together 7 distinct species were identified, 60 more traditional uses of bamboos were documented and these uses are categorized into broad groups viz. structural use, consumptive use, environmental value, religious and cultural use, agricultural use, and other use. Apart from these ethnobotanical uses, Nepal has already become parties of many national and international networks regarding bamboos to explore potential opportunities regarding the species. These opportunities could be, in principle, climate change mitigation and carbon trading, soil quality indexing, and replacement of mine and wood-based products in more effective, efficient, and with a low level of technical inputs. Grasping such opportunities without jeopardizing indigenous traditional knowledge in bamboo use would be a great achievement for the locality as soon as for the country as a whole. These findings would be a reference for shaping appropriate policy to the country and other countries where the bamboos are distributed for materializing bamboo-based prosperity.

Author Contributions

We, both authors were involved in designing the concept, model of research, data collection in the field. The first author prepared the manuscript, edited it, and proofing whereas the second author thoroughly copy-edited polished, and proofing. Both authors read the manuscript and agreed to take public responsibility regarding this paper.

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Ethnomedicinal Plants of Kanchanrup Municipality Saptari, Nepal

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Abstract

The study was carried out in Kanchanrup Municipality-06, Spatari district. The exploration of ethnomedicinal plant and their traditional knowledge practices by local people of the study area. The knowledge is far beyond any modern medicinal practice. The study area is very rich in plant diversity including medicinal plants. The plants are used by local people as different remedies are only viable in the study area. The study area was surveyed from 21 April to 13 June 2016 to collect medicinal plants and information on traditional medicinal practices by interviewing with local healers, Dhami, Jhakari, and some knowledgeable old persons who have been experiencing the particular use for the treatment of the diseases. The survey depended on semi-structured questionnaires in the local language. A total of 40 household surveys were done in the study area. All total118 plants species were identified of 93 genera and 62 families. Among these, 48 herbs, 24 shrubs, 32 trees, and 14 climbers species were documented which are used for medicinal purpose. A total of 50 types of health problems were found, which was cured by using local plants. The common health problems were sexual disorder, cough and cold, diarrhea & dysentery, gastric, skin diseases, cuts and wounds.

Keywords: Dhami, Jhakari, Local people, Traditional knowledge.

Introduction

The term ethnobotany was first coined by Harshberger, who defined it as the study of plants used by primitive and aboriginal people (Harshberger, 1896). Ethnobotany is the relationship between people and plants in their surrounding area. This is common in Himalayan Terai region where an enormous wealth of medicinally important plant species commonly used in the society (Bajpai et al., 2016). Plant and plant products form an integral part of our life and it is extremely difficult to imagine the survival of humans without them. Traditional medicine is widespread throughout the world (WHO, 2002). Recently 88% of the global population turns to plants derived medicine as their first line of defense for maintaining health and combating diseases (Mahato & Sharma, 2015). In facts, the traditional beliefs to the varied uses of plants are deeply rooted in Nepalese culture (Bhattarai, 2018). Many plants have significance in terms of medicine (Mahato & Sharma, 2015).

The traditional knowledge of local people has high ethnobotanical importance due to cultural values and faith in indigenous knowledge. Indigenous knowledge is such a type of firsthand idea and practices refined from selected knowledge through thousands of years or even more (Karna, 1997; Magar & Neupane, 2016). The rural people of Nepal continue to depend on the local therapy for their health care as it is cheap, convenient, and freely available (Manandhar, 2002; Baral & Kurmi, 2006). It is interesting that whatever we have been enteredin the 21st century, 80% of villages' residence people's health problem is tackled by using herbal medicine prescribed by Vaidhya or traditional medicinal person or from guided by older people prescriptions. The ethnobotanical research acts as a bridge between traditional knowledge in medicinal plants.

Many traditional systems of medicine are now being gradually documented in Nepal. It has been estimated that various communities in Nepal use approximately 1000 species of wild plants in traditional medicinal practice (Chaudhary, 1998). According to Baral and Kurmi (2006) and Rokaya et al. (2010), 1792 to 2331 medicinal and aromatic plants in Nepal (Kunwar et al., 2013). These are particularly based on true folk and ethnomedicines purpose (Kurmi & Baral, 2004), which pass from one generation to another simply by verbal arguments. The WHO has been also estimated that about 80% of the populations in developing countries depend on traditional medicine for their primary health care needs. Many such plants also have other domestic uses.

The traditional use of plants collected through ethnobotanical research plays an important role in the practical aspect of traditional medicine. It is particularly important that studies in ethnobotany and ethnopharmacology continue to preserve traditional knowledge (Kurmi & Baral 2004). The aim of this study was documentations and identification of the ethnomedicinal plants and their local uses by the tribal people of the study area. The reason behind that study was various parts of the country; the ethnobotanical works have been well documented by the Governmental and Non-Governmental organizations like Universities, researchers, NGO, INGO, etc in different indigenous communities. Despite such studies, the research related to the use of medicinal plants in Kanchnrup Municipality, Saptari district is still lacking. The study was one such attempt, it documented traditional knowledge on the use of plants for curing various aliments by the residents of Kanchanrup Municipality, Saptari district. The information accumulated here will be of use to the readers, and related researchers in the future.

Materials and Methods

Study area

Saptari district is located in the Sagarmatha zone in the Province no. 2. The total area of this district is 1,359.28 Sq.km. The study area Kanchanrup Municipality-06, Saptari district, Nepal was shown in Figure 1. In this district, the altitude varies from 64 - 457 m asl (above sea level). The temperature varies from 7 to 40°C and the average rainfall is 1,336 mm to 1,835 mm. It is situated between 26°41' to 26°39' N latitude and 86°56' to 86°57' E longitude. The study area is frequently dominated by the Tharu community i.e. about 80% population of people belongs to the cast and the rest are followed by Mushar, Batar (Sardar), Malah (Mukhiya), Muslim, Thakur, Horizon (Ram), Newar, Brahmin, Chhetri, etc. Most of the elderly people are illiterate and no one has a higher education degree. Agriculture is the major occupation. However, agricultural products are not enough to meet their basic food need for the whole year.

The herbarium made from the collected plants has been deposited at the Department of Botany Tri-Chandra Multiple Campus, Ghantaghar, Kathmandu.

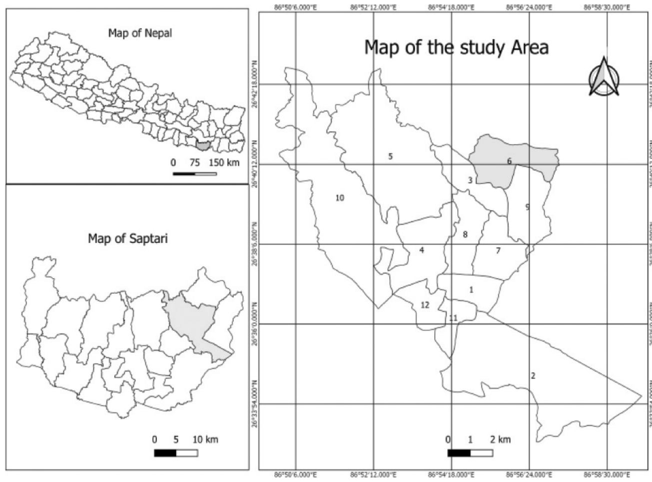

Figure 1: Map of Kanchanrup Municipality showing study area

Field Visit and Data Collections

The area was surveyed frequently during the study period from 2016 to 2017. In each visit, the local healers (Dhami, Jhakari, and Vaidya) or elderly people who knew medicinal plants were requested for the information about the utilization, mode of preparation of the drug, parts used the form of medicines through a semi-structured questionnaire in the local language. Sampled herbs, climbers, twigs, shrubs, and trees were identified in the field with the help of locals and available knowledge-based of local informants.

The plants were collected in their flowering and fruiting stage as far as possible from the natural habitat with the help of local healers for herbarium preparation. The plant specimens were pressed, through locally available instruments and materials with the guidance of the respective lecturer and professor of the Tri-Chandra Multiple Campus, Tribhuvan University, Kathmandu, Nepal.

The plant specimens were identified with the help of standard literature, journals, and reports accessed from the central library of Tribhuvan University (TU), and the Department of Plant Resources, Government of Nepal. Similarly, the plant specimens that were collected and preserved were crosschecked with the herbarium of National Herbarium (KATH), Tribhuvan University Central Herbarium (TUCH), Central Department of Botany, and taxonomic expert. Plants with their respective uses, parts used, mode of drug preparation, the life form of plants, family, local name have been listed in Table 1.

Commonly used forms of medication:

The form of medication was followed as mentioned by Mahato and Sharma (2015).

- Decoction: It is prepared by boiling the plant parts in water to extract the drug in liquid.
- Infusion: It is prepared by soaking the plant's parts in water overnight or for some hours.
- Paste: The fresh plant parts are ground in water by stone mortar and pestle.
- Juice: It is obtained by squeezing the plant parts between hands or crushing the plant parts with a stone mortar and pestle and the obtained juice is filtered through a clean cloth.
- Liquid drug: The plant parts are crushed squeezed and the required amount of water is added to dilute them.
- Powder: It is prepared by crushing the dried plant parts with stone mortar and pestle

Results and Discussion

A total of 118 plant species were recorded as medicinal values in the Kanchanrup Municipality - 06. The plants were written with their local name, Botanical name, uses & their mode of application in the form of medicine for curing & preventing various types of diseases that are far from any modern medicine system available (Table 1). Based on the habit of the used medicinal plants, several herbs were highly (48 spp.) used followed by the tree (32 spp.), shrub (24 spp.), and climber (14 spp.) Figure 2.A similar result of medicinal plant habit was recorded from several authors (Pande, 2013; Bhattarai & Acharya 2015; Magar & Neupane, 2016; Tamang et al., 2017).

