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DISTRIBUTION OF LIVERWORT FLORA ACROSS VEGETATION TYPES IN MT. BAGALBAL, PHILIPPINES: BASIS FOR IEC MATERIAL

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Abstract

The primary objective of this study is to assess the distribution of liverwort flora across different vegetation types in Mt. Bagalbal, evaluate their conservation status, and develop educational materials to raise public awareness. Habitat degradation poses a significant threat to liverwort biodiversity in Mt. Bagalbal, underscoring the need for conservation efforts. This investigation identified 31 liverwort species across fourteen families, with Plagiochilaceae being the most diverse, followed by Lejeuneaceae, Marchantiaceae, and Pallaviciniaceae. Species distribution patterns revealed that while some species exhibit broad dispersal, with two species recorded across eight locations, 18 species are confined to a single coordinate. Conservation assessments indicated that 14 species lack data on their status, 11 are classified as Least Concern, five as Data Deficient, one as Vulnerable, one as Critically Endangered, and one as Near Threatened. To promote awareness and conservation, an Information, Education, and Communication (IEC) material was developed, comprising five sections: an overview of liverwort biology, photographs of representative species with their scientific names and IUCN conservation statuses, guidelines for proper collection and examination, acknowledgments of contributing agencies, and information about the authors. All photographic content in the IEC material was sourced from the field investigation at Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon, Philippines. This study demonstrates the high sensitivity of liverwort flora in Mt. Bagalbal to environmental changes, with significant implications for future conservation strategies.

Keywords: liverwort flora, conservation, distribution, IEC materials.

INTRODUCTION

The Philippines is regarded as a biodiversity hotspot, with its terrestrial and marine ecosystems harboring some of the region's most diverse flora and fauna. However, several threats to these biological treasures could lead to their extinction. One significant threat is the lack of public awareness regarding biodiversity, which is sometimes viewed merely as a resource to exploit. Education, according to UNESCO, is critical for the sustainable and equitable use of biodiversity. Therefore, it is essential to integrate biodiversity into teaching and to develop educational materials and opportunities to raise awareness, particularly in areas rich in biological diversity, such as mountain ecosystems. Of the seventeen Sustainable Development Goals (SDGs) established by the United Nations, three are particularly relevant to the development of

learners: Quality Education (SDG 4), Climate Action (SDG 13), and Life on Land (SDG 15).

Currently, the state of knowledge regarding bryophyte and lichen taxa in the Philippines requires comprehensive exploration. This should include the identification of unique micro-environmental niches that are limited in extent and threatened by various factors. Observations indicate that Philippine forests are ecologically disturbed, with some areas converted into agricultural landscapes. As a result, most bryophyte and lichen life forms demonstrate a distribution pattern influenced by a limited number of land use intensity classes (Balansag et al., 2024). Furthermore, ongoing forest denudation and adverse natural calamities affecting non-vascular flora necessitate immediate attention to prevent their loss from the biosphere.

The discipline of ethnobotany is a multidisciplinary field that examines the interaction between plants and human cultures, encompassing aspects of healthcare, education, and environmental conservation. Thus, the preservation of the natural environment and the implementation of conservation measures in the wild must be prioritized.

In teaching the taxonomy of non-vascular flora, such as liverworts, instructional field guides—including Information, Education, and Communication (IEC) materials, checklists, and scientific teaching brochures—are essential resources for educators, students, budding researchers, professionals, and other stakeholders. These materials communicate the importance of these species and the necessity for their inventory and conservation. Furthermore, classroom teachers can utilize these instructional resources to enrich the concept of biodiversity management, particularly in mountain ecosystems focusing on liverworts.

This investigation aims to develop and produce IEC materials based on research findings. The goal is to create instructional resources beneficial for biology and science education, serving as an effective tool for fostering recognition and appreciation of liverworts among teachers and students.

MATERIALS AND METHODS

PHASE I- Identification and Distribution of Liverwort flora

A letter of request was sent to the local government unit of Mt.Nebo, Valencia City, for the approval of the fieldwork and submission of informed consent before the conduct of the study. An Entry Protocol from the City Government of Valencia,

Bukidnon, Philippines, followed this. Likewise, meetings with the local guides were conducted.

