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# Species diversity of Annonaceae in the four selected protected areas in the Bicol Region, Philippines

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**Abstract.** *Retuerma-Dioneda A, Alejandro GJD. 2023. Species diversity of Annonaceae in the four selected protected areas in the Bicol Region, Philippines. Biodiversitas 24: 5428-5438.* An explorational survey of four selected protected areas (PAs) was conducted in the Bicol region for Annonaceae. The study aimed to provide species diversity of Annonaceae with an account of their endemicity and distribution. The four PAs were the Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA), Bulusan Volcano Natural Park (BVNP), Mt. Isarog Natural Park (MINP), and Mt. Mayon Volcano Natural Park (MMVNP). Thirty samples were collected and identified, 16 species belonging to 13 genera, namely *Annona, Artabotrys, Cananga, Drepananthus, Goniothalamus, Fissistigma, Friesodielsia, Meiogyne, Monoon, Phaeanthus, Polyalthia, Popowia,* and *Uvaria*. Miliuseae is the most species-rich tribe with 7 species (43.75%), followed by Uvarieae with 4 species (25%), Annoneae with 2 species, Canangeae with 2 species (12.5% each), and Xylopieae with 1 species (6.25%). A key of all Annonaceae species collected in the four PAs is provided here. Five Philippine endemic species were identified, namely *G. elmeri* in the four PAs; *P. luzonensis* in three PAs; *F. lanceolata,* and *P. lanceolata* in AMMNBA; and *U. valderramensis* in BVNP. AMMNBA has the highest number of species (43%). The species identified comprises 10.88% of the 147 recorded Philippine Annonaceae species. The results highlight the presence and occurrence of Annonaceae essential for management and conservation policy.

**Keywords:** Annonaceae, Bicol region, explorational survey, protected areas, species diversity

## INTRODUCTION

Annonaceae is one of the largest pantropical families of trees, shrubs, and lianas that play a significant ecological role in diversity in tropical forests as key habitat organisms (Handayani 2018). Most species are also known for their economic uses as food and beverages (Ma et al. 2017; Meade and Parnell 2018), essential oils (Thang et al. 2013), medicine (Macabeo et al. 2014; Malaluan et al. 2022), and traditional treatments for fever, malaria, ulcers, tuberculosis, dysentery, and skin diseases (Christopher 2022; Ilagan et al. 2022). The family is distinct and recognized with aromatics, exstipulate, distichous leaves, and fibrous bark traits. The flowers have trimerous perianth with two whorls of petals, numerous stamens, mostly free carpels, and large seeds with ruminate endosperm (Couvreur et al. 2012; Turner 2018).

Annonaceae is the largest family in the clade Magnolideae, comprising 110 genera and approximately 2500 species (Xue et al. 2020; Johnson et al. 2021). It has 4 subfamilies, namely Anaxagoreoideae (30 species), Ambavioideae (60 species), Annonoideae (1600 species), and Malmeoideae (800 species). Most species thrived in the equatorial belt, such as *Fissistigma* Griff., *Meiogyne* Miq., and *Trivalvaria* Miq. (Couvreur et al. 2012; Erkens et al. 2022), especially in the Asia-Pacific region, which is rich in different Annonaceae species, such as *Goniothalamus* (Blume) Hook.f & Thomson and *Uvaria* L. (Turner 2018).

Merrill (1912-1926) made the first record of Annonaceae in the Philippines. He collected and recorded 25 genera and 139 species in his renowned book, "Enumeration of Flowering Plants of the Philippines." Co's Digital Flora of the Philippines (CDFP 2023) has recognized 33 genera with 147 species. The following studies conducted on Annonaceae showed the extent of its distribution and biodiversity in the Philippines, such as Samson (2000), Wang and Saunders (2006), Cabuang et al. (2012), Tang et al. (2013), Arriola et al. (2020), and Dioneda and Alejandro (2022).

In the Bicol region, Philippines, there are 11 mountainous Protected Areas (PAs) categorized as natural parks and natural biotic areas by the National Integrated Protected Areas System (NIPAS). Floristic surveys, such as ethnobotanical surveys, yielded 27 endemic plants in Mt. Malinao in Albay (de Guzman et al. 2014). Ninety-one species of plants were found at the Caramoan National Park (CNP) in Camarines Sur (Hernandez et al. 2021), 202 species of plants in the Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA) in Camarines Norte (Terbio et al. 2022). Both studies in CNP and AMMNBA recorded high biodiversity values. The only published paper on Annonaceae in the Bicol region was in AMMNBA, Camarines Norte and recorded 3 subfamilies, 5 tribes and 11 genera, namely *Artabotrys, Drepananthus, Fissistigma, Friesodielsia, Goniothalamus, Meiogyne, Monoon,*

*Phaeanthus*, *Polyalthia*, *Popowia*, and *Uvaria* (Dioneda and Alejandro 2022).

The present study made explorations and collections of Annonaceae species in the four major PAs in the Bicol region, Philippines, namely Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA), Bulusan Volcano Natural Park (BVNP), Mt. Isarog Natural Park (MINP), and Mt. Mayon Volcano Natural Park (MMVNP) in Albay. These PAs must be explored for plant families because of the threats, destruction and extinction caused by natural disasters like typhoons, volcanic eruptions, and anthropogenic activities (Barit et al. 2022). Floristic assessments still need to be expanded on Annonaceae, because most assessments are general listings of plants, and some focus on timber trees and their economic aspects (Hernandez et al. 2021; Banag-Moran et al. 2022). Furthermore, Annonaceae collections and listings are also very limited; hence, the present study aimed to provide species diversity of Annonaceae in the four selected PAs in the Bicol Region, Philippines with an account of their endemicity and distribution.

## MATERIALS AND METHODS

### Study site

Bicol Region is located in southern Luzon Island, has a land area of 17,632 km$^2$, situated between 11° 30' to 14° 20' N and 122° 20' to 124° 30' E, and is slightly over 2,400 m in elevation. It covers six provinces namely Albay, Camarines Norte, Camarines Sur, Catanduanes, Sorsogon, and Masbate (Figure 1). Much of the region is mountainous, dominated by volcanoes and tablelands. The topographic features of the region are the Mayon Volcano and Mt. Isarog, the summits of which are 2,460 m and 1,966 m asl, respectively. The climate is affected by rainfall and tropical cyclones. The dominant wind systems in the region are the northeast monsoons which occur from October to March, the southwest monsoon, occurring at the end of May to the middle of September; and the north Pacific trades (easterlies), dominant during April to early May (BRDP 2023-2028).