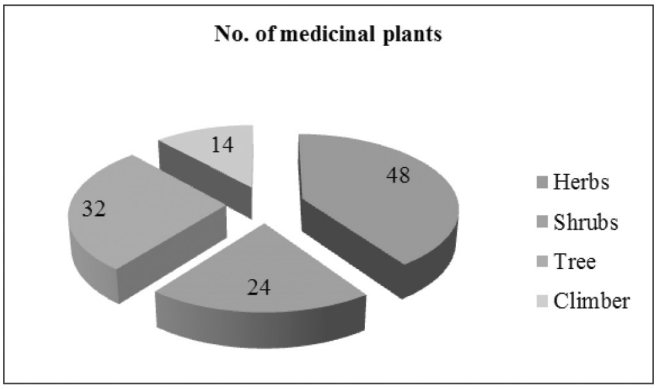

Figure 2: Habit of medicinal plants in the study area.

Out of 118 identified plant species, 117 plant species were identified up to species level, 1 species up to genera level. All total 93 genera belonged to 62 families were recorded during the survey (Table 1).The dominant genera wereficus (3 genera) and followed by 2 genera each for *Allium*, *Artocarpus*, *Calotropis*, *Clerodendrum*, *Cyanodon*, *Jatropa*, *Musa*, *Phyllanthus*, *Remusatia*, *Terminallia* and *Trichosanthes*. The largest family was Poaceae having 7 species followed by Euphorbiaceae, Fabaceae, and Malvaceae (5 spp.) in each, Apocynaceae, Araceae, Cucurbitaceae, and Moraceae (4 spp. in each), and others as shown in Figure 3. According to Acharya & Pokharel (2006); Bhattarai & Acharya (2015) revealed Fabaceae was the dominant family followed by Asteraceae in the second position in medicinal use.

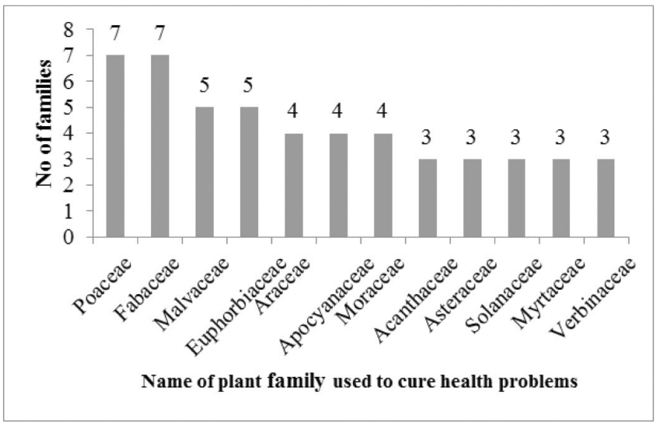

Figure 3: Families of most useful medicinal plants

Among the different medicinal used plant parts, leaves (21spp.) were the most useful plant parts followed by root (19 spp.) and others as shown in Figure 4. The study also showed that stem, bark, shoot the whole plant, flower, rhizome, hardwood, stem bulb, and root bulb were used for the medicinal purpose in the study area. According to Shah & Lamichhane (2017) and Acharya (2012), leaves were the most dominant parts prescribed for curing the health disorders. Harvesting of leaves is not very much harmful to the plants than other parts like stem, root, barks, and whole plants, and in the way for flowers and fruits available in seasonally.

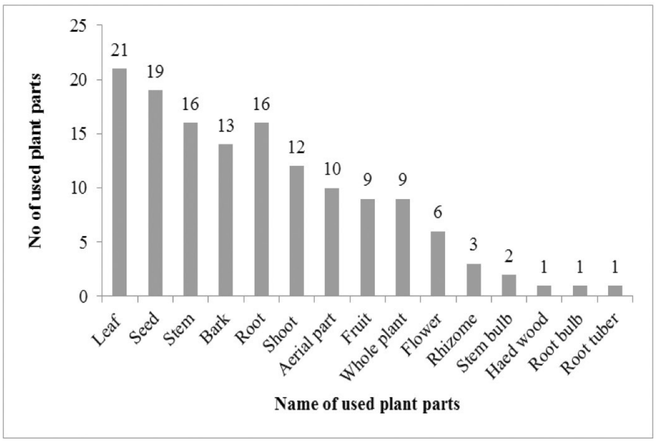

Figure 4: Number of used plant parts for medicinal purpose

In this study, 50 types of human health disorders were cured by using local plants and their system of the traditional therapeutic process. The maximum number of plants i.e. 96 was reported to cure human health disorder followed by 19 for veterinary uses. Among them 4 plants were commonly used in both human health disorder and veterinary uses shown in Figure 5. Gacchadar (2006) was also reported Tharu community of Lakhantari, Pakali, and Jagatpur of Morang, Sunsari and Saptari districts respectively were used to cure 43 types of health problems by the local therapeutic process using local plants. Additionally, Chaudhary et al. (2020) has repoted37species of medicinal plants among them 25 species were used for the various health alignment by Tharu community of Eastern Nepal. Similarly 93 plants reported from Manag (Bhattarai, 2006); 32 from Upper Mustang (Bhattarai et al., 2009); 72 medicinal remedies from Dhadhing (Poudel & Gautam 2008); plants using 18 different health aliments (Maden et al., 2008) and many more from different part of the country.

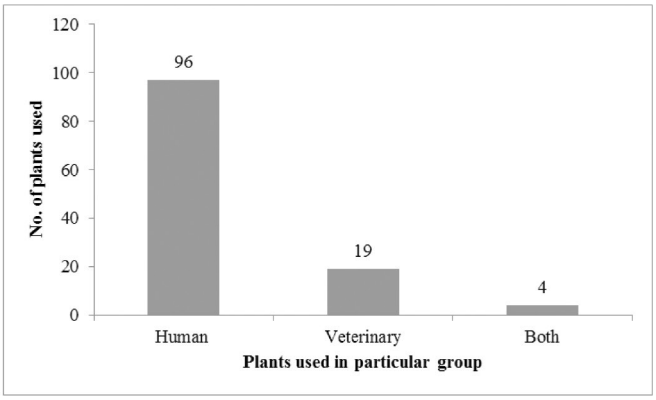

Figure 5: Medicinal plants used in a particular group (Human, Veterinary & both)

Conclusion

A total of 118 plant species under 93 genera and 62 families were used in 50 different health problems by local peoples in Kanchanrup Municipality-6. The common health problems were sexual disorder, cough & cold, diarrhea & dysentery, gastric, skin diseases, cuts & wounds, & others tabulated in (Table 1) also very important health problems. The study area is rich in plant diversity and ethnomedical knowledge of plants. The plants are used by local people as different remedies are only viable in the study area and far beyond any modern medicinal practices.

Author Contributions

All the authors were involved in concept development, research designing, defining of intellectual content and literature research. Vijay Kumar Chaudhary collected and analyzed data, and prepared manuscript. Suman S. Bhattrai edited and reviewed the manuscript. Binod Gautam was helped in the preparation of herbarium and assisting in identification process.

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Table 1: List of the medicinal plants and their ethno medicinal uses

S.N.	Vaucher specimen no.	Botanical Name	Local name	Family	Habit	Habitat	Plant availability	Form of medication	Used parts	Uses in health disorders	Used for
1	S_{05}	*Abelmoschus esculentus* (L.) Moench	Ramjhingani /Bhindi	Malvaceae	S	P	O	Liquid	shoot, root	Dysentery	H
2	S_{55}	*Abrus precatorius* L.	Kajaurni	Fabaceae		W	R	Infusion	Leaf, root	Rheumatism, Joint pain, Arthritis	H
3	S_{06}	*Abutilon indicum* (L.) Sweet	Sakharibhakari/ Bilaaekethopa	Malvaceae	S	W	R	Liquid	Root	Body fever	H
4	S_{11}	*Acacia catechu* (L.) Willd.	Khyar	Fabaceae	T	W	C	Paste	Hardwood	Tongue infection	H
5	S_{15}	*Achyranthes aspera* L.	Ultachichri	Amaranthaceae	H	W	C	Solid	Leaf, stem	Dysentery, toothache	H
6	S_{03}	*Acoruscalamus* L.	Achchheni	Araceae	H	P	C	Liquid	Rhizome	Diarrhea and Dysentery	H/V
7	S_{118}	*Adina cordifolia* (Roxb.) Brandis	Karmain	Meliaceae	T	W	C	Decoction	Bark	Weakness, Tonic for baby mom after delivery	H
8	S_{04}	*Aegle marmelos* L.	Bel	Rutaceae	T	P	R	Liquid	Fruit	Dysentery	H
9	S_{07}	*Allium cepa* (L.) Correa	Pyaj	Amaryllidaceae	H	P	C	Juice	Stem bulb	Ear pain	H
10	S_{17}	*Allium sativum* L.	Lassun	Amaryllidaceae	H	P	C	Cooked in oil	Stem bulb	Cold, joint pain, Arthritis, Antiseptic and pain killer	H/V
11	S_{25}	*Aloe barbadensis* (L.) Webb	Ghee Kumari	Liliaceaea	H	P	R	Juice	Leaf	Stomachache, Dysentery, Skin diseases	H
12	S_{99}	*Alstonia scholaris* (L.) R. Br.	Chhatiyan	Apocynaceae	T	W	R	Infusion, Latex	Bark	Menstrual disorder, Anti worming, weakness, Blood purification	H
13	S_{12}	*Alternanathera sessilis* (L.) R. Br. ex DC	Sarhauchi	Amaranthaceae	H	W	C	Vegetable	Shoot	Loss of appetite, Avitaminosis	H
14	S_{26}	*Amorphophallus campanulata* (Roxb.) Blume ex Decne	Ol	Araceae	H	P	C	Latex, paste	Stem, flower	Inflammation , Skin boil (pilo)	H
15	S_{23}	*Andrographis paniculata* (Burm. f.) Wall. ex Nees	Kalapnath	Acanthaceae	H	W	R	Liquid	Leaf, shoot	Body fever	H
16	S_{22}	*Annona reticulata* L.	Saripha	Annonaceae	T	P	O	Juice	Leaf	Lice, external body parasites	H/V
17	S_{39}	*Argemonemexicana* L.	Surujkant	Papaveraceae	H	W	C	Oil	Seed	Skin-itching	H
18	S_{27}	*Artocarpus integra* (Thunb.) Merr.	Katahar	Utricaceae	T	P	C	Liquid	Seed	Diarrhea	H
19	S_{08}	*Artocarpus lakoochha* Roxb.	Badhar	Moraceae	T	W	C	Liquid	Bark, root	Diarrhea and Dysentery	H
20	S_{19}	*Asparagus racemosus* Willd.	Sitabari	Liliaceaea	H	W	C	Powder	Root tuber	Menstrual disorder, for boosting milk	H/V
21	S_{10}	*Azadirachta indica* A. Juss.	Neem	Meliaceae	T	P	C	Decoction, solid	Leaf, stem	Skin allergy, Blood purification, Anti worming	H
22	S_{18}	*Basella alba* L.	Porosag	Basellaceae	Cl	W	C	Vegetable	Aerial parts	Avitaminosis	H/V