The study was conducted in Mt. Bagalbal, Sitio Migtulod, Brgy. Mt. Nebo, Valencia City, Bukidnon, is approximately 7.9728, 124.9866, or 70 56’ 27” N and 1240 57’ 14” E. The peak is 1 226 meters above sea level and consists of trees, shrubs, herbs, and weeds.

The floristic survey method was followed in the conduct of the study. This was done by listing the entire liverwort flora seen or collected along the trail the researcher had to tread to.

The collected specimens of liverworts were placed in a plastic bag with field label data: altitude, collection number, date of collection, and their ecology and associated habitats. The specimen was then air-dried and placed in the packet (envelope) and will be labeled appropriately for herbarium vouchers.

The specimens were identified based on taxonomic characteristics, and microscopy examinations were done on specimens that exhibited unique characteristics using field lenses and dissecting microscopes. Taxonomic keys by Gradstein (2012), Inoue (1997), checklist from Zhu et al. (2018), Bakalen& Nguyen (2016), Thouvenot et al. (2011), Lai et al. (2008), and Logatoc et al. (2019) were used. A database was made for the entire liverwort flora collected for future examination and research. Likewise, a photomicrograph was performed in the field and the laboratory.

Coordinates were measured using Altimeter ® software and tallied during the collection of each liverwort sample. This information was then forwarded to the GeoMin of the College of Forestry, CMU for the mapping of the species distribution pattern of the liverwort flora. PAST® V 4.03 statistical tool was also utilized to support the results of the distribution pattern. It was used to create the graphs of cladogram showing similarity of species composition, family distribution, and diversity indices of the liverwort flora.

The conservation status of liverwort flora was determined using the available online data from the International Union of Conservation of Nature (IUCN, 2023) and articles such as that of Angeles et al. (2020), Prescott (2016), Hodgetts and Lockhart (2015), and Azuelo (2005).

Photographs were made from the actual field observations regarding the species' natural habitat. Likewise, a micrograph was also secured using the Biomex microscope and the Image Focus plus® V.2 application.

PHASE II- Instructional Material Development

The instructional material, such as information, education, and communication (IEC), was designed for the community, teachers, and students. The instructional material was initially content validated, and the final product may be valuable and informative. This teaching material may serve as interactive learning material. The students using the IEC material would be actively engaged, working through their unique problems and laboratory work. More importantly, the instructional material developed is a product of the current research.

RESULTS AND DISCUSSION

Description and identification of liverwort flora of Mt. Bagalbal

The description and identification of each of the families, genera, and species were made through proper visual observation of its morphological characteristics in their natural setting during the field sampling and through diligent microscopy examination of its overall characteristics, including the cell shape, presence of oil bodies, and other distinguishing characteristics.

Taxonomic key by Gradstein (2012), Inoue (1997), checklist from Zhu et al. (2018), Bakalen& Nguyen (2016), Thouvenot et al. (2011), Lai et al. (2008), and Logatoc et al. (2019) were used for proper identification. Lastly, the identification for each specimen was confirmed by Bryologists from Central Mindanao University.

As shown in Table 1, fourteen (14) families were recorded: Aneuraceae, Aytoniaceae, Cyathodiaceae, Frullaniaceae, Herbertaceae, Lejeuneaceae, Lepidoziaceae, Marchantiaceae, Metzgeriaceae, Pallaviciniaceae, Plagiochilaceae, Ricciaceae, Schistochilaceae, and Trichocoleaceae. Among these families, family Plagiochilaceae harbors the most number of species having eight (8) total species: *Chiastocaulon dendroides* (Nees) Carl., *Plagiochila arbuscula* (Brid. Ex Lehm.) Lindenb., *Plagiochila frondescens* (Nees) Lindenb., *Plagiochila integerrima* Steph., *Plagiochila javanica (SW.) Dum., Plagiochila massalongoana* Schiffn., *Plagiochila nobilis* Gottsche, and *Plagiochila spathulifolia* Mitt.; this has been followed by Lejeuneaceae with six (6) species: *Cololejeuneatenella* Benedix, *Lopholejeuneaceylanica* Steph., *Lopholejeuneasubfusca* (Nees) Schiffn., *Mastigolejeunea virens* (Aongstr.) Steph, *Ptychanthus striatus* (Lehm & Lindenb.) Nees, and *Spruceanthus polymorphous* (Sande Lac.) Verd.; Marchantiaceae and Pallaviciniaceae with three (3) species representatives; two representative species for the families Metzgeriaceae, Ricciaceae, and Schistochilaceae; while only one representative species for the families Aneuraceae, Aytoniaceae, Cyathodiaceae, Frullaniaceae, Herbertaceae, Lepidozeaceae, and Trichocoleaceae.

