

Pteridophytes in four key biodiversity areas of Columbio, Sultan Kudarat, Philippines

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ABSTRACT

The first record of pteridophyte species from Columbio, Sultan Kudarat were documented from its four key areas and identified along with their conservation status. A 2-km transect line was established in each of the four key biodiversity conservation sites. Sixty-six (66) pteridophyte species belonging to seventeen (17) families were identified across all areas. Family Polypodiaceae was observed with the highest number of recorded species (16). Of the four sites surveyed, Bulol-lumot harbored the highest number of species (56). Additionally, seven species were listed as endemic to the Philippines: *Diplazium sibuyanense* (Copel.) Alderw., *Polystichum elmeri* Copel., *Selliguea elmeri* (Copel.) Ching, *Lindsaea apoensis* Copel., *Lindsaea adiantodes* J.Sm., *Phlegmariurus delbrueckii* (Herter) A.R.Field & Bostock, and *Tectaria athyriosora* M.G.Price. Moreover, one was noted as Other Threatened Species, *Diplazium sibuyanense* (Copel.) Alderw. Three species were categorized as vulnerable: *Asplenium vittaeforme* Cav., *Drynaria aglaomorpha* Christenh., and *Drynaria heracleum* (Kunze) T.Moore. Lastly, one endangered species was identified, *Lepisorus platyrhynchos* (Kunze) Li Wang. Similarity index showed that the species across all sites is 27.08% similar. Results of this study showed that selected biodiversity key areas in Columbio supported high pteridophyte diversity. Thus, implementation of conservation measures and local strategies in these areas should be strengthened given that species with conservation issues were recorded in these areas.

Keywords: assessment, biodiversity, Columbio, conservation status, lower vascular, plants, pteridophytes

INTRODUCTION

Pteridophytes are seedless vascular plants with about 12,000 known species in recent data (Della and Falkenberg, 2019) and share a unique life cycle with independent gametophytes and sporophyte phases (Haufler *et al.*, 2016). These plants are widely distributed and more diverse in the equatorial region (Moran, 2008). Ten percent (10%) of the pteridophyte population thrived in the Philippines. Based on Co's Digital flora of the Philippines, over 40 families exist in the country; it comprises 1,030 species and 260 endemic species (Pelser *et al.*, 2021). Aside from their invaluable impact on global plant diversity, ferns have been discovered to be good sources of medicine, food, aesthetics, fuel (Benjamin and Manickam, 2007; Jaman and Yusuf, 2010; Akomolafe and Sulaimon, 2018; Rahman and Akomolafe, 2018), and a good indicator of disturbances in an ecosystem (Cano-Mangaoang *et al.*, 2020).

Columbio, Sultan Kudarat is known for its ecotourism sites Fekung Bula, La Palmera Mountain Ridge, Pangadilan Falls and Rock Formation, the Seven Falls of Columbio, and the Sinapulan Underground River (Orange, 2024) in addition to its rich flora and fauna. However, Columbio significantly reduced its forest cover due to deforestation from 2002 to 2023. During this period, 153 hectares of its humid primary forest are lost, accounting for 11% of its total tree cover. Subsequently, the humid primary forest cover in Columbio further decreased by 2.9%. In 2010, Columbio's natural forest spanned 22.9 thousand hectares, which constituted approximately 44% of its total land area, however, by 2023, the region had experienced a loss of 51 ha of natural forest, resulting in 28.7 kt of CO₂ emissions. With these data, the Local Government of Columbio took several initiatives and one of those is the assessment of the biodiversity of the known last forest areas of the Municipality.