S.N.	Vaucher specimen no.	Botanical Name	Local name	Family	Habit	Habitat	Plant availability	Form of medication	Used parts	Uses in health disorders	Used for
23	S_{16}	*Bauhinia vahlii* Wight *and* Arn.	Malahan/ patripata	Fabaceae	V	W	C	Powder	Stem, root	Piles	H
24	S_{106}	*Blainvillea acmella* (L.) Philipson	Mirchaiyajhar/ Lang jhar	Asteraceae	H	W	C	Solid	Fruit	Tongue infection	H
25	S_{47}	*Blumea lacera* (Burm.f.) DC.	Mokarajhar	Asteraceae	H	W	C	Juice	Leaf, shoot	Cut	H
26	S_{58}	*Bombax ceiba* L.	Simar	Bombaceae	T	W	C	Latex	Stem	Dysentery	H
27	S_{14}	*Brassica campestris* L.	Tori	Brassicaceae	H	P	C	Oil	Seed	Nausea, Cold fever, Skin healthy	H/V
28	S_{09}	*Brayophyllum pinnatum* L.	Agarmause	Crassulaceae	H	P	R	Liquid , Juice	Leaf	Stomachache, Dysentery, Cut	H
29	S_{01}	*Bryonialacinosa* L.	Ladvadi	Cucurbitaceae	Cl	W	R	Ash paste	Aerial parts	Skin diseases	H
30	S_{10}	*Calotropis gigantean* (L.) Dryand	Ujra Yank	Asclepiadaceae	S	W	R	Liquid	Root	Menstrual disorder	H
31	S_{75}	*Calotropis procera* (Aiton) Dryand	Nilo Yank	Asclepiadaceae	S	W	C	Liquid	Root	Weakness	H
32	S_{64}	*Cannabis sativa* L.	Bhang	Cannabaceae	H	W	C	Juice, Smoke	Aerial parts	Diarrhea, Dysentery and Tiredness	H/V
33	S_{117}	*Capsicum annum* L.	Marchaie	Solanaceae	H	P	C	Oil	Fruit	Ear pain	H
34	S_{29}	*Carea arborea* Roxb.	Kumhi	Myrtaceae	T	W	C	Liquid	Bark	Dysentery	H
35	S_{31}	*Carica papaya* L.	Areleba	Caricaceae	S	P	C	Latex	Aerial parts	Ringworm infection, Jaundice	H
36	S_{61}	*Catharantus roseus* (L.) G. Don	Sdabaharphool	Apocynaceae	H	P	O	Liquid	Leaf	Diabetes (Sugar imbalance)	H/V
37	S_{77}	*Centella asiatica* (L.) Urb.	Bhatpurain	Ulmiferae	H	W	C	Liquid	Whole plants	Gastric Diarrhea and Dysentery	H
38	S_{92}	*Cereus peruvianus* (L.) Mill.	Lohajan Kant	Cactaceae	S	P	C	Juice	Stem	Cough	H
39	S_{40}	*Chenopodium album* L.	Bathuwa	Chenopodiaceae	H	W	C	Vegetable	Shoot	Blood pressure, Avitaminosis	H
40	S_{32}	*Cinnamomum tamala* (Buch.-Ham.) Nees and Eberm.	Patrak	Lauraceae	T		C	Paste	Bark	Headache	H
41	S_{35}	*Cissus quadrangularis* L.	Giraha bath/ Lahar bath	Vitaceae	Cl	P	R	Fried vegetable	Shoot	Joint pain/ Arthritis	H
42	S_{37}	*Citrus limon* (L.) Burm.	Nemo	Rutaceae	S	P	C	Juice	Fruit	Diarrhea, Dysentery and cough	H
43	S_{21}	*Clerodendrum indicum* (L.) Kuntze	Saharphoka	Verbinaceae	S	P	R	Solid	Stem	Skin allergy	H
44	S_{73}	*Clerodendrum viscosum* Vent.	Bhaeet	Verbinaceae	S	W	C	Liquid	Shoot, Leaf	Blood purification, Anti-worming and Ear pain	H
45	S_{60}	*Coix lachryma*-jobi L.	Baijanti/ Aronagarona	Poaceae	H	W	O	Solid	Seed	Skin boil (Pilo)	V
46	S_{46}	*Corchorus capsularis* L.	Patwa	Malvaceae	H	P	C	Ash paste	Bark	Skin burning	H
47	S_{30}	*Croton bonplandianus* Baill.	Anchin	Euphorbiaceae	S	W	C	Juice	Shoot, Leaf	Cut	H/V
48	S_{13}	*Cucuta reflexa* Roxb.	Amarlati	Cuscutaceae	Cl	W	C	Liquid	Whole plants	Jaundice	H
49	S_{02}	*Curcuma angustifolia* Roxb.	Hardi	Seitaminae	H	P	C	Powder	Rhizome	Cough cold and Sneezing	H
50	S_{20}	*Cyanodon dactylon* (L.) Pers.	Deebghans	Poaceae	Cr	W	C	Solid, Paste	Whole plants	Cut	H

S.N.	Vaucher specimen no.	Botanical Name	Local name	Family	Habit	Habitat	Plant availability	Form of medication	Used parts	Uses in health disorders	Used for
51	S_{62}	*Cyanodon dactylon* (L.) Pers.	Oojaradeebghan	Poaceae	Cr	W	C	Paste	Whole plants	Headache	H
52	S_{48}	*Cyperus rotundus* L.	Mothaghans	Cyperaceae	H	W	R	Solid	Root bulb	Headache	H
53	S_{63}	*Dalbergia sissoo* Roxb.	Sisau	Fabaceae	T	W/ P	C	Liquid	Leaf	Dysentery	H/V
54	S_{36}	*Datrura stramonium* L.	Dhutur	Solanaceae	S	W	C	Solid, smoke	Fruit	Diarrhea, Dysentery and Tiredness	H
55	S_{44}	*Dendrocalamus hamiltini* Nees and Arn. ex Munro	Bans	Poaceae	S	P	C	Powder	Bark	Wounds	H
56	S_{89}	*Dolichos lablab* L.	Chhimi sag	Fabaceae	Cl	P	O	Juice	Leaf	Ringworm infection	H
57	S_{33}	*Dropteris* sp.	Dhakiya sag	Dryopteridaceae	H	W	C	Liquid	Root	Miscarriage	H
58	S_{37}	*Eclipta prostrate* (L.) L.	Bhamorya	Asteraceae	H	W	C	Juice	Whole plants	Hands and foot healings	H
59	S_{24}	*Eleusine indica* (L.) Gaertn.	Marwainighans	Poaceae	H	W	C	Solid, Liquid	Root	Eye infection	H
60	S_{28}	*Eulaliopsis binata* (Retz.) C. E. Hubb.	Saabai	Poaceae	H	W	C	Paste	Whole plants	Urinary problem	H
61	S_{34}	*Euphorbia royleana* Boiss.	Pasid	Euphorbiaceae	S	P	R	Solid	Leaf	Cough and cold	H
62	S_{41}	*Ficus glomerata* Roxb.	Dumair	Moraceae	T	W	C	Latex	Aerial parts	Cough and cold	H
63	S_{38}	*Ficus hispida* L. f.	Khokhas	Moraceae	T	W	C	Pudding, Latex	Aerial parts	Miscarriage, cough and cold	H
64	S_{45}	*Ficus religiosa* L.	Peepal	Moraceae	T	W/ P	C	Decoction	Decoction	Foot and moth diseases	V
65	S_{42}	*Glycyrrhiza glabra* L.	Jethimandu	Fabaceae	Cl		NA	Solid	Stem	Dry cough	H
66	S_{57}	*Hibiscus rosa-sinensis* L.	Arhulphool	Malvaceae	S	P	C	Liquid	Flower	Menstruation disorder	H
67	S_{70}	*Holarrhena pubsence* (Buch.-Ham.) Wall.	Koraiya	Apocynaceae	T	W	C	Decoction	Bark	Blood pressure, Mental disorder	H
68	S_{59}	*Hygrophila auriculata* (Schumach.) Heine,	Bauglakant	Acanthaceae	S	W	O	Liquid	Seed	Sexual disorder (Dhaturog)	H
69	S_{52}	*Ipomoea carnea Jacq.*	Karmi sag/ Latikarmi	Convolvulaceae	Cl	W	R	Juice	Whole plants	Skin allergy	H
70	S_{51}	*Jatropa gossypiofolia* L.	LalkaBaghandi	Euphorbiaceae	S	W	C	Infusion	Stem, root	Weakness, loss of appetite, Tonic for child delivered women	H
71	S_{50}	*Jatropha curcas* L.	Baghandi	*Euph*orbiaceae	S	W	C	Infusion, solid	Stem, root	Weakness, loss of appetite, Tonic for child delivered women	H
72	S_{65}	*Justica adhathoda* L.	Bakas	Acanthaceae	S	W	R	Decoction	Bark, Leaf	Blood purification, Asthma, cough and cold	H
73	S_{68}	*Lagenaria siceraria* (Molina) Standl.	Sajwine/ Lauka	Cucurbitaceae	Cl	P	O	Ash paste	Aerial parts	Skin diseases	H
74	S_{53}	*Lepidium sativum* L.	Chamsoor	Brassicaceae	H	P	C	Solid	Seed	Eye infection (Eye clearance from dust and any causality from external bodies)	H
75	S_{79}	*Leucas indica* L.	Dulphii	Labiateae	H	W	C	Juice, Pickle	Shoot	Cough and Cold	H/V
76	S_{116}	*Machilus gamblei* King ex	Daradmeda	Lauraceae	T	W	R	Paste	Bark	Bone dislocation, Fracture of	H

