Short Communication

ASSESSMENT OF INSECT-INDUCED DAMAGE IN NATIVE TREES OF THE UPLB-EDC BINHI BIODIVERSITY PARK

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ABSTRACT

Insect-related damage to trees within the UPLB-EDC BINHI Biodiversity Park was evaluated through opportunistic sampling, beating techniques, Malaise trapping, and direct field observations. A total of 29 distinct arthropod morphospecies were identified, predominantly consisting of Hemiptera, Lepidoptera, and Coleoptera. The most prevalent forms of insect-induced damage observed at the site were defoliation and infestations caused by scale insects. Additionally, a significant population of the ant species *Technomyrmex* sp. was noted, which is hypothesized to be linked to the high numbers of scale insects present. The findings of this study are significant as a preliminary baseline data for monitoring and designing conservation strategies in the area.

Keywords: endemic, native trees, pests, Philippines, plantation

INTRODUCTION

The UPLB-EDC BINHI Biodiversity Park is a forestry repository project by the Energy Development Corporation (EDC) for its BINHI reforestation and biodiversity restoration project. The park houses the Philippines' 96 premium endangered species with the goal to "rescue and secure" their gene pool for the future (Malabrigo et al. 2017). BINHI Biodiversity Park is a forest plantation as most of its trees are established by planting and/or seeding (Evans 2009) and is considered a social and community plantation as it serves its community through repository and research laboratory for the UPLB community and the general public.

Most forest plantations in the Philippines plant trees with economic value for hardwood. These plantations commonly utilize non-endemic species such as Teak *Tectona grandis* L.f (Lamiaceae), Gmelina *Gmelina arborea* Roxb. (Lamiaceae), Acacia *Acacia mangium* Willd. (Fabaceae), Eucalyptus *Eucalyptus* spp. (Myrtaceae), Ipil-ipil *Leucaena leucocephala* (Lam.) de Wit (Fabaceae),

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Falcata *Falcataria falcata* (L.) Greuter & R. Rankin (Fabaceae), and Mahogany *Swietenia macrophylla* King (Meliaceae) (Yamane et al. 1994; Nair 2001; Romano 2017). Consequently, studies on forest plantations in the country are mainly focused on non-native tree species. Likewise, studies on forest insect-pest damages are also majorly focused on agroforestry settings, usually on species such as coconut and palms (Peters et al. 2008; Watson et al. 2015; Acevedo 2015).

A 2017 study at the Energy Development (EDC) Eco-Park plantation, then a one-year-old stand, recorded 83 arthropod families belonging to 12 orders in the 11 dipterocarp saplings (Mondal & Rojo 2017). Of these, 49 families were classified as herbivores; however no arthropods were identified as causing significant damage that could be a potential pest. No further studies on arthropod diversity in the BINHI Biodiversity Park were conducted after this. This lack of subsequent studies creates a critical knowledge gap, as it remains unclear whether arthropods pose potential threats to the endangered and native tree species in the park. Without such baseline information, monitoring and designing appropriate conservation strategies could not be done and could compromise the park's role as a genetic repository of significant tree species.

Studies on arthropods associated with tree species found in the BINHI Biodiversity Park are scarce, particularly concerning their potential pest species. Among the country's native trees, dipterocarps have received the most research attention. Longatang et al. (2021) reported that orders Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Odonata, and Orthoptera caused significant leaf damage in six dipterocarp species, four of which are also present in BINHI. In Sabah, fruit infestations by insect families Scolytidae (Coleoptera), Pyralidae (Lepidoptera), and other microlepidopterans were also recorded on *Dipterocarpus grandiflorus* (Blanco) Blanco (Dipterocarpaceae) (Chey 1986). Similarly, *Kingiodendron alternifolium* (Elmer) Merr. & Rolfe (Fabaceae) fruits have been reported to suffer insect attacks in Papua New Guinea (Ctvrtecka et al. 2016). Studies on *Agathis dammara* (Lamb.) Poir. (Araucariaceae) has been more extensive due to its resin-production activity. No specific insect was identified, but it has been reported to be "attacked by insects" (Jose 2018). *Reutealis trisperma* (Blanco) Airy Shaw (Euphorbiaceae), one of the two Euphorbiaceae species present in the park, has previously been reported to be infested by bagworms, fire Caterpillars (Lepidoptera), and mealy bugs (Hemiptera) in Indonesia (Indriati et al. 2022).

