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Research Paper

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MOTH COMMUNITY STRUCTURE (LEPIDOPTERA: GEOMETROIDEA) AT RANU DARUNGAN RESORT, BROMO TENGGER SEMERU NATIONAL PARK

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ARTICLE HIGLIGHTS

- Forest moth diversity is higher than in other zones (CCA)
- Moth-host plant relationship revealed by PCA
- Two polyphagous pests found in different zones
- Invasive weed dominates and affects moth diversity

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ABSTRACT

Moths show a habitat preference for the Ranu Darungan Resort, a conservation area within Bromo Tengger Semeru National Park (BTSNP). The phenomena of Mount Semeru's eruption and anthropogenic activities can pose a threat, causing damage to primary and secondary forests, which leads to a reduction in vegetation cover and host plants. This research aimed to analyze the structure of the moth community and identify potential host plants at the Ranu Darungan Resort. The sampling locations were determined using purposive sampling, while moth specimens were collected using light trap and road sampling methods. We documented ten moth species and thirty-eight plant species. Research has documented the wide host range of *Conogethes punctiferalis* (forest zone) and *Duponchelia* sp. (utilization zone), which encompasses various agricultural and forestry plants. Data analysis showed that the forest zone has higher moth species diversity (H' = 2.332) than the utilization zone (H' = 2.244). In contrast, the data show slightly higher species evenness in the Utilization Zone (1.05 vs. 1.03). Both zones demonstrated low dominance and high community similarity. *Ageratina riparia*, an invasive plant that spreads rapidly, dominated both habitats and had the capability of dominating new ones. Canonical Correspondence Analysis showed that *Asota heliconia, Plodia* sp., *Conogethes punctiferalis*, and *Eacles* sp. associated with soil moisture, light intensity, wind speed, and air humidity in the forest zone. Principal Component Analysis revealed a strong association between *Clidema hirta*, *Crytococcoum patens*, and *Ageratina riparia* in the same habitat. Our findings demonstrated that moth presence directly depends on the availability of potential host plants, highlighting the importance of plant diversity in sustaining moth species richness.

Keywords: canonical correspondence analysis, diversity, forest, moth, principal component analysis

INTRODUCTION

Moths inhabit a range of habitats, including primary forests in mountainous tropical rainforests and secondary forests in pine and recission forests as well as lowland woods (Ashton *et al.* 2016; Ferracini *et al.* 2020; Montañez *et al.* 2023). Altitude variations also impact the spatial arrangement of moths (Valente *et al.* 2024). Forest structure beneath the canopy impacts moth communities' distribution, abundance, and movement (La Cava *et al.* 2024). Topographic variances provide microclimatic variables, including differences in solar exposure. Furthermore, moths exhibit preferences for specific host plants unique to their species, while some can feed on various plants (polyphagous). According to research by He *et al.* (2022), *Hadula trifolii* has a wide-ranging diet and feeds numerous cultivated plants in Asia.

Moths can be distinguished by the presence of feather-like antennae in males and thread-like antennae without knobs in the females (Roh *et al.* 2021; Lin *et al.* 2020). Furthermore, when not in flight, the wings extend horizontally. Moths primarily exhibit nocturnal behavior, although certain species may also engage in diurnal activity (Walton *et al.* 2020). Moths play several roles in ecology, including serving as pollinators (Borges *et al.* 2016). Moths serve as widely recognized ecological indicators, addressing various pressing environmental concerns, including climate change and habitat fragmentation (Dar & Jamal 2021). According to research conducted by Buxton *et al.* (2023), moths can act as pollinators for *Persea americana*. Another function of this organism is to remove leaves from forest plants, a process known as defoliation (Wagner 2020). Certain species, such as *Bombyx mori*, possess significant economic worth (Chung *et al.* 2015).

According to the International Union for Conservation of Nature (IUCN 2023) five moth species are classified as vulnerable or threatened. These include two Geometridae family members, *Scopula separata* and *Eupithecia ogilviata*, which are listed as vulnerable, and three extinct species: *Tritocleis microphylla*, *Scotorythra nesiotes*, and *Scotorythra megalopylla*. Additionally, several moth species native to Indonesia, such as *Syntherata apicalis*, *Lyssa zampa*, *Cleora cornaria*, *Eupithecia centaureata*, *Instrugia disputaria*, and *Scopula decorate* (Maury *et al.* 2022), have been documented.

Ranu Darungan Resort is located within the Bromo Tengger Semeru National Park (BTSNP). This area is situated at an elevation ranging from 800 m to 3.360 m above sea level (masl). Moths inhabit the area, which includes the forest zone and the utilization zone. Ranu Darungan resort of BTSNP is characterized by its rugged terrain and lush tropical rainforest. Due to the volcanic eruption on Mount Semeru, significant threats such as intense heat from the clouds has caused harm to both primary and secondary trees. Moreover, the surrounding human activities could also potentially alter habitats, leading to a decrease in vegetation coverage. Reforestation can impact moths communities (Tyler 2020). Due to this association, vegetation structure and species composition can be assessed, by monitoring moths' population and community structure, particularly in Ranu Darungan Resort, BTSNP.

Data on moths in the Ranu Darungan Resort area of Bromo Tengger Semeru National Park (BTSNP) remain highly limited. Specifically, there is a clear knowledge gap regarding the relationship between moth community structure and host plant composition in this area, particularly how habitat degradation from volcanic eruptions and human activities affects moth diversity across different vegetation zones. No previous studies have explicitly compared moth communities between the forest and utilization zones at Ranu Darungan Resort, nor have they identified which host plants are critical to sustaining Geometroidea moths in this post-eruption landscape. Therefore, comprehensive research on moths in both forest and utilization zones of this area is critically needed. Given the aforementioned context, this study on the Community Structure of Moths (Lepidoptera: Geometroidea) in Ranu Darungan Resort BTSNP, holds significant importance. The findings can be used to develop management and conservation policies, particularly for the Ranu Darungan Resort area within BTSNP.

MATERIALS AND METHODS

This study was carried out at the Ranu Darungan Resort in the Bromo Tengger Semeru National Park area (BTSNP). A purposive sampling method were applied to establish the selection of the sampling points. A combination of light traps and road sampling were used for sampling. ArcGIS 10.8 software was employed to create the map. (Fig. 1), showing the forest zone (points 5 and 6) and the utilization zone (points 1 to 4).