S.N.	Vaucher specimen no.	Botanical Name	Local name	Family	Habit	Habitat	Plant availability	Form of medication	Used parts	Uses in health disorders	Used for
		Hooke.f.								external body parts	
77	S_{66}	*Macrotyloma uniflorum* (Lam.) Verdc	KurthiDail	Fabaceae	H	P	C	Infusion	Seed	Kidney stone	H
78	S_{54}	*Madhuca longifolia* (Koenig) Macbride	Mahuwa	Sapotaceae	T	W	R	Liquid	Flower	Tiredness	H
79	S_{71}	*Mangifera indica* L.	Aaam	Anacardiaceae	T	P	C	Decoction	Bark	Jaundice	H
80	S_{84}	*Mimosa pudica* L.	Lajaunijhar	Fabaceae	H	W	C	Latex	Aerial parts	Eye infection	H
81	S_{98}	*Musa balbisiana* Colla	Aathiyakera	Musaceae	H	P	C	Solid	Fruit, root	Dysentery, Naseko, Vedeko	H
82	S_{76}	*Musa paradyaica* L.	Natwarkera	Musaceae	H	P	C	Solid	Fruit	Piles	H
83	S_{86}	*Nelumbo nucifera* Gaertn.,	Kamal phool	Nymphiaceae	H	W	R	Liquid	Flower	Excess bleeding during menstruation periods	H
84	S_{90}	*Nigella sativa* L.	Mangrel	Rannunculaceae	H	P	C	Powder	Seed	Cough and cold	H
85	S_{67}	*Ocimum tenuiflorum* L.	Tulsi	Labiateae	S	P	C	Liquid, Paste	Seed, Leaf , Shoot	Vomiting, Snake bite, Cough and cold	H
86	S_{56}	*Opuntia monocantha* Haw.	Bagiyakant	Cactaceae	S	W	R	cooked in oil	Leaf	Rheumatism, Joint pain, Arthritis, Diarrhea	H/V
87	S_{69}	*Oroxylem indicum* (L.) Kurz	Patsan/ Sonpati	Bigoniaceae	T	P	R	Infusion	Bark	Hepatitis, Jaundice	H
88	S_{74}	*Oxalis corniculata* L.	Amrola	Oxalidiaceae	H	W	C	Paste	Whole plants	Skin boil (Pilo)	H
89	S_{87}	*Phyllanthus emblica* L.	Rikhya	Phyllanthaceae	T	W	C	Powder, Paste	Fruit	Gastric, Indigestion, Hairtonic	H
90	S_{49}	*Phyllanthus reticulatus* Poir.	Sikait/ Sikraitjhar	Phyllanthaceae	S	W	C	Liquid	Stem	Ear pain	H
91	S_{72}	*Piper betle* L.	Paan	Piperaceae	Cl	P	C	Solid	Leaf	Harital, Naseko	H
92	S_{91}	*Polygonum barbatum* L.	Bisnaayar	Polygonaceae	T	W	C	Solid	Whole plants	Lice, external body parasite	V
93	S_{78}	*Psidium gaujava* L.	Latam	Myrtaceae	T	P	C	Liquid	Shoot	Vomiting	H
94	S_{95}	*Rauwolfia serpentina* L.	Isarganj	Apocynaceae	S	P	R	Powder	Root	Blood purification, Anti-worming, Gastric and Loss of appetite	H
95	S_{80}	*Remusatia hookeriana* Schott	OojraKachchu	Araceae	H	P	C	Liquid	Root	Tail wound	V
96	S_{100}	*Remusatia vivipara* (Roxb.) Schott	Kariyakachchu	Araceae	H	W	C	Latex	Stem, root	Eye infection, Skin boil (Pilo)	H
97	S_{88}	*Rhododendron arboreum* L.	Laligurans	Ericaceae	T	W	NA	Juice, Paste	Flower	Throat infection by ingestion of fish spine	H
98	S_{126}	*Ricinus communis* L.	Andi	Euphorbiaceae	T	W	C	Oil	Seed	Inflammation , Skin boil (pilo)	H
99	S_{135}	*Saccharum* spontaneum L.	Ranrighans/ Kushyaeer	Poaceae	H	W	C	Juice	Stem	Urinary problem	H
100	S_{81}	*Schleichera oleosa* (Lour.) Oken,	Aathiyar/ Kusum	Spinadaceae	T	W	C	Oil	Seed	Hand and foot healing	H
101	S_{97}	*Scoparia dulsis* L.	Mishrikant/ Chinijhar	Scrophulariaceae	S	W	C	Liquid	Leaf	Menstruation disorder, Diabetes	H
102	S_{85}	*Semecarpus anacardium* L.	Bhela	Anacardiacae	T	W	C	Resin	Seed	Inflammation and Joint pain	H/V

S.N.	Vaucher specimen no.	Botanical Name	Local name	Family	Habit	Habitat	Plant availability	Form of medication	Used parts	Uses in health disorders	Used for
103	S_{111}	*Sesamum orientale* L.	Til	Pedaliaceae	H	P	C	Infusion	Seed	Menstruation disorder	H
104	S_{101}	*Shorea robusta* Gaertn., Fruct.	Sakhwa	Dipterocarpaceae	T	W	C	Resin	Stem	Dysentery	H
105	S_{104}	*Solanum xanthocarpum* Schrad. and Wendl.	Katgaini	Solanaceae	S	W	C	Smoke	Seed	Toothache	H
106	S_{93}	*Strychnos nux-vomica* L.	Koechla	Loganiaceae	T	P	R	Infusion	Seed	Blood purification, Dog bite, Poisonous for dog	H/V
107	S_{131}	*Syzygium cumini* (L.) Skeels	Jaum	Myrtaceae	T	W	C	Decoction, Juice , Paste	Seed, Bark, Leaf	Mouth and foot diseases, Dysentery, Blood pressure	H/V
108	S_{102}	*Terminalia bellirica* (Gaertn.) Roxb.	Behra	Combretaceae	T	W	C	Powder	Seed	Dysentery , Gastric	H
109	S_{96}	*Terminalia chebula* Retz.	Hairra	Combretaceae	T	W	C	Powder	Seed	Dysentery, Gastric	H
110	S_{82}	*Tinospora cordifolia* (Willd.) Hook. f. and Thoms.	Gurujlati	Menispermiaceae	Cl	W	C	Infusion	Stem	Gastric, Urinary problem	H
111	S_{83}	*Trachyspermum ammi* (L.) Sprague	Jamain	Apiaceae	H	P	C	Solid, Decoction	Seed	Indigestion, Promote lactation baby's mom after delivery	H/V
112	S_{119}	*Trichosanthes tricuspidata* Lour	Oojaramahkari	Cucurbitaceae	Cl	W	R	Powder	Root	Paralysis, Promote lactation baby's mom after delivery	H/V
113	S_{94}	*Trichosanthes wallichiana* (Ser.) Wight, Ann. and Mag.	Lalakamahkari	Cucurbitaceae	Cl	W	R	Solid	Fruit	Miscarriage	V
114	S_{103}	*Ulmus* sp.	Bhalser	Ulmaceae	T	P	R	Liquid	Flower	Menstruation disorder	H
115	S_{129}	*Urena lobata* L.	Bariyar	Malvaceae	S	W	R	Paste	Root	Ringworm infection	H
116	S_{121}	*Vitex negundo* L.	Sinmaeer	Verbinaceae	T	W	C	Juice	Shoot	Headache	H
117	S_{105}	*Zingiber officinale* Rosc.	Aadi	Zingiberaceae	H	P	C	Juice, Solid, Paste	Rhizome	Paralysis, cough and cold	H/V
118	S_{108}	*Zizyphus mauritiana* Lam.	Bair	Rhamnaceae	T	W/P	C	Solid	Aerial part	Eye infection	H

Note: H=Herb, S=Shrub, T=Tree; P=Planted, W=Wild, W/P= Wild and Planted; C=common, R=Rare, O= Occasional; H=Human, V=Veterinary and H/V= Both (Human and Veterinary).

Traditional Knowledge on Use of Medicinal Plants by Tamang Community of Dolakha, Nepal

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Abstract

Ethnobotanical knowledge is precious knowledge for drug discovery. Not only documentation of such knowledge but also the validation and actual field observation through scientific approach is necessary. The purpose of this study was to document medicinal plants (MPs) used by Tamang community of Dolakha district, Central Nepal. Ethnomedicinal knowledge was documented and validated through semi-structured interviews, focus group discussions with key informants, transect walks and workshops. A total of 57 (5 cultivated and 52 wild) medicinal plants belonging to 38 families of angiosperms with 55 genera, 1 lichen and 1 fungus to treat various 42 ailments has been documented. Herbs were most popular life form of MPs (36), while root was most used part of MPs (11). Juice was common mode of preparation of remedies (36%). Opthalmologocal disorders, urinary disorders, cancer had higher FIC value (1) indicating higher agreement among the respondents. Similarly *Swertiya chirayta*, *Parispolyphylla*, *Taxus wallichiana*, *Gaultheria fragrantissima* and *Bergenia ciliata* had high preference for treatment of various diseases as well as trade value. Public awareness regarding identification, conservation and long term utilization of potential medicinal plants in the local habitat along with preference to cultivation practice for trade value is recommended.

Keywords: Ailment category, Conservation, Ethnomedicine, Focus group discussions, Indigenous knowledge, Informant consensus factor

Introduction

Traditional knowledge, also known as folk knowledge, refers to the perception of natural environment by local people (Martin, 1995). Ethnobotany is directly linked to numerous entities like food, shelter, medicine, entertainment, livelihood improvement and conservation of natural resources. Among the other applications of ethnobotany, medicinal use of plants is one of the major applications which consequently contribute to drug discovery and socio-economic development by exposing the historical and present use of plants.

Nepal, due to its specific geographical features, landscape and vegetation, is rich in biological diversity. Potential biodiversity, phytogeographical variation within short distance has ensured the existence of multi-cultural and different socio-economic variation among people. Such aspects reflects variation in Traditional Knowledge and practices among different ethnic groups. Nepal is considered as the excellent repository of the cultural heritage for diverse ethnic groups and it has a rich tradition of folk practices for utilization of wild plants (Manandhar, 1991).