To address these gaps, this study aims to assess the damage that is caused by insects to tree species within the UPLB-EDC BINHI Biodiversity Park. Specifically, (1) to classify and assess the extent of arthropod-induced damage on endemic Philippine tree species at the park; and (2) to provide a list of potential insect pests associated with significant Philippine tree species in the BINHI Biodiversity Park.

MATERIALS AND METHODS

Site description

UPLB-EDC BINHI Biodiversity Park is a 2.5-hectare forest plantation located at the Department of Forest Biological Sciences Building, College of Forestry and Natural Resources, University of the Philippines Los Baños, Laguna, Philippines. The park houses Philippine endemic tree species from 18 families: (1) Dipterocarpaceae, (2) Myrtaceae, (3) Fabaceae, (4) Sapotaceae, (5) Ebenaceae, (6) Dilleniaceae, (7) Moraceae, (8) Myristicaceae, (9) Burseraceae, (10) Anacardiaceae, (11) Euphorbiaceae, (12) Cannabaceae, (13) Sapindaceae, (14) Lauraceae, (15) Araucariaceae, (16) Podocarpaceae, (17) Meliaceae, and (18) Lamiaceae, which 96 of these species are considered to be threatened (Malabrigo et al. 2017). The area consists mainly of uneven terrains and thick understory vegetation.

Sampling

Three sampling methods were conducted to assess the arthropod community in the UPLB-EDC BINHI Biodiversity Park: Opportunistic sampling, Beating, and Malaise Trapping.

Opportunistic sampling was conducted on 27 March 2024, 27-28 April 2024, and 14 May 2024 across different sections of the park categorized by tree families. Arthropods were collected using fine-tipped forceps and sweep nets then preserved in vials with 95% Ethyl Alcohol. Leaves infested with scale insects were collected for further observation and documentation in the laboratory.

Beating was conducted concurrently with opportunistic sampling, in which branches were struck with a stick for 10x and a 1x1 m white cloth was used to collect dislodged arthropods. Only the tree branches accessible to the collector were struck. All specimens obtained through this method were also preserved in vials with 95% ethyl alcohol.

Additionally, a single Malaise trap was deployed in the T13 Moraceae-Myristicaceae section (14°09'16.7"N 121°14'12.1"E) and was left for 72 hours from 27-30 April 2024. The trap was installed on even ground with minimal understory vegetation to ensure optimal functioning. Although a single trap is not enough to cover the entire park, most of which has dense foliage and uneven terrains, it served as a supplementary method to detect flying insects that may not be captured in the previous methods. The use of a single trap only provides partial data on the total insect community but it contributed to the initial assessment of the area. Collected samples were transferred to the laboratory for identification.

Documentation

Field photographs were taken with a Xiaomi Note 10Pro smartphone. Evidence of defoliation, termite mounds, leaves with netting caused by hemipterans, and damaged bark were captured. Aphids associated with infested leaves, and other insects collected were photographed in the laboratory using Olympus SZ61 dissecting microscope with an attached digital camera.

Sampling and documentation done were limited to the understorey layer of the forest and those that are within the reach and visible to the collector. Notably, a clearing operation was conducted in the BINHI Biodiversity Park after the first sampling, which contributed to the decrease in insect population in the understory, as observed in the following sampling events.

Data analysis

Collected arthropods were identified to morphologically distinguishable species, called morphospecies. This was done by grouping organisms based on observed morphological similarities. Morphospecies identification is proven to be valuable especially in rapid monitoring surveys as it overcomes the challenge of identifying less studied taxa such as arthropods. (Derraik et al. 2010; Encinares & Lit 2014).

The collected specimens were categorized by the type of damage observed or noted as “no direct harm” if no significant and/or direct harm to plants was detected. In addition, species not directly collected but inferred to occur in the site based on evidence such as exuviae, mound trails, or visual observations were also recorded.

Identifications were done using dichotomous keys such as General & Alpert (2012), Gilligan & Epstein (2014), and Jocque and Dippemaar-Schoeman 2007.

Deposition

Collected insects were pinned and dried for preservation while non-insect arthropods such as arachnids were placed in a vial with 95% Ethanol for wet preservation. Appropriate labels were attached and deposited in the Insectary of Department of Forest Biological Sciences, College of Forestry and Natural Resources, University of the Philippines Los Baños.