Pteridophytes play vital roles in the environment's ecological stability (Azevedo-Schmidt *et al.*, 2024), biodiversity (Decombeix *et al.*, 2021), increase soil organic carbon, nitrogen and phosphorus (Zhao *et al.*, 2012), influencing plant community assembly (Yang *et al.*, 2021) and ethnobotanical uses (Muhammad *et al.*, 2020), having records of them in some key areas of Columbio will contribute to the baseline data of the Philippine pteridophytes, especially on their distribution. Hence, this study aimed to determine the diversity and conservation status of Pteridophytes in 4 key biodiversity areas of Columbio, Sultan Kudarat, namely: (1) Fekung Bula Falls, Brgy. Bantangan; (2) Bulol-lumot and (3) Bong Dat'l in Brgy. Dat'lblao; and (4) Bukay-El in Brgy. Sinapulan

MATERIALS AND METHODS

Sampling sites

The pteridophyte survey was conducted in four key areas of Columbio, Sultan Kudarat namely, (1) Fekung Bula Falls, Brgy. Bantangan; (2) Bulol-lumot and (3) Bong Dat'l, Brgy. Dat'lblao; and (4) Bukay El, Brgy. Sinapulan (Figure 1). A 2-km transect walk was done in every sampling site, and with an elevation of 1,200–2,000 meters above sea level (masl). Moreover, Bulol-lumot was identified by the Local Government Unit as the last standing

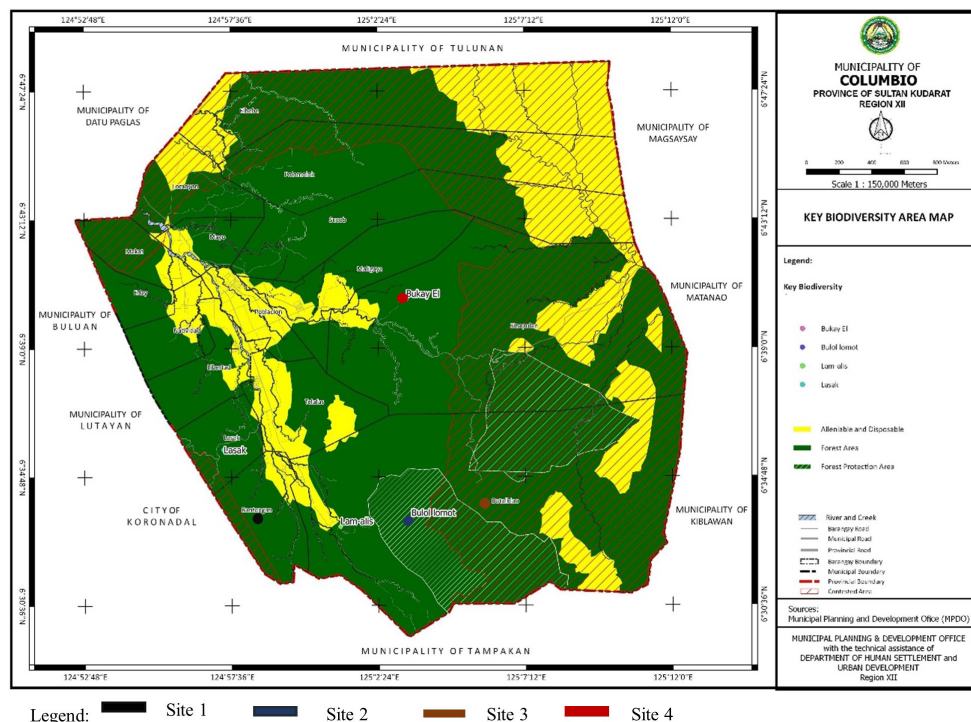


Figure 1. Map of Columbio showing the 4 sampling sites: Site 1- Fekung Bula, Brgy. Bantangan; Site 2- Bulul-lumot, Brgy. Dat'lbloa; Site 3- Bong Dat'l, Brgy. Dat'lbloa; Site 4- Bukay-El in Brgy. Sinapulan.

intact forest in the area with an elevation of 1300–1800 masl.