Table 1. Collected liverworts flora in Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon, Phils.

Family	Genera and Species
Aneuraceae	*Riccardia tamariscina* (Steph.) Schiffn.
Aytoniaceae	*Reboulia hemisphaerica* (L.) Raddi
Cyathodiaceae	*Cyathodium foetidissimum* Schiffn.
Frullaniaceae	*Frullania microauriculata* Verd.
Herbertaceae	*Herbertus dicranus* (Tayl. Ex Gottsche et al.) Trevis
Lejeuneaceae	*Cololejeunea tenella* Benedix
	Lopholejeunea ceylanica Steph.
	Lopholejeunea subfusca (Nees) Schiffn.
	Mastigolejeunea virens (Aongstr.) Steph
	Ptychanthus striatus (Lehm&Lindenb.) Nees
	Spruceanthus polymorphus (Sande Lac.) Verd.
Lepidoziaceae	*Bazzania erosa* (Reinw. et al.) Trevis
Marchantiaceae	*Marchantia emarginata* Reinw., Blume &Nees
	Marchantia polymorpha L.
	Marchantia treubii Schiffn.
Metzgeriaceae	*Metzgeria foliicola* Schiffn.
	Metzgeria furcata (L.) Dum.
Pallaviciniaceae	*Pallavicinia levieri* Schiffn.
	Pallavicinialyellii (Hook.) Carruth.
	Podomitrium malaccense (Stephani) Campb.
Plagiochilaceae	*Chiastocaulon dendroides* (Nees) Carl.
	Plagiochila arbuscula (Brid. Ex Lehm.) Lindenb.
	Plagiochila frondescens (Nees) Lindenb.
	*Plagiochila integerrima*Steph.
	Plagiochila javanica (SW.) Dum.
	Plagiochila massalongoana Schiffn.
	Plagiochila nobilis Gottsche
	Plagiochila spathulifolia Mitt.
Ricciaceae	*Riccia fluitans* L.
	Riccia junghuhniana Nees&Lindenb.
Schistochilaceae	*Schistochila sciurea* (Nees) Schiffn.
	Schistochila reinwardtii (Nees) Schiffn.
Trichocoleaceae	*Trichocolea tomentella* (Ehrhart) Dumortier

Overall, the collected liverwort flora belonged to thirty-three (33) species, twenty-one (21) genera, and fourteen (14) families.

Liverworts have a unique adaptation to high-altitude environments, allowing them to thrive in harsh environments. They have a slow growth rate and can withstand desiccation, cold temperatures, and extreme weather conditions. Furthermore, liverworts have a high dispersal capacity, allowing them to colonize new areas quickly

and easily. These characteristics help the liverworts of Mt. Bagalbal to sustain their existence and colonize the area well.

According to Smith et al. (2018), factors such as soil chemistry, moisture availability, and vegetation cover all influence the diversity of liverworts in mountainous areas. In some mountainous areas, for example, liverwort diversity positively correlates with soil pH and nutrient availability.

Species distribution pattern of liverwort flora of Mt. Bagalbal

Data containing the species name of each collected specimen and their respective latitudes and longitudes were used to determine the species distribution.

In the context of the study, QGIS used by the Center for Geomatics Research and Extension in Mindanao (GeoMin) of the College of Forestry, CMU was utilized so that the quality and assurance of the data will be secured as experts and qualified technicians confirmed it.