RESULTS AND DISCUSSION

A total of 29 arthropod morphospecies were documented in the BINHI Biodiversity Park, distributed across nine insect orders and one non-insect order. Among these, orders with the highest species richness were Lepidoptera (S=7, 24.1%) and Hemiptera (S=7, 24.1%). Lepidoptera included representatives from the families Gelechiidae, Pyralidae, and Oecophoridae, with the genera *Eurema* sp. and *Trichodezia* sp. Hemiptera mostly consists of members from the suborder Sternorrhyncha, including Coccidae, Pseudoccidae, Aphidoidea, and Aleydoridae. Coleoptera (S-5, 17.2%) followed in richness, then Hymenoptera (S=3, 10.3%), Diptera (S=2, 6.9%), and finally Blattodea, Mantodea, Orthoptera, Psocodea, and Araneae (S=1 each, 3.5%).

The collected arthropods were classified into four feeding guilds based on observed behavior and literature inferences (Table 1): (1) Sap suckers, (2) Leaf feeders, (3) Wood borers, and (4) no direct harm to the plants. While arthropods in the "no direct harm" guild may indirectly affect pest populations through predation, analysis of these interactions is beyond the scope of this study.

Guild level species richness (S) showed that leaf feeders were the richest with 11 morphospecies (37.9%), followed by no direct harm (S=8, 27.6%), sap suckers (S=5, 17.2%), and wood borers (S=1, 3.4%).

Table 1. Potential arthropod pests recorded in the BINHI Biodiversity Park.

Guild	Order	Morpho species	Associated Host	Plant Family
Sap Sucking	Hemiptera	Coccidae sp. 1	*Shorea guiso*	Dipterocarpaceae
	Hemiptera	Pseudococcidae sp. 1		Dipterocarpaceae
	Hemiptera	Chremistica sp.**		Myristicaceae
	Hemiptera	Unidentified scale insects	*Sindora supa*	Fabaceae
			Intsia bijuga	Fabaceae
			Balakata luzonica	Euphorbiaceae
			Kingiodendron alternifolium	Fabaceae
			Celtis luzonica	Cannabaceae
	Hemiptera	Aphidoidea		Dipterocarpaceae
	Hemiptera	Aleydoridae	*Shorea malibato*	Dipterocarpaceae

Leaf Feeder	Lepidoptera	*Eurema* sp.	*Shorea malibato*	Dipterocarpaceae
	Orthoptera	Acridiidae sp. 1		Dipterocarpaceae
				Ebenaceae
	Lepidoptera	Trichodezia sp.		Dipterocarpaceae
				Sapotaceae
	Lepidoptera	Lepidoptera sp. 1 (Larva)		Araucariaceae
	Lepidoptera	Gelechiidae sp. 1		Araucariaceae
	Lepidoptera	Pyralidae sp. 1		Araucariaceae
	Lepidoptera	Pyraloidea sp. 1		Araucariaceae
	Coleoptera	Curculionidae sp. 1		Ebenaceae
	Coleoptera	Cerambycidae sp. 1 (Adult)*	*Diospyros philippinensis*	Ebenaceae
	Coleoptera	Coleoptera sp. 1		Dilleniaceae
	Coleoptera	Chrysomelidae sp. 1		Dipterocarpaceae
Wood Borer	Blattodea	Termitidae sp.*		Dipterocarpaceae
			Diospyros philippinensis	Ebenaceae
			Sympetalandra densiflora	Fabaceae
No direct harm to the plants	Psocodea	Psocodea sp. 1	*Shorea ovata*	Dipterocarpaceae
	Hymenoptera	Odontoponera sp. 1		Dipterocarpaceae
				Araucariaceae
				Podocarpaceae
				Fabaceae

				Ebenaceae
	Hymenoptera	*Technomyrmex* sp. 1	present in almost all species.	
	Hemiptera	Reduviidae sp. 1		Dipterocarpaceae
	Hemiptera	Reduviidae sp. 2	*Hopea acuminata*	Dipterocarpaceae
	Mantodea	Mantidae sp. 1		Dipterocarpaceae
	Diptera	Phoridae sp. 1		Dipterocarpaceae
	Diptera	Phoridae sp. 2		Dipterocarpaceae
	Hymenoptera	Mymaridae sp. 1		Dipterocarpaceae
	Lepidoptera	Oecophoridae sp.		Dipterocarpaceae
	Araneae	Salticidae sp. 1		Araucariaceae
				Ebenaceae
	Coleoptera	Cantharidae sp. 1		Ebenaceae

**Observed but not collected*
***inferred from the presence of exuviae, mounds, etc.*
Blank cells on the plant host column indicate that the arthropods were not directly found on one species but are present within the area.