Processing, and Identification of Specimens

Pteridophyte species were pre-identified in the field using a pictorial guide and for those species that could not be identified, photographs were taken for further identification. Pictures of the following were taken for easy identification: habit, frond, stipe, sori arrangement, and even the whole plant. Confirmation of the species was done based on available monographs, Co's digital flora of the Philippines, and by comparing with the available e-herbarium from the JSTOR Global Plants website. The classification scheme was based on Pteridophyte Phylogeny Group I (PPG 1, 2016).

Conservation Status and Distribution

The conservation status was based on the Department of Environment and Natural Resources (DENR) Administrative Order No. 2017-11 "Updated National List of Threatened Philippine Plants and their Categories." The distribution data was based on Co's Digital Flora of the Philippines and the conservation status was taken from IUCN website - <https://www.iucnredlist.org>.

RESULTS AND DISCUSSION

Species Richness

There were 66 species of pteridophytes identified in all sampling sites; these species belong

to 17 families and 34 genera. Of these, four species were lycophytes under Lycopodiaceae and Selaginellaceae, and 62 were ferns. The highest number of species was recorded in Site 2 (Bulol-lumot, Brgy. Dat'Iblao) with 56 species. Polypodiaceae has the highest number of species across all sampling sites with 16 species, followed by Aspleniaceae with 9 species, Dryopteridaceae (8 species.), Athyriaceae (7 species.), Hymenophyllaceae and Lindsaeaceae (4 species.), Lygodiaceae and Nephrolepidaceae have 3 species each. In addition to this, Daval-

Table 1. Identified species of pteridophytes in all sampling areas in Columbio, Sultan, Kudarat along with their conservation status and distribution.

| Family | Species | National Conservation Status | IUCN Conservation Status | Distribution | Site |
|--------------|---|------------------------------|--------------------------|--------------|-------|
| Aspleniaceae | <i>Asplenium affine</i> Sw. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Asplenium cuneatum</i> Lam. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Asplenium horridum</i> Kaulf. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Asplenium nidus</i> L. | Other Wildlife Species | Unlisted | Native | 1,2,3 |
| | <i>Asplenium pellucidum</i> Lam. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Asplenium tenerum</i> G.Forst. | Other Wildlife Species | Unlisted | Native | 2,4 |
| | <i>Asplenium thunbergii</i> Kunze | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Asplenium vittaeforme</i> Cav. | Vulnerable | Unlisted | Native | 2 |
| | <i>Hymenasplenium cheilosorum</i> (Kunze ex Mett.) Tagawa | Other Wildlife Species | Unlisted | Native | 2 |
| Athyriaceae | <i>Diplazium dilatatum</i> Blume | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Diplazium esculentum</i> (Retz.) Sw. | Other Wildlife Species | Least Concern | Native | 2 |
| | <i>Diplazium fraxinifolium</i> C.Presl | Other Wildlife Species | Unlisted | Native | 2,3 |
| | <i>Diplazium irigense</i> (Copel.) M.G.Price | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Diplazium pallidum</i> (Blume) T.Moore | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Diplazium sibuyanense</i> (Copel.) Alderw. | Other Threatened Species | Unlisted | Endemic | 2 |
| | <i>Diplazium sylvaticum</i> (Bory) Sw. | Other Wildlife Species | Unlisted | Native | 1,2,4 |