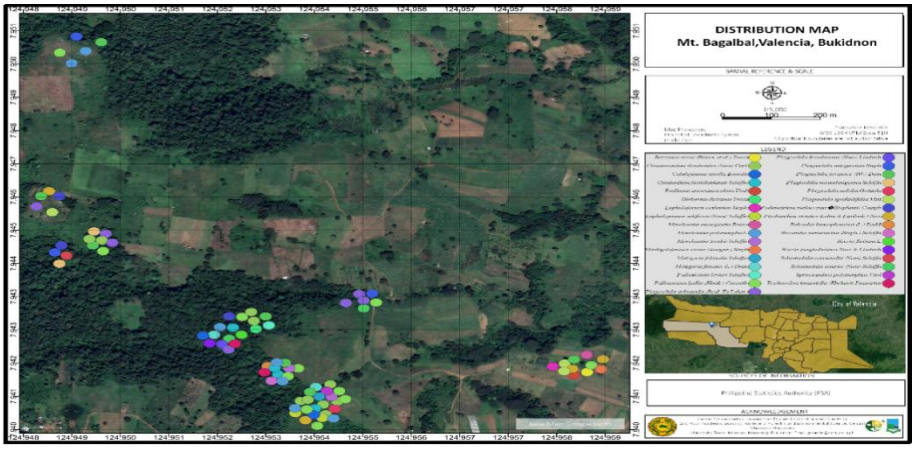

Figure 1. Species Distribution Pattern of Liverwort flora at Mt. Bagalbal

As gleaned from the data in Figure 1, the species distribution pattern of the liverwort flora from Mt. Bagalbal showed a definite and clear dispersal of most lowly plants. Two species were found to be inhabiting eight out of the ten unique coordinates that were recorded during the investigation: *P. llyelii* and *P. javanica*; four species were distributed in four coordinates: *P. arbuscula, C. dendroides, M. polymorpha,* and *P. striatus*; three species were distributed in three coordinates: *C. foetidissimum, P. malaccense,* and *P. integerrima*; six species were dispersed in two unique coordinates: *T. tomentella, S. sciureae, P. spathufolia, M. furcata, M. treubii,* and *C. tenella;* lastly, all the remaining 18 species were limited only on one separated unique coordinate.

The distribution of liverwort flora noted in the investigation could be attributed to the low temperature, shaded area, and rich humus content of the microhabitat where liverworts thrive. The ability of liverwort flora to tolerate harsh environmental conditions, their distinct morphological structure, and their capacity for sexual and asexual reproduction also allow them to colonize various mountain regions. These adaptations have allowed these plants to flourish at high altitudes and successfully establish themselves in mountain habitats.

The data are consonant with the findings of Staniaszek-Kik et al. (2019), stating that the ability of the majority of the liverwort flora to withstand harsh environmental conditions, such as freezing temperatures, high altitudes, and low oxygen concentrations, is one of the key traits that allow it to colonize different areas of the mountain.

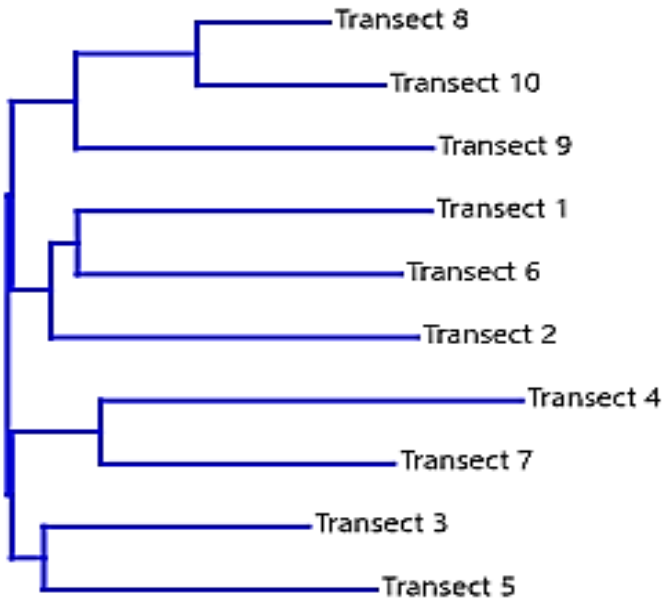

Figure 2. Cladogram representation of Species Composition in Mt. Bagalbal

Figure 2 presents the cladogram representation of the species composition of the collected liverwort flora in Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon. A high degree of similarity was observed among the four transect points: transects 5, 3, and transects 4, 7. This similarity is attributed to the high abundance of microhabitats that support the thriving of these plant species. Following this, transects 1, 6, and 12 exhibited a moderate level of similarity, while transects 8, 10, and 9 demonstrated the

lowest similarity. The decline in species similarity observed in the latter transect points may be attributed to the expansion of agricultural lands, increased sunlight saturation, and the loss of trees that traditionally serve as the primary habitat for liverwort flora.