Assessment of damages on the BINHI Biodiversity Park

Sap suckers

Scale insects, identified as Coccidae sp. 1 and Pseudococcidae sp. 1 (Hemiptera), were observed abundantly on the leaves and stems of trees across different sections of the park (Figure 1B-C). Although *Ficus* species (Moraceae) are not part of the BINHI tree list, their fruits were observed to be infested by Coccidae spp. Their proximity to the park entrance poses a risk of potential spread to the valuable endemic tree species.

Evidence of sap sucking damage such as yellowing (chlorosis) and wilting (Sakthivel et al. 2010) was observed in *Hopea malibato* Foxw. (Diptercarpaceae) (Figure 1A), *Tristaniopsis decorticata* (Merr.) Peter G. Wilson & J. T. Waterh. (Myrtaceae), *Agathis dammara* (Lamb,) Poir. (Araucariaceae), which also have traces of webbing, *Balakata luzonica* (Vidal) Esser (Euphorbiaceae), *Diospyros* *cauliflora* Blume (Ebenaceae), and *Myristica philippinensis* Lamk. (Myristicaceae).

Pupae of Aleydoridae (whiteflies) were observed alongside *Technomyrmex* sp. (Hymenoptera: Formicidae) on the leaves of *Shorea malibato* Foxw. (Dipterocarpaceae) (Figure 1G). The same ant species were observed on the trunks of *Toona calantas* Merr & Rolfe (Meliaceae), associated with other unidentified Coccidae. Webbing traces, which are indicative of scale insect activity, were observed on leaves of *Palaquium philippense* (Perr.) C. B. Rob (Sapotaceae), *Sindora supa* Merr. (Fabaceae), *Intsia bijuga* (Colebr.) Kuntze (Fabaceae), and *Knema alternifolium* Merr. (Myristicaceae).

Leaf feeders

Most of the tree species in the park showed signs of defoliation with *Mallotus philippensis* (Lam.) Muell.Arg. (Euphorbiaceae) and *Celtis luzonica* Warb. (Cannabaceae) exhibiting the most severe damage. *C. luzonica,* a vulnerable endemic tree species, is represented by only a single individual in the park, which currently has almost no remaining leaves with some of the remaining defoliated leaves also observed to be infested with sap sucking insects.
No leaf-feeding arthropods were directly collected from these plants. However, the Malaise Trap placed near the affected tree species captured various microlepidopterans. These include individuals from the family Pyralidae, which were previously documented pests of agroforestry, hardwood, and crop species (Lapis 1985; Nuss et al. 2003–2018; Cunningham et al. 2005; Torshiz et al. 2017; Poltavsky et al. 2018).

While the extent of damage in the Dipterocarpaceae section was not severe, signs of defoliation were also evident. Adults of *Eurema* sp. (Lepidoptera: Pieridae), *Trichodezia* sp. (Lepidoptera: Geometridae), and Gryllidae sp. (Orthoptera) were collected in the T8-T9 Dipterocarpaceae section. Though adults do not feed directly on leaves, their larvae are known to be leaf feeders and were recorded to be pests of many plant species (Irianto et al. 1997; Khan & Sahito 2012). Other species showing defoliation include *Aglaia edulis* (Roxb.) Wall. (Meliaceae) and *Balakata luzonica* (Vidal) Esser (Euphorbiaceae), with the latter also exhibiting evidence of leaf mining.

Wood borer

Termite mounds (Figure 1D) were documented at the bases of *Sympetalandra densiflora* (Elmer) Steenis (Fabaceae), *Diospyros blancoi* A. DC. (Ebenaceae), *D. philippinensis*, and various Sapotaceae and Dipterocarpaceae species. Only one termite individual was observed, with most of the mounds appearing empty. However, mounds located beyond reach could not be assessed.