Different 123 ethnic communities with 125 dialects are living in Nepal (CBS, 2011). The perception of nature by various ethnic communities is different. This makes the nation rich in traditional knowledge of utilization and conservation of natural resources.

According to Manandhar (2002) about 80% population of Nepal depend on traditional medicine for primary healthcare. But, indigenous culture along with ethnnomedicinal plants are decreasing day by day due to lack of concern, proper knowledge of scientific harvesting technique and conservation program (Kunwar & Duwadee, 2003). Hence, it is crucial to document traditional knowledge related to plant use before it vanished from the society.

Since the late 19th century (1885-1901) the concept of etnomedicine has been developed in Nepal. In

1969 the first book "Chandra-Nighantu" or "Bir-Nighantu" regarding medicinal plants was published by the Royal Nepal Academy. Later many botanists (Pandey, 1964; Adhikari & Shakya, 1977; Malla & Shakya, 1984-1985; Manandhar, 1985, 1990, 1994; Malla & Chhetri, 2009; Singh et al., 2012; Shrestha et al., 2014) carried out number of ethnobotanical studies on different parts of Nepal. Although several ethno botanical studies have been carried out in Nepal, many areas still remain unexplored (Uprety et al., 2010). Such explorations are important for finding interesting plants with great bioprospecting potential which can cure lethal diseases of human. Therefore the aim of this study was to explore traditional knowledge on use of medicinal plants by Tamang community.

Materials and Methods

Study area

The present study was carried out in Jugu, mountainous village of Dolakha District which lies in Gaurishankar Rural Municipality ward number 1 and 2. It is the north-east part of Dolakha District and extends from 27º50' to 27º43' north and 86º8' to 86º15' east, and has altitude range from 950 m asl. to 3000 m asl. Depending on the altitudinal gradient, the climate of Jugu can be categorized into Sub-tropical, Warm temperate and Sub-alpine. The average annual temperature of Jugu ranges from 8.17°c (minimum) to 20.71°C (maximum) (Karki & Ghimire, 2020). The village covers anarea of 34 sq. km where 40% of the land is cultivated and 60% of the land is forest (Jugu VDC Profile, 2009).

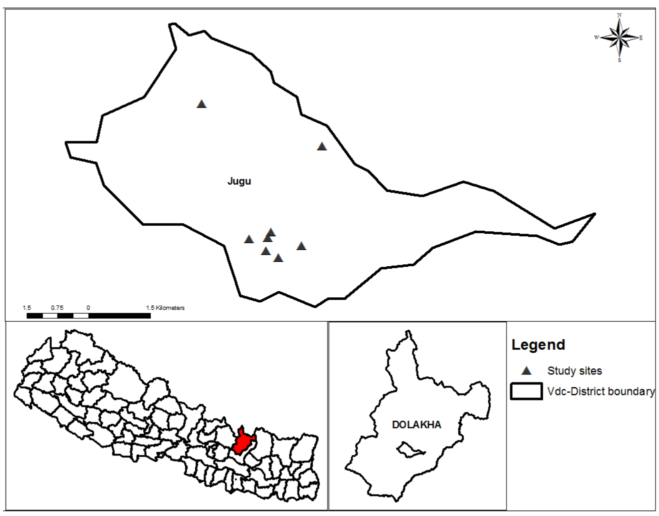

Figure 1: Map of the study area (Jugu).

Sampling informants in Tamang community

The communities which generally reside away from the modern cities and closure to the nature and have their own cultural practice, own mother tongue are called as indigenous communities (Bhattachan, 2000). Tamang is one of the most dominant indigenous communities of Central Nepal. Etymologically, Tamang (Ta= horse and Mang= trader) means horse traders which accounts 5.8% of total population of the nation (NPHC, 2011). This community is second dominant population after Brahman and Chhetri in Dolakha district (DDC, 2016).Tamang people of study area follow both Hindu and Buddhist religion, and celebrate Dashain, Tihar andLhosar. They are engaged in agriculture, cultivation, collection and trade of medicinal plants, animal rearing and few in governmental service.

The practice of using plant resources vary according to tradition viz. during marriage, father and elders of groom visit brides home 'Aling' with 'Sagun' (a bottle of local alcohol covered with seed of *Oroxylum indicum*). Accepting the 'Sagun' by bride family means the acceptance of request of bride family.

Data Collection and analysis

The ethnobotanical study was carried out by six field visits during October 2017 to December 2018. Ethnobotanical knowledge documented by purposive sampling and validated through 40 household survey (semi-structured questionnaire), focused group discussion and resource mapping, transect walk involving local people and village workshops. Medicinal plant cultivators, traders and collectors were considered as key informant. The questionnaire was mainly focused to gather local names of plant, parts used, diseases, and method of preparation.

Specimen collection, identification and documentation

Specimens of cited ethnomedicinal plants were photographed and collected from various sites with their Tamang names during transect walk along the walking trails and inside forest with local people. Field note for each species was recorded in the field meanwhile. The specimens were identified using standard literatures (Polunin & Stainton, 1984) and with the help of experts as well as cross checked with specimen housed in National Herbarium, Godawari, Nepal (KATH) and mounted in standard herbarium sheet following standard method (Rajbhandari & Rajbhandary, 2015). The plants which were rare were not collected but photographed. Herbarium specimens have been deposited at Tribhuvan University Central Herbarium (TUCH). The identified scientific name and families of medicinal plants were checked with www.catalogueoflife.org.

Factor of informants consensus, also called as informant consensus factor (ICF) by Trotter and Logan (1986), was calculated in order to validate the homogeneity of informant's knowledge. It was calculated as:

$$FIC = N_{ur} - N_t / (N_{ur} - 1)$$

Where, 'N_{ur}' is the number of use reports in each ailment category and 'N_t' is the total number of taxa used in each ailment category. High valued medicinal plants of study area were identified based on the result obtained from preference ranking, the method used in Makawanpur district by Joshi (2014) modified from Martin (1995).

Preference ranking

Firstly total medicinal plants of the study area were listed and 15 informants (out of 40 interviewed), based on their experience, knowledge were asked to give the rank from 1-5 to each medicinal plants based on local use and trade value. Rank 5 was used for most used or high valued plant in terms of both local use and trade value and decreasing number was for decreasing value, hence 1 for least used species. Rank given for each species were summed and 6 species with highest rank score were considered as most preferred species.Six most preferred species were then again used for preference analysis separately based ontheir local use value and trade value according to Martin (1995).

Results and Discussion

Ethnobotanical knowledge of Tamang communities

Mainly plants are used for medicinal, edible, fiber, religious, fodder and firewood purposes. Tamang community in the study area was not totally isolated from other cultural societies hence, the culture of Tamangs do not seems to totally different than that of others. However some elderly people and leaders of Tamangs have retained their traditional knowledge & culture. They have enough knowledge of use of plant resources for their subsistence and livelihood. Several potential medicinal plants are found in the study area but most of the people were quite unknown about them. However people have very common practice of use of some common herbs as medicinal plants for cutting wounds, cold and cough. A total 57 plant species were used for medicinal purpose.

Taxonomic distribution of medicinal plants

A total of 57 medicinal plants belonging to 38 families of flowering plants belonging to 55 genus and one lichen and one fungus have been documented which has been used for treatment of 42 ailments (Table1). However, 161 medicinal plants were reported from Tamang community of Makawanpur District to cure various 89 human ailments (Luitel et al., 2014). Similarly 46 medicinal plants were reported from Tamang community of Rasuwa District to cure 38 human ailments among which 13 medicinal plants had culinary and cultural use also (Shrestha et al., 2014).

Asteraceae was the largest family with 7 species because Asteraceae have maximum number of genera among dicot plants, followed by Ericaceae and Rosaceae with 3 species each. Nine families (Apiaceae, Amaryllidaceae, Araceae, Asparagaceae, Polygonaceae, Ranunculaceae, Saxifragaceae, Urticaceae and Zingiberaceae) had 2 species while remaining 25 families with single species.

Life form of medicinal plants (MPs)

Among total documented medicinal plant species, 36 species were herbs, followed by nine, tree species, and four species of shrub and climbers each and two parasite species. *Viscum album* and *Cuscutacas sytoides* were the parasitic plants that are used for medicinal purpose (Figure 2). The potential use of herbs as medicine could be high availability in study sites in comparison to shrubs and trees. This result was similar to the ethnobotanical study of Nepal (Shrestha & Dhillon, 2003; Uprety et al., 2010).

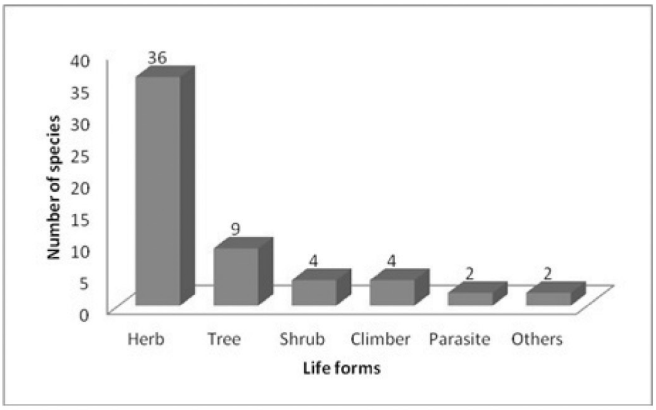

Figure 2: Number of different life form of MPs.

Parts used of medicinal plants (MPs)

Different parts of medicinal plants were used for treating different diseases. These included roots of 11 species, leaves of nine species, rhizomes of seven species, whole plants of five species, stems, tubers and barks of four species each, fruits of five species were used. Flowers and seeds were found least used part i.e., only of three species (Figure 3).

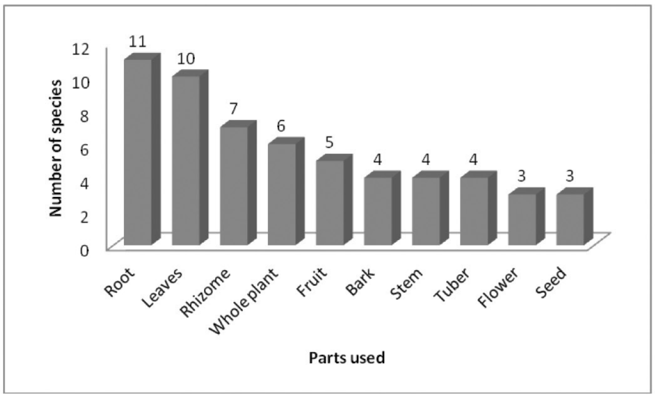

Figure 3: Different parts used of MPs.