The four PAs included in the study are described (PAMP 2023-2030) below, and some portions of their habitat are shown in Figure 2.

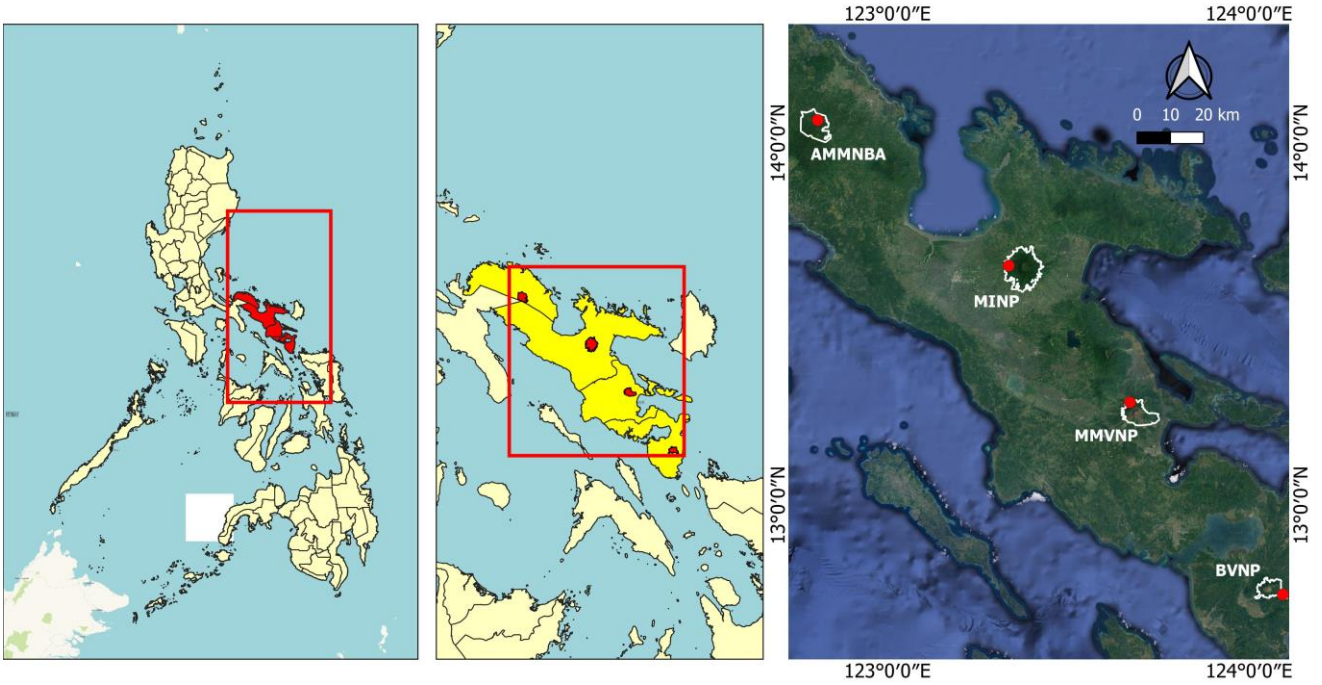


**Figure 1.** Location of the study site shows the Bicol region and the four PAs. AMMNBA: Abasig-Matogdon-Mananap Natural Biotic Area, MINP: Mt. Isarog Natural Park, MMVNP: Mt. Mayon Volcano Natural Park, BVNP: Bulusan Volcano Natural Park. The collection sites were marked with green circles. The map was prepared using ARC-GIS (DENR-Region V 2022)