Evidence of wood damage was observed near the roots of *Palaquium luzoniense* (Fern.-Vill.) Vidal (Sapotaceae), on the trunks of *Dracontomelon edule* (Blanco) Skeels (Anacardiaceae), and on other tree species not included in the BINHI "Tree for the Future", but are present in the area. In the Ebenaceae section, a piece of dried wood showing signs of termite feeding was noted. Although no active termite activity was detected, this wood may represent remnants of a previous termite infestation or control activity in the site.

No direct harm

Arthropods not directly harming plants included one Psocodea, two morphospecies of Reduviidae and Phoridae (Diptera), Mymaridae (Hymenoptera), Oecophoridae (Lepidoptera), and Salticidae (Araneae). Psocids feed on stored products such as wheat and starch-based materials, algae and lichens on plant surfaces without causing direct harm to the plant (Green & Turner 2004; Saville 2010). Reduviid bugs and mantis are predatory and thus do not damage plants directly. They typically feed on other arthropods such as spiders, ants, termites, and other potential insect pests (Weirauch & Munro 2009; Khokhar et al. 2021). While Phorids and Oecophorids species are primarily detritivores (Merrit et al. 2009; Brown 2015; Owens et al. 2016). However, some Oecophorid species may also feed on fruits and flowers, and a few are known to be predators (Brown 2015). Mymaridae are parasitoids of scale insects (Capinera 2001), and Salticidae are generalist predators. Some species may scavenge dead insects or consume nectar, but they do not inflict direct damage to the plants. (Jackson et al. 2001). Collectively, these species may indirectly regulate pest populations without causing plant damage.

Possible *Technomyrmex* and Scale Insects mutualism

Among all arthropods documented, *Technomyrmex* sp. were the most frequently observed across nearly all sampled tree species. These ants occurred on leaves (Figure 1G), branches, and bark (Figure 1H), fruits (Figure 1I), and even roots of most species within the BINHI Biodiversity Park. Their high population may be associated with the presence of scale insects recorded at the site. Members of the superfamily Coccoidea (scale insects) excrete honeydew after feeding on plant sap; this honeydew serves as a nutrient-rich food source for many arboreal ants, forming a mutualistic relationship known as trophobiosis (Delabie 2001). Such ant-scale insect associations have been widely documented (Gullan 1997; Gullan & Kosztarab 1997). When not attended by ants, scale insects are unable to remove their honeydew excretions, which can lead to mortality through fungal contamination or drowning.

Within the genus *Technomyrmex, T. difficilis*–native to Madagascar but now cosmopolitan and present in the Philippines–has been reported as an invasive pest in Florida, USA, due to its large and difficult to control populations (Warner & Scheffren 2005). This species has also been observed tending Hemipterans on citrus trees (Florel 1892; Wetterer 2012). Similarly, *T. albipes,* attends soft scales and mealybugs (Githae et al. 2020). Based on observations, this relationship is hypothesized to also be occurring at the BINHI Biodiversity Park.

Given the observed co-occurrence and potential mutualistic interaction, populations of both *Technomyrmex* sp. and scale insects may continue to increase, as the ants obtain sufficient nutrients from honeydew while the scale insects benefit from prolonged survival through ant tending. Future studies on this ant-hemipteran interaction should be done to assess their impact on tree health and pest management within the area.