| Family | Species | National Conservation Status | IUCN Conservation Status | Distribution | Site |
|------------------|--|------------------------------|--------------------------|--------------|-------|
| Davalliaceae | <i>Davallia denticulata</i> (Burm.f.) Mett. | Other Wildlife Species | Unlisted | Native | 2,4 |
| | <i>Davallia trichomanoides</i> Blume | Other Wildlife Species | Unlisted | Native | 2,4 |
| Dryopteridaceae | <i>Arachnoides amabilis</i> (Blume) Tindale | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Bolbitis heteroclita</i> (C. Presl.) Ching | Other Wildlife Species | Unlisted | Native | 1,2,4 |
| | <i>Dryopteris formosana</i> (Christ) C.Chr. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Dryopteris hendersonii</i> (Bedd.) C.Chr. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Dryopteris sparsa</i> (D.Don) Kuntze | Other Wildlife Species | Unlisted | Native | 1,2 |
| | <i>Elaphoglossum blumeanum</i> (Fée) J.Sm | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Pleocnemia macrodonta</i> (C.Presl. ex Fée) Holttum | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Polystichum elmeri</i> Copel. | Other Wildlife Species | Unlisted | Endemic | 2 |
| Hymenophyllaceae | <i>Abrodictyum obscurum</i> (Blume) Ebihara & K.Iwats. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Callistopteris apiifolia</i> (C.Presl) Copel. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Hymenophyllum acanthoides</i> (Bosch) Rosenst. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Hymenophyllum badium</i> Hook. & Grev. | Other Wildlife Species | Unlisted | Native | 2 |
| Lindsaeaceae | <i>Lindsaea apoensis</i> Copel. | Other Wildlife Species | Unlisted | Endemic | 2 |
| | <i>Lindsaea adiantodes</i> J.Sm. | Other Wildlife Species | Unlisted | Endemic | 1,2,4 |
| | <i>Lindsaea ensifolia</i> Sw. | Other Wildlife Species | Unlisted | Native | 1,2,4 |
| | <i>Lindsaea lucida</i> Blume | Other Wildlife Species | Unlisted | Native | 2 |
| Lycopodiaceae | <i>Lycopodium clavatum</i> L. | Other Wildlife Species | Unlisted | Native | 2 |

| Family | Species | National Conservation Status | IUCN Conservation Status | Distribution | Site |
|------------------|--|------------------------------|--------------------------|--------------|---------|
| | <i>Phlegmariurus delbrueckii</i> (Herter) A.R. Field & Bostock | Other Wildlife Species | Unlisted | Endemic | 2 |
| Lygodiaceae | <i>Lygodium circinnatum</i> (Burm.f.) Sw. | Other Wildlife Species | Unlisted | Native | 1,4 |
| | <i>Lygodium flexuosum</i> (L.) Sw. | Other Wildlife Species | Unlisted | Native | 1,4 |
| | <i>Lygodium japonicum</i> (Thunb.) Sw. | Other Wildlife Species | Unlisted | Native | 1,4 |
| Marattiaceae | <i>Ptisana sylvatica</i> (Blume) Murdock | Other Wildlife Species | Unlisted | Native | 2 |
| Nephrolepidaceae | <i>Nephrolepis cordifolia</i> (L.) C.Presl | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Nephrolepis biserrata</i> (Sw.) Schott | Other Wildlife Species | Unlisted | Native | 1,4 |
| | <i>Nephrolepis falcata</i> (Cav.) C.Chr. | Other Wildlife Species | Unlisted | Native | 1,2,3,4 |
| Oleandraceae | <i>Oleandra neriiiformis</i> Cav. | Other Wildlife Species | Unlisted | Native | 2 |
| Plagiogyriaceae | <i>Plagiogyria pycnophylla</i> (Kunze) Mett. | Other Wildlife Species | Unlisted | Native | 2 |
| Polypodiaceae | <i>Drynaria aglaomorpha</i> Christenh. | Vulnerable | Unlisted | Native | 2,3 |
| | <i>Drynaria heracleum</i> (Kunze) T.Moore | Vulnerable | Unlisted | Native | 2 |
| | <i>Drynaria rigidula</i> (Sw.) Bedd. | Other Wildlife Species | Unlisted | Native | 3 |
| | <i>Goniophlebium persicifolium</i> (Desv.) Bedd. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Goniophlebium pseudoconnatum</i> (Copel.) Copel. | Other Wildlife Species | Unlisted | Native | 1,2 |
| | <i>Lepisorus accedens</i> (Blume) Hosok. | Other Wildlife Species | Unlisted | Native | 1 |
| | <i>Lepisorus platyrhynchos</i> (Kunze) Li Wang | Endangered | Unlisted | Native | 2 |
| | <i>Leptochilus hemionitideus</i> (C.Presl) Noot. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Phymatosorus commutatus</i> (Blume) Pic.Serm. | Other Wildlife Species | Unlisted | Native | 1 |