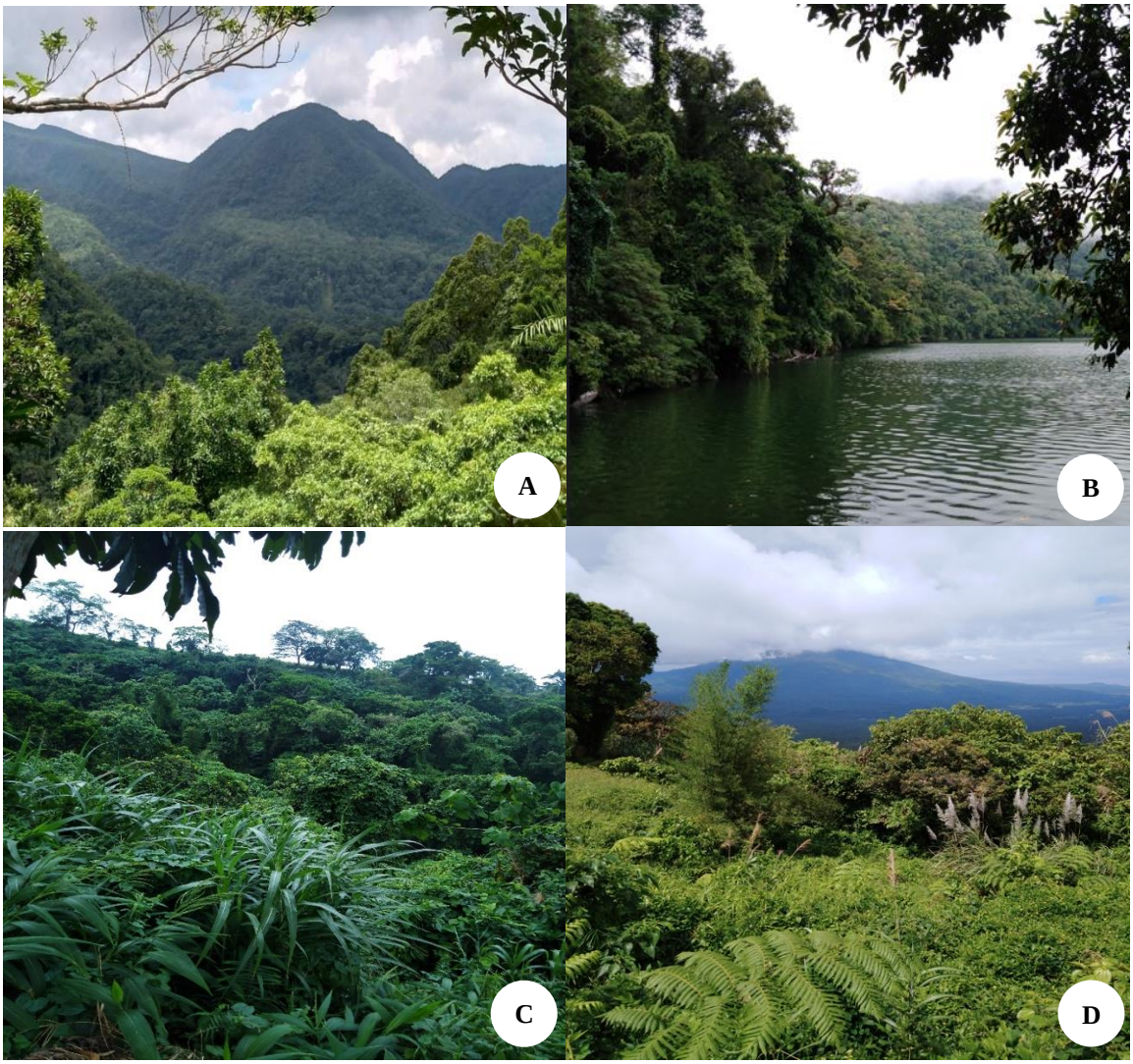


**Figure 2**. View of the four collection sites. A. Mt. Mananap in San Vicente of AMMNBA. B. Forest in Bulusan Lake part of BVNP. C. Panicuason, Naga City in MINP. D. Mayon, Tabaco City in MMVNP. Photos were taken by A. R. Dioneda

*Abasig-Matogdon-Mananap Natural Biotic Area (AMMNBA)*

AMMNBA comprises a large patch of the rainforest of 46 km$^2$ around Labo Volcano, extending to an elevation of 1,539 m asl. It serves as an important watershed for eight municipalities in Camarines Norte. The PA covers the municipalities of San Vicente, San Lorenzo Ruiz, and Labo. It has a total land area of 59 km$^2$ and was considered the major watershed forest reserve in November 1991 and declared a natural biotic area in May 2000 under Presidential Proclamation No. 318. The climatic factors affecting the AMMNBA are an average rainfall of 280 mm and temperature ranged from 29.7°C to 35°C.

*Bulusan Volcano Natural Park (BVNP)*

Mt. Bulusan is the 3$^{rd}$ most active volcano located in Sorsogon. It has a total land area of 3.67 km$^2$ and about 1,559 m asl. surrounded by the municipalities of Barcelona, Bulusan, Casiguran, Irosin and Juban. It is a major ecotourism destination because of the three lakes, namely Bulusan, Aquingay, and Black Bird; springs, rivers, and waterfalls. BVNP was declared a natural park in November 2000 under Presidential Proclamation 421. The climate in Mt. Bulusan is warm, windy, and overcast. The temperature typically varies from 23°C to 31°C.

*Mt. Isarog Natural Park (MINP)*

Mt Isarog is the highest forested peak in southern Luzon and Camarines Sur. It has about 60% forest cover and is home to 143 bird species and 1,300 species of plants (Balcita and Nolasco 2000). The PA has a total land area of 101.12 km$^2$ across the municipalities of Pili, Ocampo, Tigaon, Goa, Tinambac, Calabanga and Naga City. It was declared a national park in July 1938 and reclassified as a natural park in June 2002 under Proclamation 214. It is identified as one of the key biodiversity areas and watersheds with 16 major rivers that ensure a supply of potable and irrigation waters in Camarines Sur.

*Mt. Mayon Volcano Natural Park (MMVNP)*

Mt. Mayon is one of the world's heritage site and the most active volcanoes in Albay, with a towering height of 2,642 m asl. It has very steep upper slopes averaging from 35° to 40°. There are many narrow to very wide ravines, channels, and gullies that serve as the passageway of lava and mountain water during eruptions and heavy rains. The municipalities surrounding the volcano are Malinao, Daraga, Camalig, Guinobatan, Legazpi, Ligao, and Tabaco. MMVNP was proclaimed a natural park in November 2000 under Republic Act 11038.

**Fieldwork collection**

Before the plant survey, the research proposal was presented to the Protected Area Management Board (PAMB) of each PA and the DENR Regional Office V in Legazpi City in Albay to secure a Gratuitous Permit. Purposive sampling was done in the four selected PAs (Table 1). Plant specimens showing the characteristics of Annonaceae were collected along the trail and 10 m outside the trail. Collected plants in triplicates were pressed, poisoned and mounted as herbarium vouchers. Herbarium specimens were labeled, and one copy of each voucher specimen was deposited at the University of Santo Tomas Herbarium (USTH), Philippines.

**Identification and data analysis**

Morphological examination and identification was performed using the Kew Plant Glossary: An Illustrated Dictionary of Plant Identification of Terms (Beentje 2016), literature sources of van Huesden (1994), Couvreur et al. (2012), Chatrou et al. (2012), Turner (2018) and likewise compared to online databases in eFloras (2008), Global Biodiversity Information Facility (GBIF 2022), www.phytoimages.siu.org (2022), Co's Digital Flora of the Philippines (CDFP 2023), Plants of the World Online (POWO 2023), World Checklist of Selected Plant Families (WCSP 2023), Global Plants (JSTOR 2023), and herbarium with local collections from the Philippine National Herbarium (PNH), College of Agriculture Herbarium University of the Philippines (CAHUP) and Jose Vera Santos Memorial Herbarium (JVSMH) in University of the Philippines, Diliman. The USTH and Royal Botanic Gardens (K) curators verified the identifications.