Light traps were utilized to gather moth data by placing a single trap at each sampling location. Each light trap consisted of a 10-watt incandescent bulb that was placed at a height of 2 meters above ground level, positioned precisely at the center of a horizontally positioned white fabric screen affixed to a battery-powered light source. Moth sampling was conducted over seven consecutive nights at two-hour intervals. The white screen served as a reflective surface to maximize light dispersion and attract moths. The trap captures were analyzed daily, categorized them based on morphospecies, and quantified each species' abundance. Moth identifications were conducted using authoritative taxonomic references following Sutrisno (2015); Holloway (1987); Holloway *et al.* (2021); Common (1990); and Zborowski (2007).

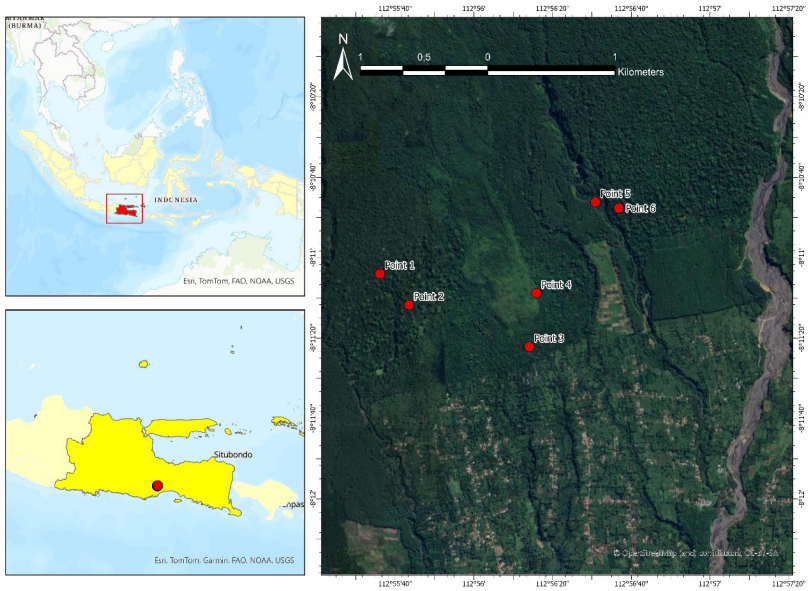


Figure 1 Research site and sampling points at Ranu Darungan Resort, BTSNP

Vegetation data were collected by creating 20 m × 20 m plots that included trees having trunk diameter of more than 10 cm. A 5 m × 5 m plot was designated to collect samples of tiny trees, saplings, and bushes. Quantitative data were collected by tallying numbers, and the various species were identified. All tree species served as crucial host plants for moths.

The measurements were taken at six sampling locations, with three repetitions each, and included parameters such as light intensity, air temperature, air humidity, wind speed, and soil moisture.

The conservation status assessment relied on the International Union for Conservation of Nature. Red List of Threatened Species (www.iucnredlist.org), Convention on International Trade in Endangered Species of Wild Fauna and Flora (cites.org), Indonesian Regulation (P.106 / MENLHK /SETJEN /KUM.1/12/2018).

Data analyses were carried out including the calculation of the Shannon–Wiener diversity index (H'), Evenness index (E'), Simpson's dominance index (D), and Relative abundance (Rdi) (Magurran 2004). The relationship between abiotic parameters and the moth were analyzed using Canonical Correspondence Analysis (CCA) and Principal Component Analysis, which were computed using the PAST 4.09 paleontological statistics software (Hammer *et al.* 2001).

RESULTS AND DISCUSSION

Moth Species Diversity

The survey documented 98 individuals from 10 moth species belonging to 6 families in the Ranu Darungan area, BTSNP (Table 1), showing that the forest zone had the most incredible diversity of moth species (ten species and 43 individuals). On the other hand, the utilization zone had the highest population (nine species totaling 55 individuals). According to Karam and Chong (2019), there is a high diversity of moth species in the Nature Reserve. Additionally, Arya *et al.* (2021) documented a significant abundance of moths in the Nandhaur Wildlife Reserve. The utilization zone exhibited the highest individual moth population due to its greater plant diversity compared with the forest zone.

Moths are phytophagous insects specializing in host plants (Orsucci *et al.* 2016). According to Conchou *et al.* (2017), moths possess the sensory capability to distinguish host plant species based solely on olfactory cues. Furthermore, moths' numerous odor receptors can detect volatile compounds from host plants (Li *et al.* 2020). The diversity of plant species significantly influences insect association patterns (Muiruri *et al.* 2019). Forest areas exhibit tree species compositions that markedly alter the species compositions of insects and forest herbivores across different forest strata (Leidinger *et al.* 2019). Insect herbivory rates are lower in mixed forest stands than in pure forest stands, contingent upon the breadth of herbivore diet and tree species composition (Jactel *et al.* 2021).

Table 1 List of moth species observed in Ranu Darungan Resort, BTSNP

Family	Species	IUCN	CITES	NS	Relative Abundance (%)	
					Forest zone	Utilization zone
Uraniidae	*Acropteris illiturata* (Ai)	NE	NA	NP	11.63	12.73
Erebidae	*Asota heliconia* (Ah)	NE	NA	NP	13.95	12.73
Erebidae	*Creatonotos* sp. (Cs)	NE	NA	NP	9.30	12.73
Erebidae	*Nudaria* sp. (Ns)	NE	NA	NP	6.98	9.09
Crambidae	*Duponchelia* sp. (Ds)	NE	NA	NP	9.30	14.55
Saturniidae	*Eacles* sp. (Es)	NE	NA	NP	2.33	0.00
Geometridae	*Xanthorhoe* sp. (Xs)	NE	NA	NP	9.30	12.73
Pyralidae	*Plodia* sp. (Ps)	NE	NA	NP	11.63	7.27
Crambidae	*Polythlipta macralis* (Pm)	NE	NA	NP	9.30	10.91
Crambidae	*Conogethes punctiferalis* (Cp)	NE	NA	NP	16.28	7.27

Notes: IUCN: NE= Not Evaluated. CITES: NA= Not Appendix; A.I= Appendix I; A.II= Appendix II. National Status (NS): P = Protected; NP= Not Protected.