| Family | Species | National Conservation Status | IUCN Conservation Status | Distribution | Site |
|------------------|---|------------------------------|--------------------------|--------------|---------|
| | <i>Phymatosorus membranifolius</i> (R.Br.) S.G.Lu | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Prosaptia contigua</i> (G. Forst.) C.Presl | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Pyrrosia sphaerosticha</i> (Mett.) Ching | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Selliguea albidosquamata</i> (Blume) Parris | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Selliguea elmeri</i> (Copel.) Ching | Other Wildlife Species | Unlisted | Endemic | 2 |
| | <i>Thylacopteris papillosa</i> (Blume) Kunze ex J.Sm. | Other Wildlife Species | Unlisted | Native | 2 |
| Pteridaceae | <i>Antrophyum immersum</i> (Bory ex Willd.) Mett. | Other Wildlife Species | Unlisted | Native | 1,2 |
| Selaginellaceae | <i>Selaginella engleri</i> Hieron. in Engl. & Prantl | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Selaginella gastrophylla</i> Warb. | Other Wildlife Species | Unlisted | Native | 1,2,3,4 |
| Tectariaceae | <i>Tectaria athyriosora</i> M.G. Price | Other Wildlife Species | Unlisted | Endemic | 1,3 |
| Thelypteridaceae | <i>Grypothrix cuspidata</i> (Blume) S.E.Fawc. & A.R.Sm. | Other Wildlife Species | Unlisted | Native | 2 |
| | <i>Pneumatopteris glabra</i> (Copel.) Holtum | Other Wildlife Species | Unlisted | Native | 1 |

liaceae, Selaginellaceae, Tectariaceae, Thelypteridaceae with 2 species while Oleandraceae, Plagiogyriaceae, and Pteridaceae with only one species (Table 1).

The result of this study agrees with Amoroso *et al.* (2016) that the most common family of ferns in the Philippines is Polypodiaceae and they are widely distributed followed by the family Pteridaceae. Coritico *et al.* (2020) also reported that the highest number of species identified in Mt. Tago Range, Bukidnon was under the family of Polypodiaceae.

The result also showed that the species richness of pteridophytes in Columbio represented 6.1% of all species in the Philippines. The observed species in Columbio were compared to be less than that of Mt Hamiguitan (Amoroso *et al.*, 2016), Mt. Limbawon and Manugawi (Coritico *et al.*, 2020), Mt. Apo Natural Park (Cano-Mangaoang *et al.* 2020), but a bit higher compared with the species identified in Mainit Hot Spring Protected Landscape, Nabunturan, Compostela Valley Province (Pilonos *et al.*, 2012).

It is also noteworthy that there is an existence of endangered species in one of the sampling sites. Despite the ongoing threats to the biodiversity in the region, the diversity of pteridophytes remains notably impressive.