The endemicity of collected specimens was referred to CDFP (2023). The conservation status of the collected species was referred to the International Union for the Conservation of Nature (IUCN) Red List (2023) and DENR-DAO (2017). Species diversity and richness were determined by getting the total number of species and the percentage of each species.

## RESULTS AND DISCUSSION

The species diversity, distribution and taxonomic descriptions are provided. The endemicity and conservation status of each species collected in the PAs are also presented.

**Species diversity of Annonaceae in the Bicol region**

Thirty Annonaceae samples were collected and identified from the four PAs. A total of 16 species belonging to 13 genera, namely *Annona, Artabotrys, Cananga, Drepananthus, Goniothalamus, Fissistigma, Friesodielsia, Meiogyne, Monoon, Phaeanthus, Polyalthia, Popowia,* and *Uvaria.* Further, the 16 species represent 3 subfamilies and 5 tribes. The subfamily Malmeoideae with tribe Miliuseae has the highest number of species (7 species), followed by the subfamily Annonoideae with tribes Uvarieae (4 species), Annoneae (2 species), Xylopieae (1 species) and subfamily Ambavioideae with tribe Canangeae (2 species). Miliuseae is the most species-rich tribe (43.75%), followed by Uvarieae (25%), Annonaeae (12.5%), Canangeae (12.5%), and Xylopieae (6.25%). Among these species, 11 (68.75%) are trees and 5 (31.25%) are lianas. The total number collected in the four PAs comprises 10.88% of the 147 recorded Philippine Annonaceae species. The list of these species is presented in Table 2.

A taxonomic key to the species of Annonaceae collected from the four PAs in the Bicol region, Philippines is presented with their distinct characteristics for identification.

**Table 1.** List of sampling sites on the selected PAs in the Bicol region, Philippines

| PAs | Areas sampled | Ecosystem type | Location | Collection Elevation (m asl.) | Date of collection |
|---|---|---|---|---|---|
| BVNP | Bulusan Lake, Bulusan, Sorsogon | Sub-Montane and Lake Ecosystem | 12°45´15.12"N 124°5´38.76" E | 360-450 | July, 2019 |
| MINP | Panicuason, Naga City, Camarines Sur | Montane Rainforest | 13°39´42.84"N 123°20´9.6"E | 440-500 | August, 2019 |
| MMVNP | Barangay Mayon, Tabaco City, Albay | Second growth Forest, bushland | 13°17´4.56"N 123°40´16.32"E | 854-860 | October, 2019 |
| AMMNBA | Mt. Mananap and Mt. Matogdon San Lorenzo Ruiz, San Vicente, Labo, Camarines Norte | Tropical lowland evergreen Rainforest | 14°3´50"N 122°48´27"E | 310-663 | January, 2020 July, 2021 |

**Table 2.** Comparative list of Annonaceae species collected in the selected PAs in the Bicol region, Philippines

| Species | AMMNBA | BVNP | MINP | MMVNP | Habitus | Endemicity | Conservation status | Coordinates | Collection No. |
|---|---|---|---|---|---|---|---|---|---|
| **Subfamily Malmeoideae** | | | | | | | | | |
| **Tribe Miliuseae** | | | | | | | | | |
| *Meiogyne cylindrocarpa* (Burck) Heusden | x | | x | | T | N | NE | 14°3´13"N 122°49´43"E | ARAM17, ARMP12 |
| *Monoon grandifolium* (Elmer) B. Xue & R.M.K. Saunders | x | | x | | T | N | NE | 13°39´42.84"N 123°20´9.6"E | ARAM31, ARMP15 |
| *Phaeanthus ophthalmicus* (Roxb. ex G. Don) J. Sinclair | x | | x | | T | N | NE | 14°3´2"N 122°47´13"E | ARAM46, ARMP17 |
| *Polyalthia lanceolata* S. Vidal | x | | | | T | E | NE | 14°3´28"N 122°47´36"E | ARAM09 |
| *Polyalthia luzonensis* (Merr.) B. Xue & R.M.K. Saunders | x | x | x | | T | E | NE | 13°39´42.84"N 123°20´9.6"E | ARAM36, ARBV10, ARMP03 |
| *Polyalthia suberosa* (Roxb.) Thwaites | x | | x | | T | N | NE | 14°3´32"N 122°47´37"E | ARAM40, ARMP11 |
| *Popowia pisocarpa* (Blume) Endl. ex. Walp. | x | | | | T | N | NE | 14°3´40"N 122°49´38"E | ARAM38 |
| **Subfamily Annonoideae** | | | | | | | | | |
| **Tribe Uvarieae** | | | | | | | | | |
| *Fissistigma latifolium* (Dunal) Merr. | x | | | x | L | N | NE | 14°3´4"N 122°47´47"E | ARAM18, ARMM04 |
| *Friesodielsia lanceolata* (Merr.) Steenis | x | | | | L | E | NE | 14°3´39"N 122°49´38"E | ARAM21 |
| *Uvaria monticola* Miq. | x | | | | L | N | NE | 14°3´33"N 122°49´50"E | ARAM51 |
| *Uvaria valderramensis* Cabuang, Exconde & Alejandro | | x | | | L | E | NE | 12°45´15.12"N, 124°53´8.76"E | ARBV55 |
| **Tribe Annoneae** | | | | | | | | | |
| *Annona glabra* L. | | x | x | | T | | NE | 13°39´42.84" N, 123°20´9.6" E | ARBV02, ARMP10 |
| *Goniothalamus elmeri* Merr. | x | x | x | x | T | E | NE | 13°17´5.56" N, 123°40´16.32"E | ARAM14, ARBV05, ARMP06, ARMM05 |
| **Tribe Xylopieae** | | | | | | | | | |
| *Artabotrys suaveolens* (Blume) Blume | x | x | x | | L | N | NE | 12°45´15.12"N, 124°53´8.76"E | ARAM70, ARBV18, ARMP20 |
| **Subfamily Ambavioideae** | | | | | | | | | |
| **Tribe Canangeae** | | | | | | | | | |
| *Cananga odorata* (Lam.) Hook.f. & Thomson | | x | | x | T | N | NE | 13°17´4.56" N, 123°40´16.32"E | ARBV01, ARMM03 |
| *Drepananthus acuminatus* (C.B. Rob.) Survesw & R.M.K. Saunders | x | | | | T | N | NE | 14°2´56"N 122°48´33"E | ARAM20 |
| Total | 13 | 6 | 8 | 3 | | | | | |