Conogethes punctiferalis had the most significant population size in the forest zone (Table 1). According to the IUCN status, *Conogethes punctiferalis* is classified as Not Evaluated (NE). Throughout the daytime, it was discovered on *Ageratina riparia* trees. Robinson *et al.* (2010) reported that this species is herbivorous, specifically feeding on plants (Phytophagus). Its primary host preferences are the Malvaceae family, specifically *Theobroma cacao*, and the Moraceae family, specifically *Ficus fistuola*. Additionally, *C. punctiferalis* is a significant insect pest that infests various crops and fruit trees (Du *et al.* 2018). According to Jung *et al.* (2018) *C. punctiferalis* severely threatened the canary fruit and leaves. This species is broadly distributed across Southeast Asia and Australia (Sridhar *et al.* 2018).

We recorded the highest abundance of *Duponchelia* sp. in the utilization zone (Table 1), where vegetation uniformity is higher. This phytophagous species feeds on plants such as *Ficus* sp. and shows a particular preference for Chrysanthemum × grandiflorum as its host plant (Kovács *et al.* 2014). Researchers classify the genus *Duponchelia* as an insect pest (Copeman & Frank 2024) and recognize it as an invasive species that threatens agricultural crops (Araujo *et al.* 2020).

Moth Index Analysis

The forest zone exhibited the highest diversity index (2.332) compared to the utilization zone (2.244) (Fig. 2). Based on the assessment criteria, the diversity index of moths in the Ranu Darungan area fell within the medium group, which is consistent with the findings of Arya *et al.* (2021) who reported that the diversity of moths in the Wildlife Reserve Forest area exhibited medium value criteria. Moths are widely distributed from lowlands to highlands in tropical regions (Ashton *et al.* 2016). Seasonal variations can significantly affect moth encounter rates, especially across habitats (Koffi *et al.* 2021). According to Moreno *et al.* (2021) species richness is notably higher at night, particularly just before dawn.

The evenness index value of the forest zone was 1.03, while the evenness index value of the utilization zone was 1.05. Based on the criteria of good evenness, a lower evenness index score indicates a higher level of unevenness in moth distribution within a community dominated by specific species.

The dominance index value in the utilization zone was higher (0.1) compared to that in the forest zone (0.09). Both zones had a low dominance index values, ranging from 0 to 0.5. A lower dominance value signifies that no single species dominates the area, indicating a stable ecological condition. This stability is reinforced by the diversity of vegetation, which fosters a balanced ecosystem where no single moth species prevails, thereby contributing to a moderate Shannon-Wiener index. According to the pattern shown in Table 1, *Conogethes punctiferalis* (Cp) had the maximum value of the Shannon-Wiener index in the forest zone, but *Duponchelia* sp. (Ds) was found to have the highest Shannon-Wiener index in the utilization zone.

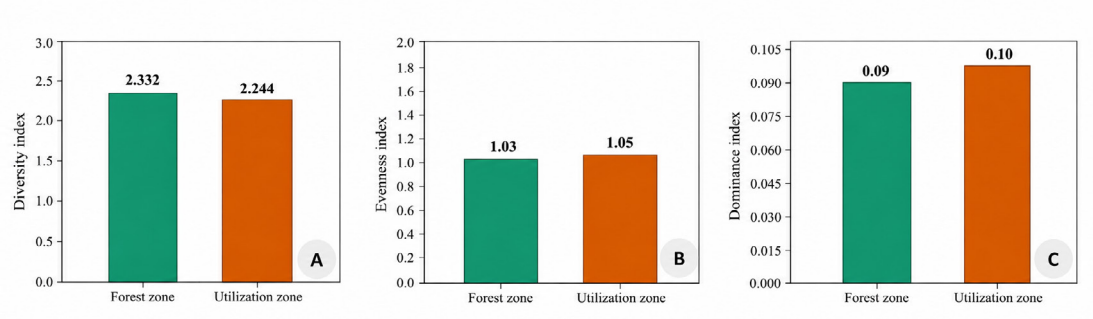


Figure 2 Moth diversity, evenness, and dominance indices at Ranu Darungan Resort, BTSNP

Table 2 List of plant species in Ranu Darungan Resort, BTSNP

No	Family	Species	Type	Forest zone	Utilization zone
1	Moraceae	*Artocarpus elasticus* (AE)	Tree	+	+
2	Moraceae	*Artocarpus heterophyllus* (AH)	Tree	+	-
3	Moraceae	*Ficus fistulosa* (FF)	Tree	-	++
4	Cyatheaceae	*Alsophila lepifera* (AL)	Tree	+	-
5	Cyatheaceae	*Alsophila spinulosa* (AS)	Tree	+	-
6	Asteraceae	*Ageratina riparia* (AR)	Herb	++	++
7	Asteraceae	*Synedrella nodiflora* (SN)	Herb	++	-
8	Asteraceae	*Ageratum conyzoides* (AC)	Herb	-	++
9	Asteraceae	*Chromolaeana odorata* (CHO)	Herb	-	++
10	Asteraceae	*Adenostemma lavenia* (ADL)	Herb	-	++
11	Fabaceae	*Hylodesmum repandum* (HR)	Herb	++	-
12	Fabaceae	*Calliandra calothyrsus* (CC)	Tree	-	++
13	Fabaceae	*Mimosa pudica* (MP)	Herb	-	+
14	Fabaceae	*Delonix regia* (DR)	Tree	-	+
15	Fabaceae	*Centrosema pubescens* (CEP)	Herb	-	+
16	Fabaceae	*Gliricidia sepium* (GS)	Tree	-	+
17	Euphorbiaceae	*Hevea brasiliensis* (HB)	Tree	-	+
18	Euphorbiaceae	*Mallotus paniculatus* (MP)	Tree	-	+
19	Nephrolepidaceae	*Nephrolepis biserrata* (NB)	Tree	-	+
20	Nephrolepidaceae	*Nephrolepis cordifolia* (NEC)	Tree	-	+
21	Araliaceae	*Trevesia palmata* (TP)	Tree	+	-
22	Araliaceae	*Poikilospermum suaveolens* (PS)	Tree	++	-
23	Poaceae	*Paspalum conjugatum* (PC)	Herb	-	++
24	Poaceae	*Cyrtococcum patens* (CP)	Herb	++	-
25	Melastomataceae	*Clidema hirta* (CH)	Herb	+	++
26	Sapindaceae	*Nephelium lappaceum* (NL)	Tree	+	-
27	Pandanaceae	*Pandanus tectorius* (PT)	Tree	++	-
28	Solanaceae	*Brugmansia suaveolens* (BS)	Tree	+	-
29	Onagraceae	*Fuchsia boliviana* (FB)	Tree	+	-
30	Asparagaceae	*Dracaena fragrans* (DF)	Tree	+	-
31	Oleaceae	*Osmantus fragrans* (OF)	Tree	+	-
32	Rubiaceae	*Neolamarckia cadamba* (NC)	Tree	-	+
33	Arecaceae	*Arecha catechu* (ARC)	Tree	-	+
34	Verbenaceae	*Lantana camara* (LC)	Herb	-	++
35	Meliaceae	*Tonna sinensis* (TS)	Tree	-	+