Similarity of Species Composition Among Sites

Using Bray-Curtis Cluster Analysis, the similarity of species composition in the four sampling sites was determined. The dendrogram shows an overall similarity of 27.08% of all sampling sites based on species composition. Based on the dendrogram, Bulol-lumot and Bong Dat'l form a distinct cluster, whereas Bukay-El and Fekung Bula were grouped (Figure 2). This suggests that Bulol-lumot and Bong Dat'l provide a good habitat for pteridophytes to thrive. Additionally, it is important to note that Bulol-lumot and Bong Dat'l are situated at higher elevations than the other two sites. However, only 2 species were common in both sites - *Diplazium fraxinifolium* and *Drynaria aglaomorpha* and the latter was categorized as vulnerable based on DENR Administrative Order (DAO) 2017-11. These mentioned species can be an epiphyte if there's an available phorophyte or host tree for attachment and usually thrived in higher elevations (Jimenez-Lopez *et al.*, 2020). Intact forest in Columbio can still be observed in Bulol-lumot and Bong Dat'l as previously mentioned, this might explain presence of these epiphytic ferns in the area due to availability of phorophytes or host plants for attachment (Cano-Mangaoang *et al.* 2020). Zotz *et al.* (2014) and Hirata *et al.* (2009) emphasized the importance of phorophytes in the existence of epiphytic species. Furthermore, the presence of trees provides shade to forest floor plants including pteridophytes and according to Anderson (2018) that ferns tolerate short periods of full sun but prefer strong filtered or reflected sunlight throughout the day. This could be the factor of high species richness in Bulol Lumot and forming a distinct cluster. On the other hand, some species that can only be seen in Bukay El and Fekung Bula are *Lygodium circinnatum* (Burm.f.) Sw., *L. flexuosum* (L.) Sw., *L. japonicum* (Thunb.) Sw., and *Nephrolepis biserrata* (Sw.) Schott. These ferns can live in a disturbed environment, especially the *N. biserrata* (Sw.) Schott, wherein they can grow either in low or high-shade conditions (Satriawan *et al.*, 2021). Moreover, similar species were identified by Perida *et al.* (2023) along selected roadside vegetation of Macalelon and Infanta in Quezon Province. Accordingly, the fern species thriving in the roadside vegetation could adapt to disturbances and changes in the ecological and edaphic factors which makes these species potential bioindicators.

Conservation and Ecological Status

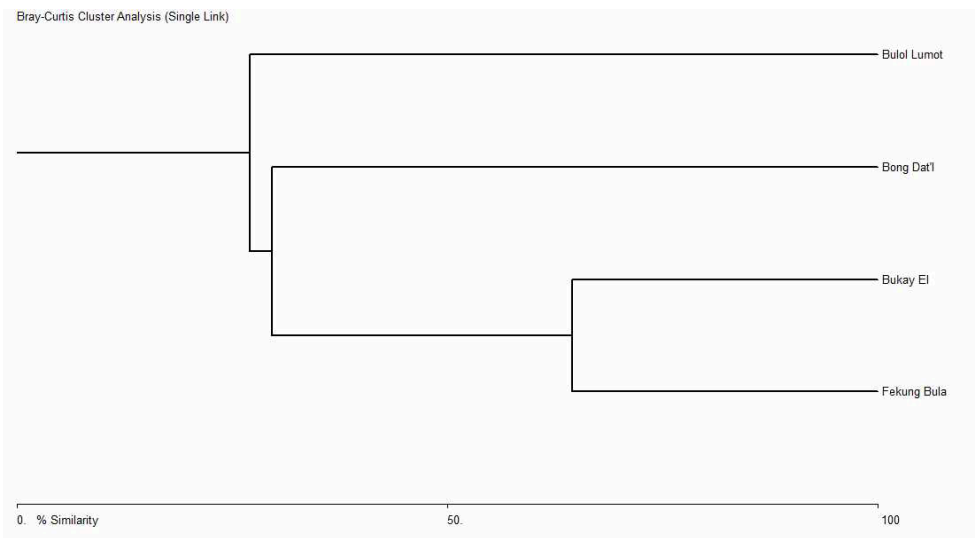


Figure 2. Dendrogram of Similarity of Species in all sampling sites.

In terms of conservation status, 92% of the species were categorized as “Other Wildlife Species.” This category includes species that are not currently classified under any specific threat level according to Section 4 of the DENR Administrative Order (DAO) 2017-11. Five percent (5%) of the species were categorized as vulnerable including *Asplenium vittaeforme*, *Drynaria aglaomorpha*, and *D. heracleum*. Two percent (2%) were identified as other threatened species, such as *Diplazium sibuyanense*. One species were classified as endangered species, specifically *Lepisorus platyrhynchos* (Figure 3). Moreover, seven species were identified as endemic to the Philippines - *Diplazium sibuyanense*, *Polystichum elmeri*, *Lindsaea apoensis*, *Lindsaea adiantodes*, *Phlegmariurus delbrueckii*, *Selliguea elmeri*, and *Tectaria athyriosora*.