Among used parts, 39% were underground parts followed by 19% of reproductive parts, leaves with 18%. Stem and bark of 14% medicinal plants is used. Whole plant of 6 species (i.e., 10%) is used (Figure 4). If the magnitude of use of MPs whose underground parts and reproductive parts increases, it can seriously damage the plant resources because those parts which make those plants vulnerable to exploit are highly used.

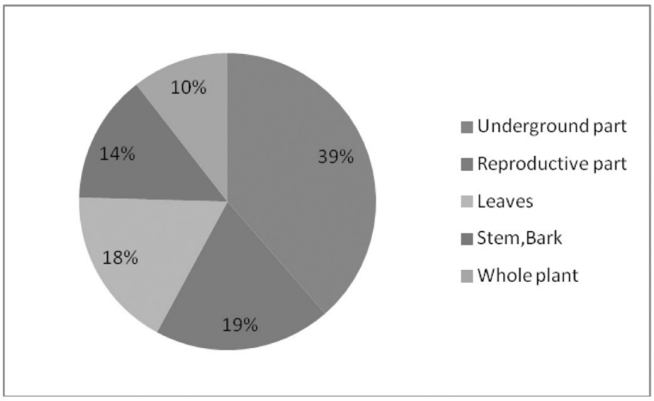

Figure 4: Percentage of different parts used of MPs.

Different parts of medicinal plants ranging from root, rhizome, tuber, stem, leaves, bark, latex, seed, fruit, flower to whole plants were used. The most commonly used part was root (19.3%) followed by leaves (17.55%), rhizome (12.29%), whole plant (10.53%), fruit (8.78%), tuber, bark and stem (7.02%), seed and flower (5.27%). Root contains comparatively more amount of bioactive compounds and available during the year (Srithi et al., 2009; Bhattarai, 2018) which may results its higher utilization in local therapeutics. Similar results were obtained in ethnomedicinal studies carried out in other parts of country and abroad (Shrestha & Dhillion, 2003; Rokaya et al., 2010; Uprety et al., 2010; Singh et al., 2012; Shrestha et al., 2014). Here underground parts (root, tuber, rhizome) of 38.6% medicinal plants were found to be used which was followed by reproductive parts (19.3%), whole plant (10.53%) indicating them to higher threat risk. Comparatively the medicinal plants whose underground parts are collected and used are more vulnerable and are more likely to become threatened because uprooting causes the destruction of whole plant and if it is before fruiting season, the vulnerability is even higher (Shrestha et al., 2014).

Use frequency of medicinal plants in different diseases categories

Number of medicinal plants used to treat different ailment categories showed that highest numbers of species were used for external injuries/ bleeding and gastrointestinal because these are most common and widespread diseases followed by parasitic and hepatobiliary disorders (12 species in each). These were followed by oral, dental and ear problems with 7 species, musculo-skeletal disorders with 6 species and so on. Ophthalmological, urinary system, glandular disorder, cancer and poison categories were treated with each 1 species (Figure 5).

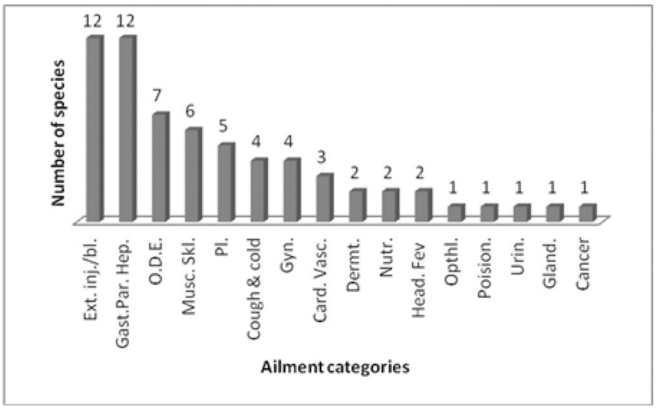

Figure 5: Number of species used in different diseases category (Note: Ext. inj./bl. : External injuries/bleeding, Gast.Par. Hep: Gastrointestinal, parasitic and hepatobilary disorders, O.D.E. : Oral, dental and ENT problems, Musc. Skl.:Musculo-skeletal disorders, Gyn.: Gynecological problems, Card. Vasc.: Cardiovascular disorders, Dermt.: Dermatological problems, Nutr.: Nutritional disorders, Head. Fev.: Headache/fever, Opthl.: Ophthalmological problems, Urin.: Urinary system disorders, Gland.: Glandular problems).

Regarding the mode of administration of medicines prepared to treat different ailments, oral application was most profound except skin diseases and bone fractures for which topical application of medicine was used. Similar findings were obtained for mode of administration of folklore medicines in other parts of the country and abroad (Bhattarai et al., 2005; Singh et al., 2012; Lulekal et al., 2013; Luitel et al., 2014; Malla et al., 2015).

Factor of informant's consensus (FIC)

Factor of informantsconsensusprovides a measure of reliability for the given claim of evidence in the ethnomedicinal studies (Malla&Chhetri, 2012). Different 16 human ailment categories were found in the study area which was used to treat by using medicinal plants (Table 1).

Table 1: Different human ailment categories, ailments and number of MPs used.

S.N.	Ailment category	Ailments	Number of species used
1	Cardio-vascular disorders	High blood pressure, Rheumatic heart diseases	3
2	Cough and cold	Common cold, Cough	4
3	External injuries/ bleeding	Cuts, wounds, Burns	12
4	Gastrointestinal, parasitic and hepatobiliary disorders	Gastritis, Stomachache, Indigestion, Diarrhea, Dysentery, Worm, Tapeworm, Jaundice	12
5	Oral, Dental and ENT	Mouth infection, Toothache, Ear infection, Sore throat, Tonsillitis, Sinusitis, Foreign body in throat	7
6	Pulmonary disease	Pneumonia	5
7	Dermatological problems	Ringworm, Itch	2
8	Ophthalmological disorder	Eye infection, Keratitis	1
9	Poisoning	Snake bite	1
10	Gynecological disorders	Post-natal mother, Lactation stimulant, Abortion, Menstruation problems	4
11	Musculo-skeletal disorders	Cracks and fractures, Body pain, Sprain	6
12	Urinary system disorders	Urination blockade	1
13	Glandular problem	Mumps	1
14	Nutritional disorders	Tonic	2
15	Headache/fever	Headache, Fever	2
16	Cancer	Cancer	1

The FIC value for each ailment categories was calculated (Table 2). The result of the FIC showed that there was greater agreement in most of the categories with more than 0.80 FIC value. Ophthalmological problems, poisoning, urinary system disorder and cancer had got highest value of FIC with 1. These ailments were followed by headache and fever with FIC value 0.98 indicating great agreement among the informants. The least agreement between the informants was recorded in the pulmonary diseases and musculo-skeletal disorders with 0.43 and 0.55 FIC value respectively.

In present study the value of FIC ranged from 0.43-1. More than 62.5% values of FIC were found to be more than 0.8 indicating more agreement among the informants. This higher level of consensus among them about the use of particular taxa for curing ailments in the study area indicates ethnomedicinal use of plants is in practice (Singh et al., 2012; Shrestha et al., 2014). But for pulmonary diseases, use of plants is varied among the informants obtaining FIC value lowest (0.43). Hence some of ailment categories like pulmonary diseases, external injuries and gastrointestinal disorder had shown lower FIC value signifying less common use of medicinal plants for treating them. It also might be due to less communication and exchange of knowledge among Tamang people caused due to modernization, less interest and faith of medicinal plants by young generation. Musculoskeletal ailment category had also lower FIC value (0.55) which was accordance with findings of Malla et al. (2015). Also it indicates these ailment categories may be more frequent in the study area as in other studies (Shrestha et al., 2014; Malla et al., 2015) for which people may have developed their own way to treat them by exploring therapeutic strength of many species.

Table 2: FIC values for different ailment categories. (Manandhar, 1991)

S.N.	Ailment category	Use reports (Nur)	Number of taxa (Nt)	FIC
1	Ophthalmological disorder	12	1	1
2	Poisoning	4	1	1
3	Urinary system disorders	4	1	1
4	Glandular problem	4	1	1
5	Cancer	12	1	1
6	Headache/fever	36	2	0.98
7	Nutritional disorders	20	2	0.95
8	Dermatological problems	8	2	0.86
9	Cardio-vascular disorders	12	3	0.82
10	Cough and cold	16	4	0.8
11	Oral, Dental and ENT	24	7	0.74
12	Gynecological disorders	12	4	0.73
13	Gastrointestinal, parasitic and hepatobiliarydisorders	30	12	0.63
14	External injuries/ bleeding	28	12	0.6
15	Musculo-skeletal disorders	12	6	0.55
16	Pulmonary disease	8	5	0.43

Preference ranking among 57 listed MPs

Out of 40 respondents, 15 were asked to give the rank from 1 to 5 for each cited medicinal plants. Ranking was based on both local use value and trade value. Rank value '1' was for least useful plant or least traded plant which accordingly increases with increasing value i.e.,5 for most useful or most traded species (Table 3). Six species viz. *Swertiya chirayita* (67), *Paris polyphylla* (65), *Taxus wallichiana* (63), *Gaultheria fragrantissima* (61) and *Bergenia ciliata* (61), *Astilberivularis* (60) got the average rank value more than 60 which considered them as most preferred species. The lowest rank value was obtained 24 for *Agapetes* sp. indicating that as the least useful or traded species.

Conclusions

Present study revealed 57 medicinal plants including one lichen and one fungi species were used to treat 42 human ailments including three animal ailments. Knowledge of plant utilization for treatment of different ailment in Tamang community was profound but at present it was less in practice due to modernization and lesser faith of local healing system by young generation. However, elder people have retained their knowledge of plant utilization. As the knowledge was limited to few healers and elder people, informant's consensus was varied from less to high (0.43-1).