Furthermore, Figure 3 illustrates the distribution pattern of the plants by their respective families. This representation corroborates the findings of species distribution of liverwort flora at Mt. Bagalbal, as determined using the QGIS® application. Notably, the family *Lejeuneaceae* exhibited the greatest distribution, followed by the family *Plagiochilaceae*, which were predominantly found in transects 7 and 10, respectively. In contrast, transects 6 and 9 displayed the least family and species distribution.

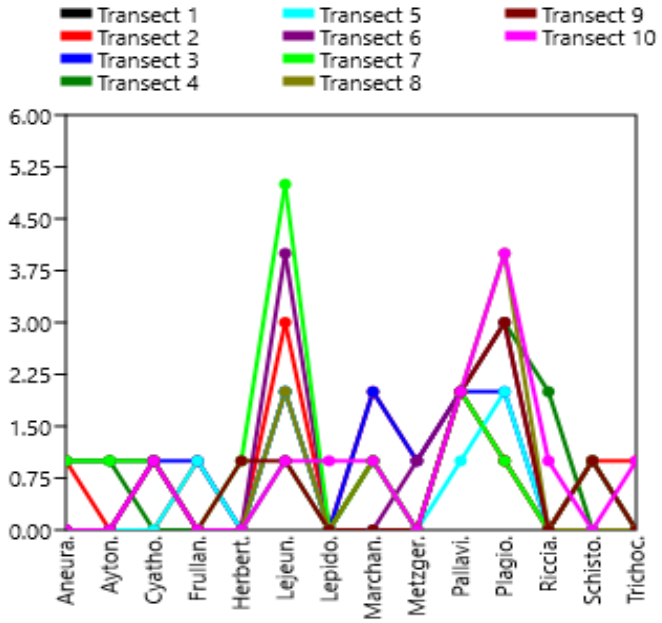

Figure 3. Family distribution of Liverwort flora in Mt. Bagalbal

IUCN Conservation status of liverwort flora of Mt. Bagalbal

Determining the conservation status of liverwort flora in any environment is crucial for providing essential information for conservation and protection efforts. This information is vital for governing bodies to develop safety measures not only for these lowly plants but also for the overall integrity of the ecosystem.

As shown in Figure 4, a total of 14 species lack recorded data regarding their conservation status on the IUCN website and in other journals. Eleven species are classified as Least Concern (LC), five as Data Deficient (DD), one as Vulnerable (VU)—*Pallavicinia lyellii* (Hook.) Carruth.—one as Critically Endangered (CR)—*Cyathodium foetidissimum* Schiffn.—and one as Near Threatened (NT)—*Trichocolea tomentella* (Ehrhart) Dumortier.

The conservation status of the liverwort flora of Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon, Philippines, presents alarming data that underscores the urgent need for timely conservation and protection initiatives by local authorities and community members. The Vulnerable, Critically Endangered, and Near Threatened statuses of certain species in the area indicate that the local ecosystem is still capable of supporting the sensitive biology of these plants. Furthermore, the data reveal factors contributing to the disturbance of the natural habitat of the liverwort flora. According to Meinunger and Schröder (2007) and Atherton et al. (2010), threats to liverworts include habitat changes, desiccation, eutrophication, overgrowth, and plant shading. Additionally, these lowly plants face serious threats from habitat degradation caused by drainage and habitat destruction resulting from afforestation.