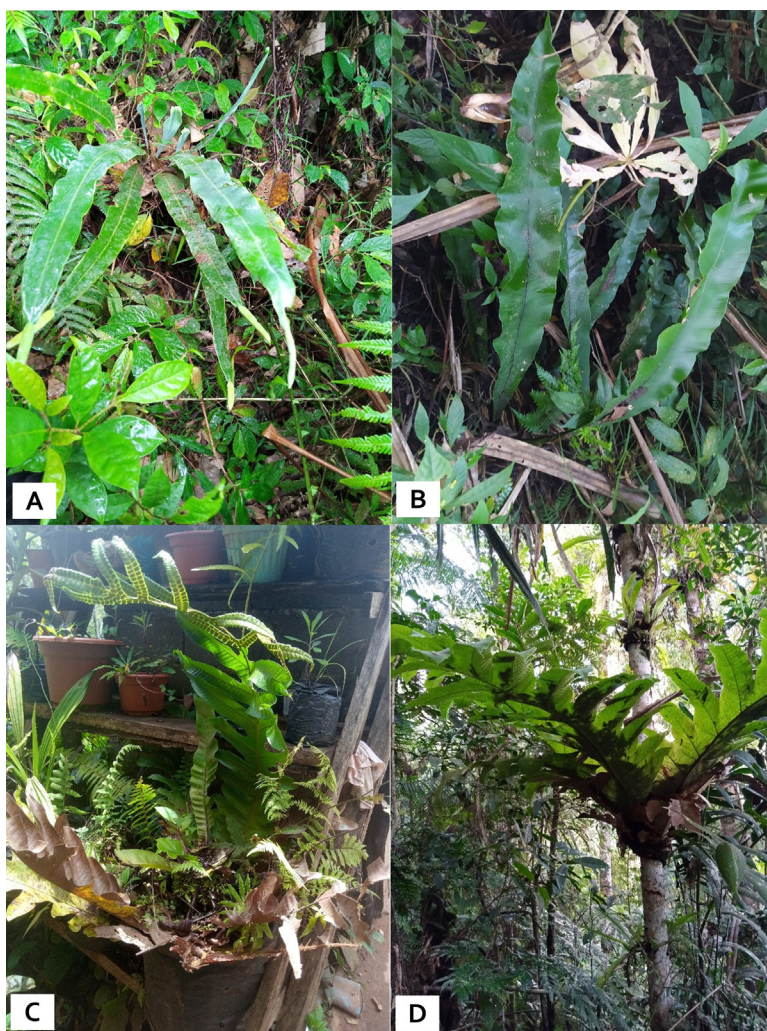


Figure 3. Species with conservation issues identified in 4 Key Biodiversity Areas of Columbio, Sultan Kudarat. A. *Lepisorus platyrhynchos* (Kunze) Li Wang (Endangered); B. *Asplenium vittaeforme* Cav. (Vulnerable); C. *Drynaria aglaomorpha* Christenh (Vulnerable); D. *Drynaria heracleum* (Kunze) T.Moore (Vulnerable).

Conclusion and Recommendation

The four key biodiversity areas in Columbio, Sultan Kudarat served as a habitat for a high number of species of pteridophytes (66 species belonging to 17 families and 34 genera). Moreover, 4 species of pteridophytes with conservation issues were identified in addition to a high proportion of species being endemic and native. Based on this observation, this study suggests a more intensive survey of pteridophyte diversity, perform regular monitoring, and strengthen implementation of both national and local policies to ensure conservation since key biodiversity sites are also within the areas open for ecotourism.

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