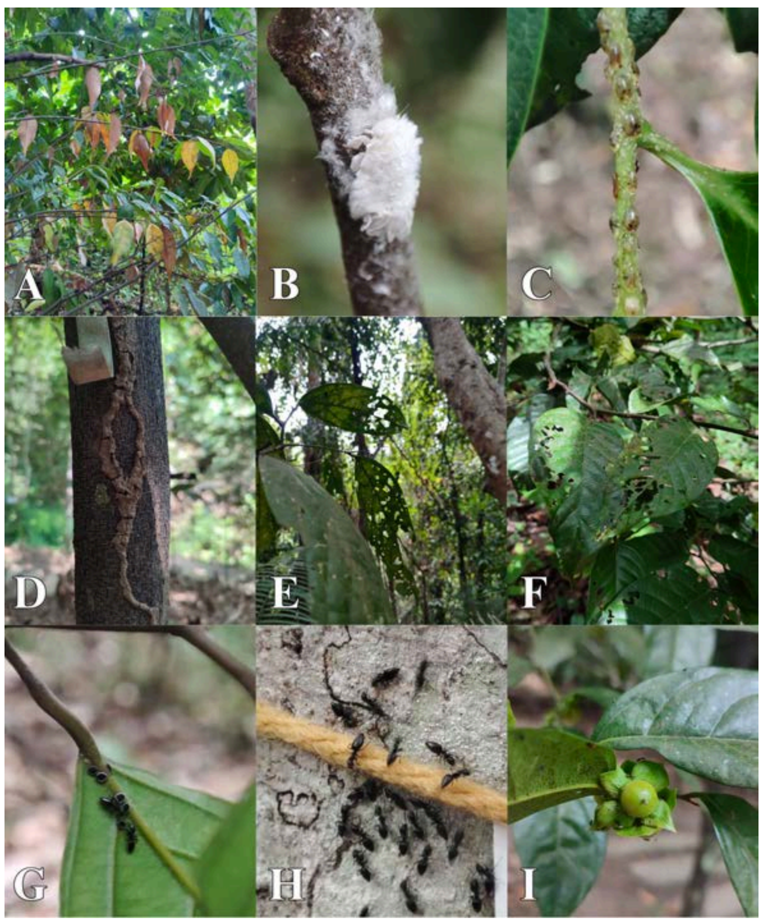

Figure 1. Insects and evidences of damages documented in the BINHI Biodiversity Park: (A) Leaf yellowing and wilting on *Hopea malibato*; (B) a Pseudococcidae (Hemiptera); (C) Scale insects on stems of *S. guiso;* (D) termite mounds found on *D. philippinensis*; Defoliation on (E) *C. luzonica* and (F) *S. guiso; Technomyrmex* sp. (G) Under the leaf of *S. malibato* alongside Aleydoridae sp.; (H) on the trunk of *Koordersiodendron pinnatum;* and (I) on fruits of *D. philippinensis.*

CONCLUSION AND RECOMMENDATIONS

The study identified 29 species of arthropods belonging to nine orders namely Blattodea, Coleoptera, Diptera, Hemiptera, Hymenoptera, Lepidoptera, Mantodea, Orthoptera, and Psocodea, and Araneae. Individuals collected from the orders Hemiptera, Lepidoptera, Orthoptera, and Blattodea have been recorded to inflict direct damage to the plants. The most common insect-related damage observed was the evidence of heavy defoliation especially in the Myristicaceae section. Many morphospecies under orders Coleoptera and Lepidoptera that were captured in the Malaise Trap have been previously recorded to be defoliators of many agricultural and forest plants.

Another prominent damage observed was the presence of a variety of scale insects and the high abundance of *Technomyrmex* sp. ants, which have been documented in previous studies to form mutualistic relationships. The large population of these ants is hypothesized to contribute to the proliferation of scale insects through their tending and protecting behavior of hemipterans. Termite mounds were also observed in several trees; however, no individuals exhibited significant surface-level wood damage.

Although the number of insect taxa documented was lower compared to previous studies, evidence of insect-related damage was widespread among tree species within the site. Major threats identified were defoliation and the high abundance of scale insects, which may require management interventions before an onset of pest outbreak. Immediate attention should be given to species with low population size such as *C. luzonica*, a threatened species that may be highly vulnerable to insect attacks. Moreover, beyond insect abundance, other factors such as plant health, habitat condition, and microclimatic factors should also be considered when assessing species vulnerability.

It is important to note that not all insects feeding on plant tissues are considered pests and must be eradicated, as some may contribute to ecological balance and serve as natural control agents. The observed arthropod diversity suggests that the plantation provides suitable habitats that support a variety of organisms within the BINHI Biodiversity Park.

For future work, scale insects are recommended to be preserved and mounted for detailed taxonomic identification. A comprehensive arthropod diversity assessment should be conducted to better evaluate the biodiversity of the UPLB-EDC BINHI Biodiversity Park. Addition of other sampling methods such as canopy malaise trapping, leaf litter collection, butterfly trapping, etc., could also be done to assess a wider scope of site and arthropod habitats. Different season sampling and long-term arthropod diversity monitoring are recommended to be done to properly document the potential pests and to have a proper baseline on the arthropod diversity of the area to aid in future monitoring and management of the biodiversity Park.

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