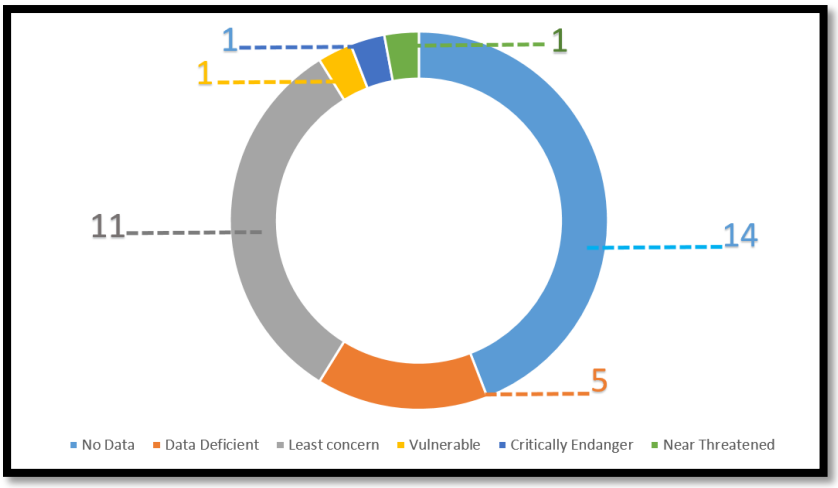

Figure 4. IUCN Conservation status of liverwort flora at Mt. Bagalbal

Information, Education, and Communication (IEC) Materials: Research-based instructional material on Liverwort biodiversity

Instructional materials such as IEC offer new approaches and learning opportunities that enhance students' knowledge and help them overcome deficiencies (Martin et al., 2013). The content included in the IEC material was all an output from the investigation of the liverwort flora of Mt. Bagalbal. It contains a brief discussion on the basic information of liverworts, a description of liverwort flora accompanied by photography to provide worthwhile information not only to students but even to local people, and a brief discussion on the proper steps in the conduct of liverwort collection from the forest. An expert content validated the biodiversity of the designed and developed liverwort flora IEC material.