Notes: Habitus, T: Trees; L: Lianas. Endemicity, E: Endemic; N: Not Endemic (CDFP 2023); BVNP: Bulusan Volcano Natural Park; MMVNP: Mt. Mayon Volcano Natural Park; MINP: Mt. Isarog Natural Park; AMMNBA: Abasig-Matogdon-Mananap Natural Biotic Area. The Conservation status of the collected species was referred to the International Union for the Conservation of Nature (IUCN) and DENR-DAO (2017)

**Key to the species of Annonaceae in the four PAs in the Bicol region, Philippines**

1a. Fruits syncarpous..... *Annona glabra*
1b. Fruits apocarpous..... 2
2a. Lianas..... 3
2b. Trees ..... 7
3a. Inflorescence peduncle formed into a hook ..... ..... *Artabotrys suaveolens*
3b. Inflorescence peduncle not formed into a hook..... 4
4a. Flowers in solitary inflorescences ……..... ..... *Friesodielsia lanceolata*
4b. Flowers in multiflowered inflorescences..... 5
5a. Stems with simple hairs..... *Fissistigma latifolium*
5b. Stems with stellate hairs..... *Uvaria monticola*
6a. Fruit monocarps oblong with constriction between seeds ..... *Uvaria valderramensis*
6b. Fruit monocarps globose without constriction between seeds ..... 7
7a. Inner petals with warty, corrugate patches at the base ..... *Meiogyne cylindrocarpa*
7b. Inner petals smooth at the base..... 8
8a. Petals connivent forming mitriform dome ..... ..... *Goniothalamus elmeri*
8b. Petals free spreading..... 9
9a. Flowers ovate-triangular, petals 6 mm long ..... ..... *Popowia pisocarpa*
9b. Flowers ovate-lanceolate, petals 10–20 mm long ..... ..... *Phaeanthus ophthalmicus*
10a. Leaves elliptic-oblong, simple with undulate margins .. ..... *Cananga odorata*
10b. Leaves ovate-oblong, simple with entire margins. ..... 11
11a. Sepals connate, monocarps fusiform shape ..... ..... *Monoon grandifolium*
11b. Sepals ovate, monocarps cylindrical shape ..... ..... *Drepananthus acuminatus*
12a. Pedicel 50 mm; petals 30-50 mm ..... ..... *Polyalthia lanceolata*
12b. Pedicel 25 mm; petals 14-50 mm ..... 13
13a. Inflorescence leaf-opposed; monocarps 5 mm in diameter ..... *Polyalthia suberosa*
13b. Inflorescence axillary; monocarps 20 mm in diameter ..... *Polyalthia luzonensis*

**Tribe Miliuseae**

Tribe Miliuseae is well-represented with 7 species, namely *Phaeanthus ophthalmicus, Polyalthia luzonensis, P. lanceolata, P. suberosa,* and *Popowia pisocarpa*. It corroborates that it is also the largest tribe in the subfamily Malmeoideae, with 25 genera and 510 species (Chatrou et al. 2012; Gou et al. 2017). They are characterized by "miliusoid" stamens and are predominantly distributed in tropical and subtropical Asia, Australia, and Oceania (Chaowasku et al. 2014).

The genus *Meiogyne* comprises 15 species of trees and shrubs distributed in India, Indomalaya, and the Australasia-Pacific region (Thomas et al. 2012). The genus is characterized by subequal petals, inner petals that are longitudinally grooved and or verrucose adaxially at the base, inner stamens with tongue-shaped apical prolongations, and sub-globose stigmas (van Huesden 1994; Xue et al. 2012). The present study recorded *Meiogyne cylindrocarpa* trees about 3 m high with leaves lanceolate in shape with pubescent, simple hair in the petiole, acuminate apex, and obtuse leaf base, looped, scalariform venation with 10-15 lateral venations. It has six white petals in 2 whorls, and the inner petals are imbricate and warty with corrugated patches at the base of the adaxial surface. Its monocarp shape is elliptic-ovoid, elongated with 25 mm apices beak, densely appressed-hirsute, and thin pericarp (Figure 3A).

The genus *Polyalthia* is one of the largest genera within the tribe Miliuseae, with about 155 species (Turner and Utteridge 2017). This genus is widely distributed in South and Southeast Asia, including India, Sri Lanka, Indochina, Thailand, and Peninsular Malaysia. Based on molecular analysis, it still forms phylogenetically and morphologically heterogeneous assemblage despite the transfer of many species to other genera (Xue et al. 2012). Out of the 10 species, 6 species are endemic to the Philippines. *Polyalthia lanceolata* has a larger flower with a petal length of 30-50 mm and pedicel of 50 mm (Figure 3D) compared to *P. luzonensis* with a petal length of 14-16 mm, axillary inflorescences, and monocarps 20 mm in diameter (Figure 3E). *Polyalthia suberosa* has an elliptic-oblong, membranous to papery leaves with 8-10 pairs of reticulate, inconspicuous looping secondary veins near the margin, leaf-opposed inflorescences, and monocarps 5 mm in diameter (Figure 3Q). These species are mostly found in both AMMNBA and MINP.

The genus *Monoon* differs from *Polyalthia* in several morphological characters, such as in the pattern of secondary leaf venation, insertion of secondary veins to midrib, shape and symmetry of leaf base, and arrangement of vascular bundles of leaf midrib (Xue et al. 2012). In contrast, *Monoon* has no obvious synapomorphies compared to *Polyalthia*. Thus, *Monoon* was resurrected as a distinct genus. The present study collected *Monoon grandifolium*, a medium-sized tree of 10 m tall with elliptic-oblong leaves, acuminate apex and rounded leaf base, indument present in stems and leaves, eucamptodromous with decurrent secondary and scalariform tertiary veins, and with imbricate, connate sepals, white flowers, and fusiform monocarps (Figure 3B, R). This species was found both in AMMNBA and MINP.