No	Family	Species	Type	Forest zone	Utilization zone
36	Cannabaceae	*Trema orientalis* (TO)	Tree	-	+
37	Myristicaceae	*Myristica fragrans* ()	Tree	-	+
38	Malvaceae	*Durio zibethinus* (DZ)	Tree	-	+

Notes: (+) = Present; (-) = Absent; (++) = Dominant.

Potential Diversity of Host Plants

Thirty-eight (38) plant species were recorded in Ranu Darungan Resort, which included 17 plant species in the forest zone and 21 plant species in the utilization zone (Table 2). According to Root *et al.* (2017) plant diversity within a habitat enhances moth diversity. Additionally, Guyot *et al.* (2017) identified a positive correlation between the richness and heterogeneity of tree species and their resistance to herbivorous insects. According to Muiruri *et al.* (2019), plant diversity and leaf trait variation together can enhance resistance via associative mechanisms. Increased tree diversity enhances resistance to disturbances due to species complementarity, reduced herbivore resources, increased diversion or disturbance processes, and multi-trophic interactions such as predation or symbiosis (Jactel *et al.* 2021).

Forest plants play a crucial role in the ecosystem as host plants for various moth species (Tyler 2020; He *et al.* 2022). These interactions between moths and forest plants create a complex and interdependent ecological relationship, essential for both organisms' survival and the ecosystem's overall balance. Plant diversity provides a variety of food sources and habitats for moths (Kusia *et al.* 2022). Each moth species has specific preferences for host plant types, often related to their nutritional requirements and life cycle (Friberg *et al.* 2016; Da Silva *et al.* 2017). This plant diversity creates complex habitats and offers various microhabitats that support moths' life cycles (Thom & Daniels 2017; Gunathunga *et al.* 2022).

Forest plants provide various nutrient sources essential for moths (Bala *et al.* 2018). Moths visit the flowers of plants that bloom at night (Dantas *et al.* 2020). Nectar from forest flowers serves as the primary energy source for adult moths (Milberg *et al.* 2016; Brzosko & Bajguz, 2019). Meanwhile, moth larvae act as leaf borers (Motta *et al.* 2021) as well as stem borers and consumers of other plant parts (Goftishu *et al.* 2018), acquiring essential proteins and nutrients for their growth and development.

Moths serve as pollinators in forest ecosystems, aiding the pollination of various plant species that bloom at night (Buxton *et al.* 2023). This pollination is crucial for the reproduction of forest plants and the continuity of the ecosystem. Additionally, moths are integral to the food chain, providing a nutritional source for natural predators such as birds and bats.

Abiotic Parameters

The air temperature in the forest zone was recorded as 25.65 °C, while it was 28.12 °C in the utilization zone (Table 3). The average temperature fluctuated between 26 to 29 °C, were within the threshold range classification and provided conditions suitable for survival. Based on the findings of Cui *et al.* (2018), larval emergence occurs most rapidly at a temperature of 28 °C. Moreno *et al.* (2021) found that temperature positively and significantly correlates with moth abundance. Furthermore, there is a correlation between air temperature and air humidity. A decrease in temperature directly impacts air humidity. The forest zone exhibits the highest level of atmospheric humidity, reaching 82%, compared to that in the utilization zone, which has a humidity level of 67%.

Daytime light intensity data were recorded. The light intensity in the forest zone was significantly higher at 1,617 lux compared to that in the utilization zone, which had a light intensity of 863.75 lux. The average wind speed in the jungle zone was 12 m/s, somewhat higher than the wind speed in the utilization zone, which was 11.8 m/s.

The soil moisture in the forest zone was 25%, while it was 18.25% in the utilization zone. Research conducted by Shi *et al.* (2021) reported that soil moisture does not significantly impact emergence rates. The majority of larvae exhibit a preference for pupating at levels ranging from 25% to 50%. However, certain larvae can burrow and pupate in either dry soil with a moisture level of 5% or in wet soil with a moisture level of 80%. Torres-Muros *et al.* (2017) highlighted the significance of habitat and soil moisture, particularly during the pupal stage.

Table 3 Abiotic parameters in Ranu Darungan Resort, BTSNP

Location	Air temperature (°C)	Light intensity (lux)	Air humidity (%)	Wind velocity (m/s)	Soil moisture (%)	Altitude (masl)
Forest zone	25.65 ± 1.48	1,617 ± 424.26	82 ± 2.83	12 ± 1.41	25 ± 7.07	850.5 ± 3.54
Utilization zone	28.12 ± 1.56	863.75 ± 335.91	67 ± 9.83	11.8 ± 2.36	18.25 ± 2.06	929.8 ± 45.67