Though the area was rich in number of useful and valuable medicinal plants, most of local people were quite unknown about them and they were involved in illegal collection (For e.g. *Allium wallichii, Pleione* *praecox* and *Trichosanthes tricuspidata)*, awareness programs and trainings regarding identification, conservation and long-term utilization of potential medicinal plants were needed urgently.

Author Contributions

A.P. Dhital, S. Karkiand S. Kafle collected all the data in the field, interviewed, conducted the research and handled the data. M. Paudel outlined the manuscript. M. Siwakoti and D. Lamichhane reviewed the manuscript. All authors read and approved the final manuscript.

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Table 3: List of total medicinal plants used by Tamang community of Jungu, Dolakha. (* Cultivated species)

S.N.	Scientific name	Family	Local name(s)	Collection number	Habit	Parts used	Diseaes	Mode of preparation and use
1	*Agapetes* sp.	Ericaceae	Totarke		Herb	Tuber (Rin)	Placenta removal (Sathi Jhareko)	Cooked
2	*Ageratina adenophora* (Spreng.) R. King & H. Rob.	Asteraceae	Banmara	D007	Herb	Leaves (Laptelaba), shoots	Cuts (Thaji), Wounds (Por)	Juice
3	*Allium sativum* L.	Amaryllidaceae	Bhotelasun, Bot-Nho (Tam.)		Herb	Tuber (Rin)	Ringworm (daad)	Paste
4	*Allium wallichii* Kunth.	Amaryllidaceae	Ban lasun, Chilime (Tam.)		Herb	Tuber (Rin)	Cough and Cold (Sorang-Syapchim)	Decoction
5*	*Aloe vera* (L.) Burm.f.	Asphodelaceae	Ghyukumari		Herb	Leaves (Laptelaba) latex	Burns (MeseKroji)	Juice
6	*Anemone* sp.	Ranunculaceae	Tinpate	D009	Herb	Leaves (Laptelaba)	Sinusitis	Juice, smell
7	*Argentina lineate* (Trevir.) Soják	Rosaceae	Mulapate/Banmula	D010	Herb	Root (Rin)	Gastritis (Phokroji), Worm (Juka), Tonsilitis (Ghati Dukheko)	Juice
8	*Arisaema* sp.	Araceae	Bako		Herb	Tuber (Rin)	Wounds (Por), Mumps	Paste
9	*Artemisia indica* Willd.	Asteraceae	Titepati, Thamja (Tam.)	D011	Herb	Shoots	Rheumatic diseaese (Sul)	Juice, To worm
10	*Asparagus racemosus* Willd.	Asparagaceae	Kurilo	D012	Herb	Tuber (Rin)	Lactation promoter (Dudh Badhaune)	Cooked
11	*Astilbe rivularis* Buch.-Ham. ex D. Don	Saxifragaceae	Thulookhati	D001	Herb	Rhizome (Rin)	Post-natal mother (Sutkeri), tonic (Tagat dine), Body pain (Jiu Dukheko)	Decoction
12	*Mahonia napaulensis* DC.	Berberidaceae	Lekchutro		shrub	Bark (Pako), Stem (Sing)	Eye infection (Mi Minji)	Paste
13	*Bergenia ciliate* (Haw.) Sternb.	Saxifragaceae	Pakhamved, Baramendo (Tam.)	D002	Herb	Rhizome (Rin)	Post-natal mother (Sutkeri), tonic (Tagat dine), Body pain (Jiu Dukheko)	Decoction
14	*Buddleja asiatica* Lour.	Scrophulariaceae	Bhimsenpati	D014	Tree	Root (Rin)s	Pneumonia (Dokh	Juice
15	*Cannabis sativa* L.	Cannabaceae	Gaja	D015	Herb	Leaves (Laptelaba)	Undigestion in animal (Dhadiyako)	Raw
16	*Centella asiatica* (L.) Urb.	Apiaceae	Ghodtapre, Ghodpaile (Tam.)	D016	Herb	Shoots	Throat pain, Tonsilitis, Pneumonia (Dokh)	Juice, Raw
17	*Chlorophytum nepalense* (Lindl.) Baker	Asparagaceae	Tite	D017	Herb	Root (Rin), Flower (Mendo)	High Blood Pressure	Decoction
18	*Cirsium verutum* (D. Don) Spreng.	Asteraceae	Sugurekanda	D019	Herb	Root (Rin)	Placenta removal (Sathi Jhareko)	Juice
19	*Clematis buchananiana* DC.	Ranunculaceae	Sinusitiselahara	D020	Climber	Shoots	Sinusitis	Juice, Powder, Smell
20*	*Curcuma aromatic* Salisb.	Zingiberaceae	Besar		Herb	Rhizome (Rin)	Cold and cough (Sorang-Syapchim)	Powder,decoction
21	*Cuscuta cassytoides* Nees	Convolvulaceae	Aakashbeli	D021	Parasite	Whole Plant (Dhong)	Jaundice (Harital)	Juice
22	*Gaultheria fragrantissima* Wall.	Ericaceae	Machhino, Chajai (Tam.)	D003	shrub	Shoots, Leaves (Laptelaba)	Sprain (Thokiyako, Markeko), Body pain (Jiudukhnu)	Oil extract
23	*Geranium* sp.	Geraniaceae	Pachamle	D028	Herb	Leaves (Laptelaba)	Pneumonia (Dokh)	Juice
24	*Hydrocotyle nepalensis* Hook.	Apiaceae	Firkejhar	D030	Herb	Whole Plant (Dhong)	Snake bite	Juice, paste
25	*Hypericum elodeoides* Choisy.	Hypericaceae	Mandanejhar	D031	Herb	Shoot	Cuts (Thaji), Wounds (Por)	Juice

S.N.	Scientific name	Family	Local name(s)	Collection number	Habit	Parts used	Diseaes	Mode of preparation and use
26	*Ixeridium* sp.	Asteraceae	Kanpate	D062	Herb	Leaves (Laptelaba)	Ear infection (minji)	Juice
27	*Leucosceptrum canum* Sm.	Lamiaceae	Ghurmis	D033	Tree	Root (Rin)	Throat pain (Ghatidukhnu)	Juice
28	Lichen	Lichen	Setojhyau		Lichen	Whole Plant (Dhong)	Cuts (Thaji), Wounds (Por)	Powder
29	*Lindera neesiana* (Wall. ex Nees) Kurz	Lauraceae	Siltimur	D034	Tree	Fruit (Rojim)	Undigestion (Dhadiyako)	Decoction
30	*Morella esculenta* (Buch.-Ham. ex D.Don) I.M. Turner	Myricaceae	Kafal, Namin (Tam.)	D037	Tree	Bark (Pako)	Sinusitis, Gastritis (Phokroji), Bone fracture (Kichchi)	Paste, Powder, smell
31	*Nicotiana tabacum* L.	Solanaceae	Kachopat		Herb	Leaves (Laptelaba)	Lice in animal (Jumra)	Juice
32	*Oreoseris* sp.	Asteraceae	Jhulo	D063	Herb	Root (Rin)	Worms in animals (Juka)	Raw
33	*Oroxylum indicum* (L.) Kurz	Bignoniaceae	Totala, Ko-Mendo(Tam.)		Tree	Seeds	Pneumonia (Dokh)	Paste
34	*Oxalis corniculata* L.	Oxalidaceae	Chari amilo, Sakirbu (Tam.)	D038	Herb	Shoot	Cuts (Thaji), Wounds	Juice
35	*Paris polyphylla* Sm.	Melanthiaceae	Satuwa, Tintalebako (Tam.)	D004	Herb	Rhizome (Rin)	Cuts (Thaji), Gastritis (Phokroji) (Gastic)	Paste, powder
36	*Pouzolzia sanguinea* (Bulme) Merr.	Urticaceae	Chiple	D039	Herb	Root (Rin), Leaves (Laptelaba)	Urination blockade (Niranja)	Juice
37	*Prunus cerasoides* D. Don	Rosaceae	Paiyu, Sinwa (Tam.)	D040	Tree	Fruit (Rojim), Bark (Pako)	Tapeworm (Namle), Bone fracture (Kichchi)	Raw, paste
38	*Rheum austral* D. Don	Polygonaceae	Padamchal, Chhurcha (Tam.)		Herb	Rhizome (Rin)	Sprain (Markeko), Body pain (Jiudukheko)	Boiled paste
39	*Rhododendron arboretum* Sm.	Ericaceae	Laligurans, Paramendo (Tam.)	D044	Tree	Flower (Mendo)	Foreign body in Throat (Ghatima Machhako Kadaadkeko)	Powder
40	*Rubia manjith* Roxb.	Rubiaceae	Majitho/Machhito	D045	Climber	Shoots	Cuts (Thaji)	Juice
41	*Rubus ellipticus* Sm.	Rosaceae	Ainselu, Pulung (Tam.)	D046	shrub	Root (Rin)s	Bone fracture (Kchchi), Pneumonia (Dokh)	Juice, paste
42	*Rumex nepalensis* Spreng.	Polygonaceae	Halhale	D048	Herb	Root (Rin)	Ringworm (daad)	Juice
43	*Scindapsus officinalis* (Roxb.) Schott	Araceae	Kanchirnu	D051	Climber	Stem (Sing)	Bone fracture (Kichchi)	Paste
44	*Smilax purhampuy* Ruiz	Smilacaceae	Kukurdaino		Climber	Stem (Sing), Root (Rin)	wand evil spirit (AakhaLageko), Abortion (Garbhapatan)	Raw
45	*Solena amplexicaulis* (Lam.) Gandhi	Cucurbitaceae	Golkakro, Golikakro	D053	Climber	Fruit (Rojim),Root (Rin)	Throat pain (Ghatidukhnu), Stomatitis (Mu minji)	Raw, paste
46	*Stellaria media* (L.) Vill.	Caryophyllaceae	Maurejhar		Herb	Shoots	Cuts (Thaji), Wounds (Por)	Juice
47	*Swertia chirayta* (Roxb.) H. Karst.	Gentianaceae	Chiraito, Timba (Tam.)	D005	Herb	Whole Plant (Dhong)	Headache (Tauko Dukheko), Fever (Jwaro Kahji), Body pain (Jiu Dukheko)	Decoction
48*	*Tagetes erecta* L.	Asteraceae	Sayapatri, Mendo (Tam.)		Herb	Flower (Mendo)	Pneumonia (Dokh)	Juice
49	*Taxus wallichiana* Zucc.	Taxaceae	Lauthsalla, Dhyangre (Tam.)	D006	Tree	Stem (Sing), Bark (Pako)	Cancer, Gastritis (Phokroji)	Decoction
50	*Trametes versicolor* (L.) Lloyd	Polyporaceae	Ratochyau, WalaSyamu (Tam.)		Fungi	Fruit (Rojim)ing body	Dysentery (Chhirwarutpa)	Cooked
51*	*Trigonella foenum-graecum* L.	Leguminosae	Methi	D056	Herb	Seed	Bone fracture (Kichchi)	Paste
52	*Urtica dioica* L.	Urticaceae	Sisno	D068	Herb	Root (Rin)/Shoot	Bone fracture (Kichchi), High blood pressure	Paste, cooked