The small genus of *Popowia* has approximately 50 to 90 species. Its placement in the Miliuseae was supported as a monophyly and sister clade to *Polyalthia* (Chatrou et al. 2012; Chaowasku et al. 2014). Flowers are small ovate-triangular, 6 mm long, yellowish-green outer and inner petals united at the base forming sympetalous corolla, pubescent, valvate, spreading, and connivent inner petals. *Popowia pisocarpa* is most similar to *Popowia bachmaensis*, but it distinctly differs in having larger leaves 5.5-14 cm, shorter petioles 2.0-7 cm, and shorter sepals 3 cm (Figure 3F) (Li and Gilbert 2011; Ngoc et al. 2016).

In the present study, *Phaeanthus ophthalmicus* is a small-sized tree, about 5 m high, with leaves ovate-lanceolate, 10-15 x 2.5-3.0 cm long, shiny adaxially, with attenuate apex and obtuse leaf base, looped and 12 pairs of lateral veins and petals 10-20 mm. This species was collected in Camarines Norte and Camarines Sur at about 342 m asl (Figure 3C). Previously, *P. ophthalmicus* was synonymy of *P. ebracteolatus*, because of its overlapping morphological characters, such as axillary inflorescence, valvate inner and outer petals, truncate stamens, club-shaped carpels and globose monocarps (Mols and Kessler 2000). However, Bangcaya et al. (2017) verified the synonymy with molecular analysis using *matK* and *rbcL* region as a result, the sequences and morphology strongly support the claim of *P. ophthalmicus* as its correct name.

**Tribe Uvarieae**

The tribe Uvarieae belongs to the subfamily Annonoideae and most of its members are lianas (Chatrou et al. 2012; Gou et al. 2017). Many species of this tribe are distributed in the lowland forests of Borneo and the Philippines (Turner 2011). Two species of *Uvaria* were collected, namely, *U. valderramensis* (Figure 3J) and *U. monticola* (Figure 3I). The former species was first recorded in Valderrama, Antique, and it resembled *U. payanensis* in leaf blade and corolla shape however, it was distinct in having ovate to obtuse sepals, large ovate to obovate leaves, distinctly yellow corolla lobes, densely pubescent carpels and monocarps oblong with constrictions between seeds, hence were named as a new species (Cabuang et al. 2012), and the latter species is a woody climber 20 m high; the main stem is 8-10 cm in diameter with stellate hairs along veins and midrib above, leaves ovate-oblanceolate, and the inflorescence is cauliflorous 1-3 flowered, pedicel 6 mm long, 1 mm thick with densely brown stellate hairs.

*Fissistigma latifolium* is a woody climber, 10 m tall with simple hairs on its stems. Leaves are oblong-elliptic, base obtuse or rounded, apex acute, chartaceous, coriaceous, dark green, glabrous above, brownish tomentose beneath, almost parallel, fine and close lateral 18-24 pairs of secondary veins, with scalariform venation. Inflorescences are leaf-opposed, with many flowers forming branched panicles. Flowers are oblong-conic, 6 petals in 2 whorls, valvate and leathery. The outer petals are tomentose outside, glabrous inside, ovate, and spreading, and the inner petals are 3-edged with a concave base (Figure 3G).

Another liana, *Friesodielsia lanceolata*, has lanceolate to oblong-lanceolate leaves with looped venation, glaucous papery adaxial, white abaxial with simple hairs, with raised 12-18 pairs of lateral veins and flower in solitary inflorescences (Figure 3H). Asian *Friesodielsia* differs from African species *F. ovata* in having elongated flowers with shorter inner petals apically connivent, forming a pollination chamber. The African species has broader flowers and loosely coherent inner petals (Gou et al. 2017).

**Tribe Annoneae**

The genus *Goniothalamus* is one of the largest genera in the tribe Annoneae, belonging to the subfamily Annonoideae, with over 134 accepted species (Gou et al. 2017). The genus is widely distributed in lowland and submontane forests from 1,200 to 1,400 m asl. in tropical Southeast Asia, including Western Malesia, Sumatra, and Peninsular Malaysia (Saunders and Chalermglin 2008; Tang et al. 2013). *Goniothalamus* has 22 species identified, making it one of the species-rich genera, 16 species endemic in the Philippines, including *G. palawanensis* (Tang et al. 2013) and recently discovered *G. luzonensis* (Arriola et al. 2020). In the present study, *G. elmeri* is a small tree about 8 m tall with leaves elliptic-oblong, apex acuminate, base cuneate to attenuate; unequal with longer outer petals 3.5 cm and inner shorter petals 2-1.5 cm apically connivent forming a mitriform dome with basal claw (Figure 3L), monocarps globose, and 20 mm in diameter (Figure 3S).

The genus *Annona* is distributed in Africa, North America, the lowland and submontane forests of tropical Southeast Asia including western Malesia, Sumatra, and Peninsular Malaysia (Saunders and Chalermglin 2008; Tang et al. 2013). However, this genus is considered an introduced and invasive species with a growth rate of 5% annually, showing rapid invasion of other species, minimizing biodiversity. It needs immediate restriction measures (Premathilaka and Jayaranthne 2020). In the present study, *A. glabra* is present in BVNP, and MINP thrives along the border of inhabited and disturbed areas. Flowers widely ovate (Figure 3K) and with syncarpous fruits (Figure 3T), ovoid shape and smooth, apex rounded with approximately 140 seeds.

**Tribe Xylopieae**

The tribe Xylopieae belongs to the subfamily Annonoideae comprised 2 genera, namely *Xylopia* and *Artabotrys* (Chatrou et al. 2012). They are primarily distinguished by their climbing habits with spiral phyllotaxis, valvate sepals and petals, and rhipidiate inflorescences. *Artabotrys suaveolens* is easily recognized by climbing habits using flattened hooks at the base of the peduncles (Ly et al. 2019). The present study collected *A. suaveolens* in the three PAs, namely AMMNBA, MINP, and BVNP, at about 517 m asl. It is about 15 m high wood climbers, chartaceous dark shining, green leaves, creamy-white cylindric and slightly curved flowers (Figure 3N), monocarps ellipsoid, 1-1.5 × 0.5-0.8 cm and apex obtuse (Figure 3P).