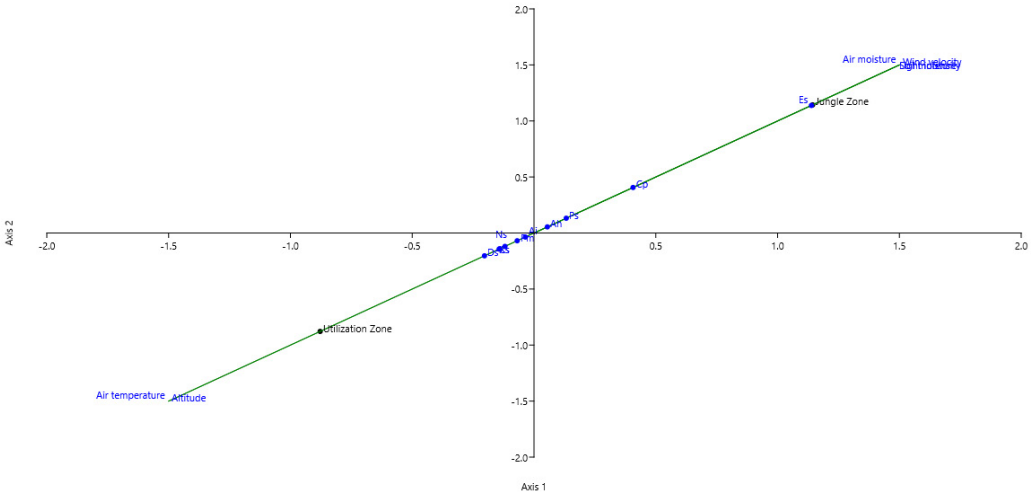


Figure 3 CCA analysis showing relationships between moths and abiotic factors

Canonical Correspondence Analysis (CCA) using Abiotic Factors and Moth Species

The CCA analysis revealed an association between *A. heliconia*, *Plodia* sp., *C. punctiferalis*, and *Eacles* sp. with environmental factors such as soil moisture, light intensity, wind speed, and air humidity in the jungle habitat (Fig. 3).

Four moth species showed associations with abiotic factors and were characterized by their small sizes. According to Jaimes *et al.* (2019), larger moths are more common at the forest edge than in its interior. This pertains to abiotic factors, suggesting that larger moths may be more drought-tolerant than the smaller ones. *C. punctiferalis* showed the greatest association with relative abundance throughout the forest. This species is a herbivore that feeds on various plants (Chen *et al.* 2018). Forests are locations characterized by diverse and varied habitats. The presence of vegetation structure enhances the accuracy of predicting species richness (Zellweger *et al.* 2016).

Six species, specifically *A. illiturata*, *Creatonotos* sp., *Nudaria* sp., *Duponchelia* sp., *Polythlipta macralis*, and *Xanthorhoe* sp. had a favorable response to the utilization zone characterized by air humidity and altitude. One member of the Geometridae family, *Xanthorhoe* sp., was among the species that displayed this favorable response. The species was discovered in the prevailing habitat of *Calliandra calothyrsus*. According to De Smedt *et al.* (2019) one moth family is abundant on the soil surface. In contrast, the Noctuidae family utilizes both the soil surface and the canopy layer.

Principal Component Analysis (PCA) Based on Habitat, Plant Species, and Moths

PCA analysis revealed two distinct groups. The first group, consisting of *Clidema hirta* (CH), *Crytococcoum patens* (CP), and *Ageratina riparia* (AR), exhibited a strong association with the forest habitat (Fig. 4). Nevertheless, the plant community did not impact the species richness of moths in this initial group. According to Delabye *et al.* (2021) moth species diversity is determined by both the variety of plants and the level of forest openness. Small canopy communities have no substantial effect on moths, as demonstrated by Delabye *et al.* (2021). Montañez-Reyna *et al.* (2023) found a strong association between vegetation variability and species diversity and abundance.

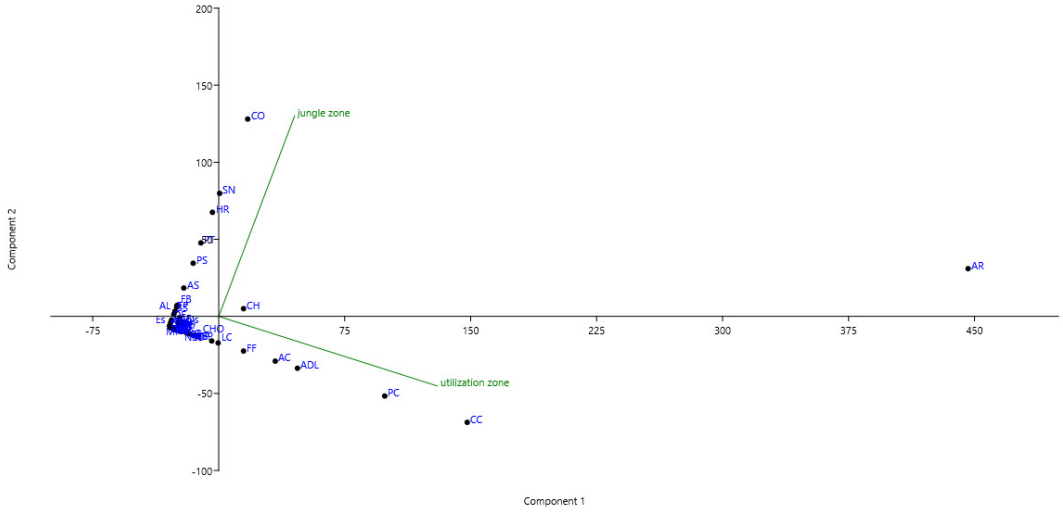


Figure 4 Principal Component Analysis (PCA) based on habitat, plant type, and moth

The second group, consisting of *Ficus fistulosa* (FF), *Ageratum conyzoides* (AC), *Adenostemma lavenia* (ADL), *Paspalum conjugatum* (PC), and *Calliandra calothyrsus* (CC), showed a correlation with the utilization zone (Fig. 4). Vegetation is a plant frequently observed growing on the crests of hills and slopes in forests. Consistent with the findings of Rabl *et al.* (2020), most species are found in ridge and slope forests, while only a tiny number are found in river forests (Rabl *et al.* 2020).

The structure of the moth community is affected by the management of the forest in the utilization zone. *Calliandra calothyrsus* primarily occupies the area and is used as animal feed. According to Moon *et al.* (2018), changes in vegetation can cause shifts in moth communities, resulting in decreased community indices. According to Root *et al.* (2017), the most effective method for conserving moth communities is to manage forests by preserving natural successional vegetation diversity. According to Kadlec *et al.* (2018) increasing the heterogeneity of native forest habitats can support more functionally diverse Lepidoptera communities.