S.N.	Scientific name	Family	Local name(s)	Collection number	Habit	Parts used	Diseaes	Mode of preparation and use
53	*Viola sp.*	Violaceae	Kalojhar, Dotarma (Tam.)	D059	Herb	Leaves (Laptelaba)	Cuts (Thaji) Wounds (Por)	Juice
54	*Viscum album* L.	Santalaceae	Harichur	D060	Parasite	Whole Plant (Dhong)	Bone fracture (KichchI)	Paste
55	*Xanthium strumarium* L.	Asteraceae	Bhedekuro		Herb	Root (Rin)	Dysentery (Chhirwarutpa)	Juice
56	*Zanthoxylum acanthopodium* DC.	Rutaceae	Timur, Promo (Tam.)	D061	Tree	Fruit (Rojim)	Toothache (Dat Dukheko), Undigestion (Dhadiyako)	Powder, decoction
57*	*Zingiber officinale* Roscoe	Zingiberaceae	Aduwa		Herb	Rhizome (Rin)	Cold and cough (Sorang-Syapchim)	Decoction

Table 4: Rank given by each respondent to 57 cited medicinal plants by 15 respondents.

S.N.	Accepted scientific name	Rank based on Local use															Score	Rank
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15		
1	*Swertia chirayta* (Roxb.) Karst.	5	4	4	5	5	4	5	4	4	5	4	4	5	4	5	67	1st
2	*Paris polyphylla* Sm.	5	4	4	5	5	4	4	3	4	4	5	5	5	4	4	65	2nd
3	*Taxus wallichiana* Zucc.	4	5	4	5	5	5	4	5	4	3	4	4	3	4	4	63	3rd
4	*Bergenia ciliate* (Haw.) Sternb.	4	4	4	3	5	5	3	4	3	4	5	4	5	4	4	61	4th
5	*Gaultheria fragrantissima*	4	5	4	4	5	5	4	5	4	4	3	4	3	4	3	61	4th
6	*Astilbe rivularis* Buch.-Ham. ex D. Don	4	3	4	5	4	4	4	3	3	5	4	4	5	4	4	60	5th
7	*Zanthoxylum acanthopodium* DC.	5	4	3	4	5	4	4	3	4	4	5	3	4	3	4	59	6th
8	*Scindapsus officinalis* (Roxb.) Schott	4	3	3	4	4	5	4	4	5	4	4	3	3	4	4	58	7th
9	*Viscum album* L.	3	2	3	4	3	4	3	4	5	4	5	5	4	3	4	56	8th
10	*Zingiber officinale* Roscoe	3	4	4	4	3	3	4	2	4	3	4	5	4	5	4	56	8th
11	*Solena amplexicaulis* (Lam.) Gandhi	3	4	3	2	5	4	5	4	4	3	4	4	4	3	3	55	9th
12	*Trametes versicolor* (L.) Lloyd	4	3	4	3	3	4	3	4	5	4	4	5	3	3	3	55	9th
13	*Prunus cerasoides* D. Don	3	2	3	2	4	5	4	5	4	3	4	4	4	3	4	54	10th
14	*Urtica dioica* L.	4	4	3	3	2	3	4	4	4	3	4	5	3	4	4	54	10th
15	Lichen	3	4	5	5	2	3	3	2	4	2	3	4	3	4	5	52	11th
16	*Lindera neesiana* (Wall. ex Nees) Kurz	4	2	3	4	4	3	4	3	4	4	3	4	3	3	3	51	12th
17	*Morella esculenta* (Buch.-Ham. ex D. Don) I.M.Turner	5	3	4	5	3	4	3	2	3	2	3	3	4	4	3	51	12th
18	*Rubus ellipticus* Smith	3	2	3	4	4	4	3	4	3	3	4	4	3	4	3	51	12th
19	*Rheum australe* D. Don	5	4	3	4	3	4	3	3	2	3	4	3	3	2	3	49	13th
20	*Viola* sp.	2	3	3	4	3	2	4	3	4	3	4	4	3	3	3	48	14th
21	*Tagetes erecta* L.	2	3	3	4	3	2	3	3	4	4	3	3	2	4	4	47	15th
22	*Trigonella foenum-graecum* L.	3	4	4	2	2	3	4	3	4	3	4	3	2	3	3	47	15th

S.N.	Accepted scientific name	Rank based on Local use															Score	Rank
		R1	R2	R3	R4	R5	R6	R7	R8	R9	R10	R11	R12	R13	R14	R15		
23	*Clematis buchananiana* DC.	2	3	2	3	2	4	3	3	4	3	2	4	4	3	4	46	16^{th}
24	*Rhododendron arboretum* Sm.	4	3	3	4	4	3	2	3	4	3	2	3	3	2	3	46	16^{th}
25	*Pouzolzia sanguinea* (Bulme) Merr.	2	1	3	4	4	3	3	2	3	4	3	3	4	3	3	45	17^{th}
26	*Smilax purhampuy* Ruiz	3	2	3	5	3	3	4	3	3	2	3	4	2	3	2	45	17^{th}
27	*Aloe vera* (L.) Burm.f.	2	3	3	2	3	3	2	4	4	4	3	4	2	3	2	44	18^{th}
28	*Curcuma aromatic* Salisb.	3	3	4	2	3	4	4	2	3	4	2	2	3	3	2	44	18^{th}
29	*Argentina lineate* (Trevir.) Soják	4	3	3	3	1	2	2	3	4	4	3	4	3	2	3	44	18^{th}
30	*Asparagus racemosus* Willd.	2	3	3	4	4	2	2	3	3	2	3	4	3	2	3	43	19^{th}
31	*Cirsium verutum* (D. Don) Spreng.	3	2	2	4	3	3	2	2	3	4	3	3	4	3	2	43	19^{th}
32	*Cuscuta cassytoides* Nees	2	3	3	2	2	3	4	3	3	2	2	3	4	4	3	43	19^{th}
33	*Berberis napaulensis* (DC.) Spreng.	2	3	2	3	3	2	3	4	3	3	2	4	3	2	4	43	19^{th}
34	*Rumex nepalensis* Spreng.	2	3	3	2	3	3	2	4	3	2	3	2	4	3	4	43	19^{th}
35	*Centella asiatica* (L.) Urb.	4	3	3	3	2	2	3	3	4	3	2	3	3	2	2	42	20^{th}
36	*Hydrocotyle nepalensis* Hook.	3	3	2	3	3	4	3	3	2	3	3	2	2	3	3	42	20^{th}
37	*Stellaria media* (L.) Vill.	3	2	3	2	2	4	3	2	2	3	2	4	3	3	4	42	20^{th}
38	*Rubia manjith* Roxb.	2	2	2	1	3	2	4	3	2	3	3	2	4	4	4	41	21^{st}
39	*Artemisia indica* Willd.	3	3	2	2	3	3	2	3	3	3	2	4	2	3	2	40	22^{nd}
40	*Cannabis sativa* L.	2	3	3	2	3	4	3	2	2	2	2	2	3	3	4	40	22^{nd}
41	*Chlorophytum nepalense* (Lindl.) Baker	2	3	2	2	1	2	3	3	2	4	2	2	3	4	4	39	23^{rd}
42	*Allium wallichii* Kunth	2	3	3	2	2	2	3	2	3	2	3	2	3	3	3	38	24^{th}
43	*Ixeridium* sp.	3	2	3	2	2	2	1	3	3	3	4	2	3	2	3	38	24^{th}
44	*Allium sativum* L.	2	3	3	4	2	2	3	2	2	3	3	3	1	2	2	37	25^{th}
45	*Nicotiana tabacum* L.	3	2	2	1	2	2	3	2	3	3	2	2	3	2	4	36	26^{th}
46	*Oxalis corniculata* L.	2	3	3	2	2	3	2	3	1	2	2	3	3	2	3	36	26^{th}
47	*Oreoseris* sp.	2	3	3	2	2	3	3	2	2	3	1	1	2	2	3	34	27^{th}
48	*Xanthium strumarium* L.	2	3	3	1	1	2	3	3	2	3	2	2	3	1	3	34	27^{th}
49	*Leucosceptrum canum* Sm.	2	2	2	3	2	3	2	2	2	1	2	2	3	1	2	31	28^{th}
50	*Oroxylum indicum* (L.) Kurz	3	3	1	2	1	2	2	1	2	2	3	2	2	3	2	31	28^{th}
51	*Ageratina adenophora* (Spreng.) R. King & H. Rob.	1	2	2	3	3	2	3	2	3	1	1	2	2	2	1	30	29^{th}
52	*Arisaema* sp.	1	2	2	1	1	2	1	3	3	2	3	2	2	2	1	28	30^{th}
53	*Geranium* sp.	1	2	2	1	2	3	2	2	1	2	2	1	2	3	2	28	30^{th}
54	*Anemone* sp.	2	2	3	1	2	2	1	2	1	2	1	1	1	2	3	26	31^{th}
55	*Buddleja asiatica* Lour.	2	3	2	1	1	2	1	2	2	1	1	2	1	3	2	26	31^{th}
56	*Hypericum elodeoides* Choisy.	2	1	2	2	1	1	2	2	3	2	2	1	2	2	1	26	31^{th}
57	*Agapetes* sp.	1	2	2	1	2	2	1	1	1	2	1	1	2	2	3	24	32^{th}

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