**Tribe Canangeae**

The genus *Cananga* is locally known as 'ylang-ylang'. *Cananga odorata* is a commercially important species for its aromatic essential oil in the perfume industry (Tan et al. 2015). It has elliptic-oblong leaves, simple with undulate margins. Most species are found in tropical Asia, including Malaysia, Indonesia, and many islands in the Indian Ocean. In the Philippines, *C. odorata* was introduced, naturalized, and cultivated in some forested areas up to 900 m asl. (Pelser et al. 2011 onwards). Several trees of *C. odorata* were found in the BVNP and MMVMP (Figure 3O).

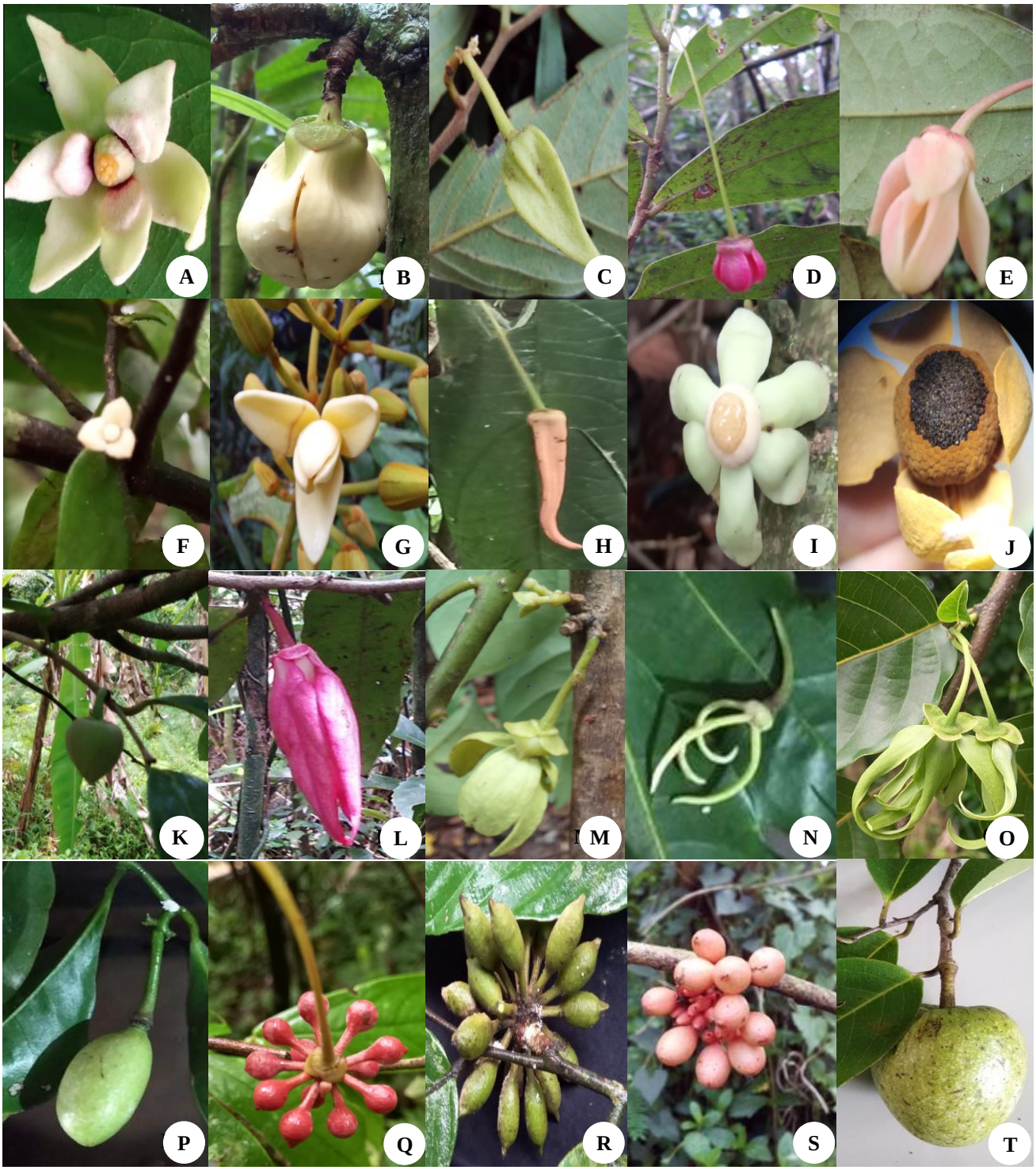


**Figure 3.** Annonaceae species collected in the PAs in Bicol region, Philippines. A. *Meiogyne cylindrocarpa*, B&R: *Monoon grandifolium*, C. *Phaeanthus ophthalmicus*, D. *Polyalthia lanceolata*, E. *Polyalthia luzonensis*, F. *Popowia pisocarpa*, G. *Fissistigma latifolium*, H. *Friesodielsia lanceolata*, I. *Uvaria monticola*, J. *Uvaria valderramensis*, K&T. *Annona glabra*, L&S. *Goniothalamus elmeri*, M. *Drepananthus acuminatus*, N&P. *Artabotrys suaveolens*, O. *Cananga odorata*, Q. *Polyalthia suberosa*. Photos were taken by A.R. Dioneda

The genus *Drepananthus* has over 20 species of trees distributed in tropical forests of Southeast Asia to the Fiji Islands. The genetic delimitation of the *Cyathocalyx* and *Drepananthus* has been controversial (Surveswaran et al. 2010). *Drepananthus* was first established by Hooker and Thomson (1872), then Scheffer (1885) and Sinclair (1955) combined them because of similarities in floral structures. Since then, taxonomists either followed the distinct genera or combined them. Wang and Saunders (2006) revised *Cyathocalyx*, and results supported the distinct clade and returned most of the species in *Cyathocalyx* to *Drepananthus*. Molecular phylogenetic analysis further confirmed this result (Surveswaran et al. 2010). *Drepananthus acuminatus* is a small woody tree 20 m tall with leaves oblong or elliptic, 11-18 x 4-6.5 cm, apex acuminate and base oblique, subcoriaceous adaxially, glabrous abaxially, primary veins impressed adaxially, looped venation with eight pairs of lateral veins, petiole 15-20 mm long, sepals ovate, and monocarps cylindric in shape (Figure 3M). It was found in AMMNBA at an altitude of 521 m asl.