CONCLUSION

The Ranu Darungan Resort within the Bromo Tengger Semeru National Park is a critical conservation area due to its potential for supporting diverse host plants that serve as moth habitats. The two distinct zones within the Ranu Darungan Resort exhibited variations in moth species diversity, evenness, and dominance, with the forest zone demonstrating higher diversity compared to the diversity in the utilization zone. Notably, *Conogethes punctiferalis* and *Duponchelia* sp. species were significant pests within various agricultural and forest ecosystems. The abiotic factors in this area fall within the tolerance range necessary to support moth populations. Additionally, 38 plant species identified within this area have the potential to serve as host plants, offering a range of microhabitats that are crucial for the moths' life cycles. The presence of these diverse moth and plant species is critical to understanding their roles as pollinators and pests, particularly in terms of their interactions with leaves, fruits, and plant stems at the Ranu Darungan Resort. Understanding the potential, roles, and impacts of these moth species can provide fundamental data that contributes to the management and conservation efforts within the Ranu Darungan Resort, BTSNP.

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REFERENCES

Araujo ES, Benatto A, Rizzato FB, Poltronieri AS, Poitevin CG, Zawadneak MA, Pimentel IC. 2020. Combining biocontrol agents with different mechanisms of action to control *Duponchelia fovealis*, an invasive pest in South America. Crop Prot 134:105184. DOI: 10.1016/j.cropro.2020.105184

Arya MK, Chandra H, Bisht S, Fasuil F. 2021. Preliminary report on moth diversity in the landscape of Nandhaur Wildlife Sanctuary: Adding subset to lepidoptera insects of protected area network. Uttar Pradesh J Zool 42(15):12–22.

Ashton LA, Odell EH, Burwell CJ, Maunsell SC, Nakamura A, McDonald WJF, Kitching RL. 2016. Altitudinal patterns of moth diversity in tropical and subtropical Australian rainforests. Aust Ecol 41(2):197–208. DOI: 10.1111/aec.12309

Bala K, Sood AK, Pathania VS., Thakur S. 2018. Effect of plant nutrition in insect pest management: A review. J Pharmacogn Phytochem 7(4):2737–2742.

Borges RM, Somanathan H, Kelber A. 2016. Patterns and processes in nocturnal and crepuscular pollination services. Q rev biol 91(4):389–418.

Brzosko E, Bajguz A. 2019. Nectar composition in moth-pollinated *Platanthera bifolia* and *P. chlorantha* and its importance for reproductive success. Planta 250:263–279. DOI: 10.1007/s00425-019-03168-5

Buxton MN, Hoare RJ, Broussard MA, Van Noort T, Fale GR, Nathan T, Pattemore DE. 2023. Moths as potential pollinators in avocado (*Persea americana*) orchards in temperate regions. NZ J Crop Hortic Sci 51(1):27–38. DOI: 10.1080/01140671.2021.1966480

Chen GM, Chi H, Wang RC, Wang YP, Xu YY, Li XD, …, Zheng FQ. 2018. Demography and uncertainty of population growth of *Conogethes punctiferalis* (Lepidoptera: Crambidae) reared on five host plants with discussion on some life history statistics. J Econ Entomol 111(5):2143–2152. DOI: 10.1093/jee/toy202

Chung DE, Kim HH, Kim MK, Lee KH, Park YH, Um IC. 2015. Effects of different *Bombyx mori* silkworm varieties on the structural characteristics and properties of silk. Int J Biol Macromol 79:943–951. DOI: 10.1016/j.ijbiomac.2015.06.012

Common IFB. 1990. Moths of Australia. Clayton (AU): CSIRO Publishing Australia.

Conchou L, Anderson P, Birgersson G. 2017. Host plant species differentiation in a polyphagous moth: olfaction is enough. J Chem Ecol 43:794–805. DOI: 10.1007/s10886-017-0876-2

Copeman SM, Frank SD. 2024. Profile of *Duponchelia fovealis* (Lepidoptera: Crambidae) as a greenhouse and nursery pest in the United States. J Integr Pest Manag 15(1):19. DOI: 10.1093/jipm/pmae011

Cui J, Zhu SY, Bi R, Xu W, Gao Y, Shi SS. 2018. Effect of temperature on the development, survival, and fecundity of *Heliothis viriplaca* (Lepidoptera: Noctuidae). J Econo Entomol 111(4):1940–1946. DOI: 10.1093/jee/toy151

Dantas J, Motta I, Vidal L, Bilio J, Pupe JM, Veiga A, …, Pujol-Luz JR. 2020. A comprehensive review of the coffee leaf miner *Leucoptera coffeella* (Lepidoptera: Lyonetiidae), with special regard to neotropical impacts, pest management and control. DOI: 10.20944/preprints202010.0629.v1

Dar AA, Jamal K. 2021. Moths as ecological indicators: A review. Munis Entomol Zool J 16 (2):830–836.

Da Silva DM, de Freitas Bueno A, dos Santos Stecca C, Andrade K, Neves PMOJ, de Oliveira MCN. 2017. Biology of *Spodoptera eridania* and *Spodoptera cosmioides* (Lepidoptera: Noctuidae) on different host plants. Florida Entomol 100(4):752–760. DOI: 10.1653/024.100.0423

Delabye S, Maicher V, Sáfián S, Doležal J, Altman J, Janeček Š, …, Tropek R. 2021. Butterfly and moth communities differ in their response to habitat structure in rainforests of Mount Cameroon. Biotropica 53(2):567–580. DOI: 10.1111/btp.12900

De Menezes CW, Stein HB, Shilap AV, Carvalho GA, Tavares WD, Pereira AI, Zanuncio JC. 2019. First record of *Duponchelia fovealis* (Crambidae) as a pest of commercial crops of strawberry in Campo Das Vertentes, Minas Gerais, Brazil. J Lepidopt Soc 73(2):131–134. DOI: 10.18473/lepi.73i2.a8

De Smedt P, Vangansbeke P, Bracke R, Schauwvliege W, Willems L, Mertens J, …, Müller J. 2019. Vertical stratification of moth communities in a deciduous forest in Belgium. Insect Conserv Divers 12(2):121–130. DOI: 10.1111/icad.12320.