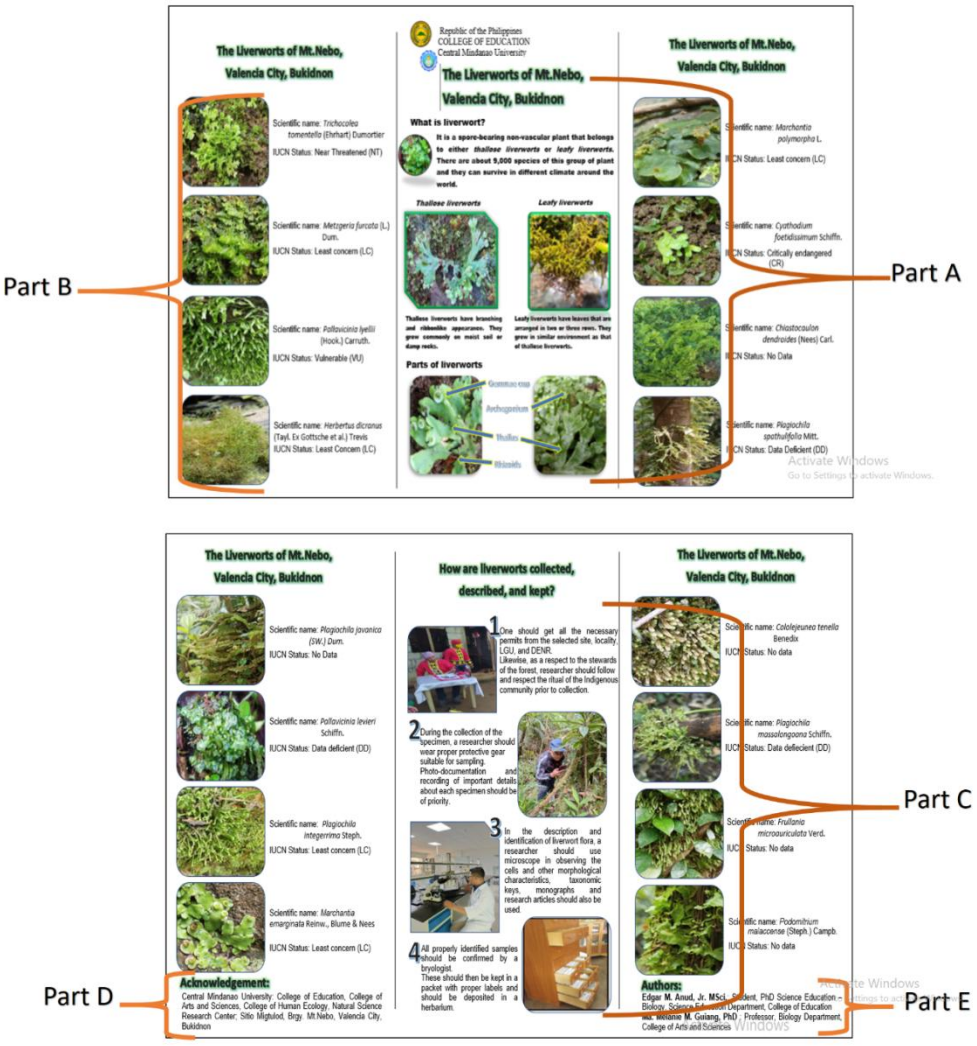

Figure 5. Parts of IEC material for Liverwort biodiversity conservation

The developed Information, Education, and Communication (IEC) materials comprise five significant parts (Fig. 5). These components are essential for achieving the aim of informing the public about the biodiversity of liverwort flora. All photographic documentation utilized in these materials is derived from the investigation conducted at Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon, Philippines.

Part A provides concise information regarding the biology of liverworts, enabling even the general public to understand what liverworts are and their basic anatomy. Part B features clear photographs of various liverwort representatives, accompanied by their scientific names and respective IUCN conservation statuses. Part C offers guidelines on the proper collection and examination of liverwort taxonomy. The second page of the IEC material includes acknowledgments of the agencies that facilitated the research endeavor (Part D) and basic information about the authors (Part E).

The production of these IEC materials aims to promote awareness, understanding, and behavioral change within the community's perspective on bryophytes, particularly liverworts. This material serves as a vital tool for emphasizing the significance of these lowly plants.

Bisang et al. (2020) found that developing IEC materials can raise awareness of the ecological importance of liverworts and encourage their protection. Similarly, Sarwar et al. (2019) indicated that producing IEC materials enhances awareness of the therapeutic benefits of liverworts and supports their sustainable use. Finally, Lücking et al. (2020) concluded that IEC materials bolster efforts to mitigate the expected decline in abundance and promote the conservation of liverwort biodiversity.

CONCLUSION

Fourteen families of liverworts were recorded: *Aneuraceae*, *Aytoniaceae*, *Cyathodiaceae*, *Frullaniaceae*, *Herbertaceae*, *Lejeuneaceae*, *Lepidoziaceae*, *Marchantiaceae*, *Metzgeriaceae*, *Pallaviciniaceae*, *Plagiochilaceae*, *Ricciaceae*, *Schistochilaceae*, and *Trichocoleaceae*. Among these families, *Plagiochilaceae* exhibited the highest species richness, with a total of eight species. This was followed by *Lejeuneaceae* with six species, and both *Marchantiaceae* and *Pallaviciniaceae* with three species each. The families *Metzgeriaceae*, *Ricciaceae*, and *Schistochilaceae* each contributed two species, while the families *Aneuraceae*, *Aytoniaceae*, *Cyathodiaceae*, *Frullaniaceae*, *Herbertaceae*, *Lepidoziaceae*, and *Trichocoleaceae* were represented by only one species each.

The species distribution pattern of the liverwort flora from Mt. Bagalbal indicated a distinct dispersal of most species. Two species were recorded at eight out of the ten

unique coordinates surveyed; four species were found in four coordinates; three species in three coordinates; six species in two coordinates; and the remaining 18 species were limited to a single unique coordinate.

A total of 14 species lack recorded data regarding their conservation status on the IUCN website and in other journals. Eleven species are classified as Least Concern (LC), five as Data Deficient (DD), one as Vulnerable (VU)—*Pallavicinia lyellii* (Hook.) Carruth.—one as Critically Endangered (CR)—*Cyathodium foetidissimum* Schiffn.—and one as Near Threatened (NT)—*Trichocolea tomentella* (Ehrhart) Dumortier.

The developed Information, Education, and Communication (IEC) materials consist of five major parts designed to inform the public about liverwort biodiversity. All photographic documentation utilized is derived from the investigation conducted at Mt. Bagalbal, Brgy. Mt. Nebo, Valencia City, Bukidnon, Philippines. Part A provides concise information on liverwort biology, while Part B includes clear photographs of several liverwort representatives, accompanied by their scientific names and respective IUCN conservation statuses. Part C offers guidelines on the proper collection and examination of liverwort taxonomy. Additionally, Part D acknowledges the agencies that contributed to the research, and Part E presents basic information about the authors.

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