**Notes on Philippine endemic species of Annonaceae and account of its distribution and conservation status**

Five Philippine endemic species were recorded in the PAs in the Bicol region, namely, *Goniothalamus elmeri, Polyalthia luzonensis, Polyalthia lanceolata, Friesodielsia lanceolata,* and *Uvaria valderramensis* according to the IUCN Red List of 2023 and Co's Digital Flora of the Philippines (Pelser et al. 2011 onwards). *Goniothalamus elmeri* was first collected from Benguet province, Sablan in 1904, Rizal province in 1911, and Mt. Bulusan, Sorsogon in 1915. It was noted that it is widely distributed from Luzon to Mindanao in the low and medium-elevation forests. *Polyalthia luzonensis* was first found in Ilocos Norte and Bicol, mostly in dry forests at low elevations, while *P. lanceolata* was also found in Cabulig River, Casiguran, Aurora, in 1925. In addition, *F. lanceolata* was first found in Dagami, Leyte in 1912 and distributed in Camarines Norte and Rizal province, while *U. valderramensis* was recently discovered in Valderrama, Antique in 2011 (Pelser et al. 2011 onwards).

In the present study, the 4 endemic species, namely *G. elmeri*, *P. luzonensis*, *P. lanceolata*, and *F. lanceolata* were found in Mt. Mananap and Mt. Matogdon in AMMNBA at an elevation of 310-663 m asl and near the Malabsay Falls in MINP at an elevation of 440-500 m asl. At the same time, a sole species of *U. valderramensis* was found in the vicinity of Bulusan Lake at an elevation of 360-450 m asl.

Regarding the conservation status, most of the collected species in the four PAs were not included in the list of threatened species and were categorized as not evaluated (DENR-DAO 2017). However, 19 species of Annonaceae in the Philippines are already threatened and vulnerable and need priority in protection and conservation in their natural habitats (Fernando et al. 2008; IUCN 2023).

**Distribution of Annonaceae species in the four PAs in the Bicol region, Philippines**

The Annonaceae collected from the PAs in the Bicol region showed AMMNBA with the highest number of species 13 species (43%), followed by MINP with 8 species (27%), BVNP with 6 species (20%), and the least was MMVNP with 3 species (10%) as showed in Figure 4.

The presence of Annonaceae in the Bicol region can be attributed to the type of soil and variation in moisture. AMMNBA has 3 types of soil-Louisiana clay soil in the upper elevation, aluminous clay loam in mid-elevation and the lower portion and San Miguel soil in the forest reservation of the protected area. It has no pronounced dry season, but a very wet period can be observed from October to January. An average annual rainfall from the northeast and southwest monsoons ranged from 69.1 to 525.8 mm in periods 2015 to 2018. The length of the dry season is from April to midway through August. The average rainfall is 280 mm and the average temperature is 29.7° to 35°C (APAMP 2021-2030). Terbio et al. (2022) confirmed that AMMNBA has a high biodiversity of 4.125, with 46 recorded species as new in the province, 58 endemic species, and 22 threatened species that contributed to the ecosystem's health. In their study, some species of Annonaceae, namely *Desmos chinensis*, *Goniothalamus amuyon*, *Uvaria peninsula*, and *Mitrephora lanotan*, appeared as new province records.

In the lowlands of MINP, temperature ranged from 20.8°C in February to 33.6°C in May (Balcita and Nolasco 2000) and was identified as a key biodiversity area (KBA) (Daipan 2021). However, only 8 species from MINP were collected and identified. Furthermore, fewer Annonaceae species were collected in BVNP, and MMVNP might be because of the frequent eruptions of Mt. Bulusan and Mt. Mayon Volcano and the series of typhoons that visit the region, and adverse human activities that affected the condition of the forest.

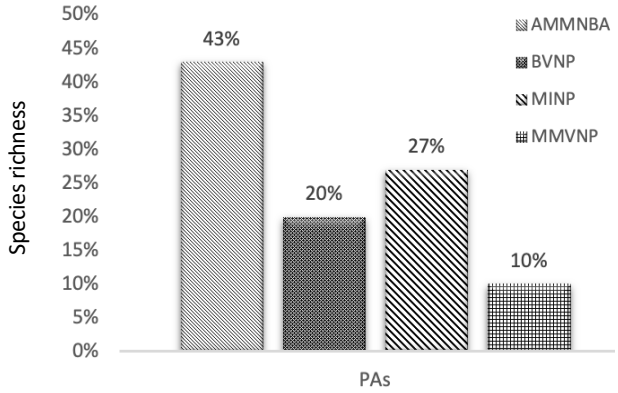


**Figure 4.** Species richness of Annonaceae in the four selected PAs

In conclusion, Annonaceae species in four selected PAs in the Bicol region recorded comprise 3 subfamilies, 5 tribes, 13 genera, and 16 species, which comprise a relatively good number of the recorded Philippine Annonaceae. The tribe Miliuseae is the most species-rich and AMMNBA has the highest number of species, showing that Annonaceae thrive more in areas with moisture-rich soil. Five endemic species were recorded in the four PAs in the Bicol region, Philippines. PAs are vulnerable to many disastrous events, such as forest fires, typhoons, floods, relentless poaching, and cutting of trees. Floristic surveys and collections are needed to cope with the fast forest degradation going on that may prevent the discovery and protection of unknown yet useful endemic plants. The result of this study contributes to and highlights the presence and occurrence of Annonaceae essential for management and conservation policy. The Department of Environment and Natural Resources, through the Protected Area Management Board (PAMB) should have a strong partnership with the academicians, private and non-government organizations for advocacies and conservation programs, biodiversity assessments, monitoring, and publication to increase awareness and protection of Annonaceae, especially the endemic species in the PAs. Future exploration of other PAs in the region is highly recommended.

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