Du YL, Li J, Wang ZY. 2018. Research progress of *Conogethes punctiferalis* (Lepidoptera: Crambidae) in China. In Chakravarthy AK (Editor), The black spotted, yellow borer, *Conogethes punctiferalis* Guenée and allied species. p. 45–66. Singapore (SG): Springer Singapore. DOI: 10.1007/978-981-13-0390-6_5

Ferracini C, Saitta V, Pogolotti C, Rollet I, Vertui F, Dovigo L. 2020. Monitoring and management of the pine processionary moth in the North-Western Italian Alps. For 11(12):1253. DOI: 10.3390/f11121253

Friberg M, Schwind C, Thompson JN. 2016. Divergence in selection of host species and plant parts among populations of a phytophagous insect. Evol Ecol 30(4):723-737. DOI: 10.1007/s10682-016-9835-6

Goftishu M, Assefa Y, Niba A, Fininsa C, Le Ru BP. 2018. Diversity and abundance of lepidopteran stem borers and their host plants in Ethiopia. J Appl Entomol 142(4):437-449. DOI: 10.1111/jen.12489

Gunathunga P, Dangalle CD, Pallewatta N. 2022. Diversity and habitat preferences of moths (Insecta: Lepidoptera) in Indikadamukalana, a lowland wet zone forest in Sri Lanka. J Trop For Environ 12:01. DOI: 10.31357/jtfe.v12i01.6109

Guyot V, Castagneyrol B, Vialatte A, Deconchat M, Jactel H. 2016. Tree diversity reduces pest damage in mature forests across Europe. Biol Lett 12(4):20151037. DOI: 10.1098/rsbl.2015.1037

Hadisusanto S, Purnomo P, Trijoko T, Reza A, Eprilurahman R, Yudha DS, …, Priyono DS. 2022. Biodiversity monitoring as a baseline for PROPER biodiversity protection program of PT. Geo Dipa Energi Dieng, Central Java, Indonesia. Biodivers 23:(9). DOI: 10.13057/biodiv/d230912

Hammer O, Harper DAT, Ryan PD. 2001. PAST: Paleontological statistics software package for education and data analysis. Palaeontol Electron. Available from: http://palaeo-electronica.org/2001_1/past/issue1_01.htm.

He L, Liu Y, Guo J, Chang H, Wu K. 2022. Host plants and pollination regions for the long-distance migratory noctuid moth, *Hadula trifolii* Hufnagel in China. Ecol Evol 12(4):e8819. DOI: 10.1002/ece3.8819

Holloway, J.D. 1987. The moths of Borneo, Part 3, Family Lasiocampidae, Eupterotidae, Bombycidae, Brahmaeidae, Saturniidae, Sphingidae. Kuala Lumpur (MY): Malayan Nature Society.

Jactel H, Moreira X, Castagneyrol B. 2021. Tree diversity and forest resistance to insect pests: patterns, mechanisms, and prospects. Annu Rev Entomol 66(1):277–296. DOI: 10.1146/annurev-ento-041720-075234

Jaimes-Nino LM, Mörtter R, Brehm G. 2019. Diversity and trait patterns of moths at the edge of an Amazonian rainforest. J Insect Conserv 23(4):751–763. DOI: 10.1007/s10841-019-00168-4

Jung, JK, Kwon HJ, Kim HS, Seo ST, Koh S. 2018. Fruit and leaf damage by *Conogethes punctiferalis* (Lepidoptera: Crambidae) and Acrocercops transecta (Lepidoptera: Gracillariidae) in walnut orchards. Korean J Appl Entomol 57(1):33–38.

Kadlec T, Štrobl M, Hanzelka J, Hejda M, Reif J. 2018. Differences in the community composition of nocturnal Lepidoptera between native and invaded forests are linked to the habitat structure. Biodiver Conserv 27(10):2661–2680. DOI: 10.1007/s10531-018-1560-8

Karam R, Chong JH. 2019. Moths of Bukit Timah Nature Reserve, Singapore. Gardens' Bulletin Singapore 71:317–330. DOI: 10.26492/gbs71(suppl.1).2019-012

Koffi D, Agboka K, Adjevi AK, Assogba K, Fening KO, Osae M, …, Nagoshi RN. 2021. Trapping *Spodoptera frugiperda* (Lepidoptera: Noctuidae) moths in different crop habitats in Togo and Ghana. J Econ Entomol 114(3):1138-1144. DOI: 10.1093/jee/toab048

Kovács A, Hunyadi I, Fejes-Tóth A, Fejes-Tóth P, Hári K, Sipos K, …, Pénzes B. 2014. Behavioral and physiological study on the European pepper moth (*Duponchelia fovealis*, Zeller) host plant selection. Növényvédelem 50(8):357–364

Kusia ES, Borgemeister C, Khamis FM, Copeland RS, Tanga CM, Ombura FL, Subramanian S. 2021. Diversity, host plants and potential distribution of edible saturniid caterpillars in Kenya. Insects 12(7):600. DOI: 10.3390/insects12070600

La Cava S, Rijllo G, Zucco G, Innocenti S, Guasti M, Puletti N, …, Scalercio S. 2024. Moths in space: The below-canopy structure of forest drives abundance and mobility-related traits of moth communities. Sci Total Environ 921:171056. DOI: 10.1016/j.scitotenv.2024.171056

Leidinger J, Seibold S, Weisser WW, Lange M, Schall P, Türke M, Gossner MM. 2019. Effects of forest management on herbivorous insects in temperate Europe. For Ecol Manag 437:232–45. DOI: 10.1016/j.foreco.2019.01.013

Li RT, Huang LQ, Dong JF, Wang CZ. 2020. A moth odorant receptor highly expressed in the ovipositor is involved in detecting host-plant volatiles. Elife 21(9):e53706. DOI: 10.7554/eLife.53706

Lin CH, Pan QJ, Waqas MS, Liu TX. 2020. Morphological traits for sex identification of the oriental armyworm, *Mythimna separata* (Lepidoptera: Noctuidae). J Integr Agric 19(6):1458–1463. DOI: 10.1016/S2095-3119(19)62862-5

Maury HK, Purwadi MA, Ramandey ER, Bisai JR, Mauri BH. 2022. Keanekaragaman ngengat superfamily Bombicoidea: Eksplorasi Potensi Ulat Sutera di Dataran Rendah Kabupaten Jayapura [Bombycoidea moth diversity and the potential of silkworms in the lowlands of Jayapura Regency]. J Biol Papua 14(2):137–142. DOI: 10.31957/jbp.2352

Milberg P, Bergman KO, Cronvall E, Eriksson ÅI, Glimskär A, Islamovic A, …, Westerberg L. 2016. Flower abundance and vegetation height as predictors for nectar-feeding insect occurrence in Swedish semi-natural grasslands. Agric Ecosyst Environ 230:47–54. DOI: 10.1016/j.agee.2016.05.029

Montañez-Reyna M, León-Cortés JL, Falcon-Brindis A. 2023. The diversity of moths (Erebidae: Arctiinae: Arctiini) from threatened mountain cloud forests in the Mesoamerican biodiversity hotspot. J Insect Conserv 27(1):141–54. DOI:10841-022-00448-6

Moon MY, Kim SS, Lee DS, Yang HM, Park CW, Kim HS, Park YS. 2018. Effects of forest management practices on moth communities in a Japanese larch (*Larix kaempferi* (Lamb.) Carrière) plantation. For 9(9):574. DOI: 10.3390/f9090574

Moreno C, Barbosa ÂS, Ferro VG. 2021. Abundance and richness of Arctiinae moths throughout the night in a Cerrado area. Biota Neotropica 21:e20201041. DOI: 10.1590/1676-0611-BN-2020-1041

Muiruri EW, Barantal S, Iason GR, Salminen JP, Perez-Fernandez E, Koricheva J. 2019. Forest diversity effects on insect herbivores: Do leaf traits matter?. New Phytol 221(4):2250–2260. DOI: 10.1111/nph.15558

Orsucci M, Audiot P, Pommier A, Raynaud C, Ramora B, Zanetto A, …, Streiff R. 2016. Host specialization involving attraction, avoidance and performance, in two phytophagous moth species. J Evolut Biol 29(1):114–125. DOI: 10.1111/jeb.12766

Pimienta MC, Koptur S. 2022. More than moths: Flower visitors of a night-blooming plant in south Florida pine rocklands, USA. Plants 11(20):2799. DOI: 10.3390/plants11202799

Rabl D, Gottsberger B, Brehm G, Hofhansl F, Fiedler K. 2020. Moth assemblages in Costa Rica rain forest mirror small-scale topographic heterogeneity. Biotropica 52(2):288–301. DOI: 10.1111/btp.12677

Robinson GS, Ackery PR, Kitching IJ, Beccaloni GW, Hernández LM. 2010. HOSTS – A Database of the World's Lepidopteran Hostplants.Natural History Museum, London. Available from: http://www.nhm.ac.uk/hosts

Roh HS, Park KC, Oh HW, Park CG. 2016. Morphology and distribution of antennal sensilla of two tortricid moths, *Cydia pomonella* and *C. succedana* (Lepidoptera). Microsc Res Tech 79(11):1069–1081. DOI: 10.1002/jemt.22747

Root HT, Verschuyl J, Stokely T, Hammond P, Scherr MA, Betts MG. 2017. Plant diversity enhances moth diversity in an intensive forest management experiment. Ecol Appl 27(1):134–142. DOI: 10.1002/eap.1426

Sridhar V, Kriticos D, Nitin KS, Chakravarthy AK, Swathi P. 2018. Predicting potential global distribution of the black spotted yellow borer, *Conogethes punctiferalis* Guenée (Crambidae: Lepidoptera) by CLIMEX Modelling. In Chakravarthy AK (Editor), The Black spotted, Yellow Borer, *Conogethes punctiferalis* Guenée and Allied Species. p. 101–114. Singapore (SG): Springer Singapore. DOI: 10.1007/978-981-13-0390-6_9

Sutrisno H, Darmawa S, Sundaiwati, Momo S. 2015. Moths of Gunung Halimun-Salak National Park. Part 2: Geometroidea & Drepanoidea. Jakarta (ID): LIPI Press.

Thom MD, Daniels J. 2017. Patterns of microhabitat and larval host-plant use by an imperiled butterfly in northern Florida. J Insect Conserv 21(1):39–52. DOI: 10.1007/s10841-016-9950-2

Torres-Muros L, Hódar JA, Zamora R. 2017. Effect of habitat type and soil moisture on pupal stage of a Mediterranean forest pest (*Thaumetopoea pityocampa*). Agric For Entomol 19(2):130-138. DOI: 10.1111/afe.12188

Tyler T. 2020. Relationship between moth (night active Lepidoptera) diversity and vegetation characteristics in southern Sweden. J Insect Conserv 24(6):1005–1015. DOI: 10.1007/s10841-020-00270-y

Valente DM, Teston JA. 2024. Vertical stratification of Sphingidae moths (Lepidoptera: Bombycoidea: Sphingidae) in the Tapajós National Forest, Pará, Brazil. Zool (Curitiba) 41:e23008. DOI: 10.1590/S1984-4689.v41.e23008

Wagner DL, Fox R, Salcido DM, Dyer LA. 2021. A window to the world of global insect declines: Moth biodiversity trends are complex and heterogeneous. Proc Nat Acad Sci 118(2):e2002549117. DOI: 10.1073/pnas.200254911

Walton RE, Sayer CD, Bennion H, Axmacher JC. 2020. Nocturnal pollinators strongly contribute to pollen transport of wild flowers in an agricultural landscape. Biol Lett 16(5):20190877. DOI: 10.1098/rsbl.2019.0877

Zárate-Santana ZJ, Patino-Alonso MC, Sánchez-García AB, Galindo-Villardón P. 2021. Learning approaches and coping with academic stress for sustainability teaching: Connections through canonical correspondence analysis. Sustainability 13(2):852. DOI: 10.3390/su13020852

Zborowski P, Edwards T. 2007. A Guide To Australian Moths. Clayton (AU): CSIRO Publishing Australia.

Zellweger F, Baltensweiler A, Ginzler C, Roth T, Braunisch V, Bugmann H, Bollmann K. 2016. Environmental predictors of species richness in forest landscapes: abiotic factors versus vegetation structure. J Biogeogr 43(6):1080-1090. DOI: 10.1111/jbi.12696