SPECIAL ISSUE: *5th INTERNATIONAL SYMPOSIUM ON INSECTS (ISOI2023), "UNVEILING THE HIDDEN PROSPECT OF INSECTS", 11-13 SEPTEMBER 2023*

Serangga 2024, 29(2): 63-78. *Irham et al.*

https://doi.org/10.17576/serangga-2024-2902-06

CHECKLIST OF ARACHNIDS IN THE HIGHLANDS AREA OF GUNUNG LEDANG NATIONAL PARK, JOHOR, MALAYSIA

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Received: 14 December 2023; Acceptance: 10 June 2024

ABSTRACT

Mount Ledang National Park is one of the famous hiking spots in Johor, Malaysia which is the 1,276-meter peak of Mount Ledang. Between 21st-25th August 2023, a visual encounter survey method was conducted from 0900-1700 and 2000-2300 hours to document the Arachnid species that occur at 900-1200 meters above sea level. In total, 27 species from 14 families of arachnids were recorded from two orders; Araneae and Opiliones. Clustering analysis showed

that Pendeta Trail and Batu Hampar Trail have 70% similar species composition, and Telekom Trail has a 37% difference between the two trails. Extrapolation of the species accumulation curve shows an increasing trend and has not reached an asymptote. The analyses on estimated species richness revealed that Arachnid species richness was at a minimum of 32 species, and a maximum of 47 species. Interestingly, a new record of tube trapdoor spider, *Damarchus workmanii,* and an undescribed *Psednocnemis* tarantula species found from this survey shows the importance of preserving the highland areas of this national park which remains to be further explored.

Keywords: Arachnid, species richness, tarantula, visual encounter survey

ABSTRAK

Taman Negara Gunung Ledang merupakan salah satu tempat mendaki yang dikenali di negeri Johor Malaysia yang mempunyai puncak tertinggi pada ketinggian 1276 meter. Pada tarikh 21 Ogos hingga 25 Ogos 2023, tinjauan pertemuan visual telah dijalankan pada 0900-1800 dan 2000-2300 pukul 9 pagi hingga 6 petang dan pada pukul 8 malam sehingga 11:30 malam untuk mengdokumenkan spesies Araknida yang boleh dijumpai pada ketinggan 900-1200 meter. Secara keseluruhannya, 27 spesies dari 14 famili dan dua order iaitu Araneae dan Opiliones berjaya direkodkan. Analisis pengelompokan menunjukkan denai Pendeta dan Batu Hampar berkongsi persamaan sebanyak 70% bagi kepelbagaian speseis, dan denai Telekom berbeza sebanyak 37% berbanding kedua lagi denai. Ekstrapolasi lengkung pengumpulan spesis menunjukkan peningkatan tetapi tidak mencapai garisan mendatar. Analisis untuk pengumpulan kekayaan spesies menunjukkan bahawa minimum bagi spesies adalah 32 dan maksimum adalah 47 spesies. Penemuan menarik pada kajian kali ini padalah penemuan labah-labah dari spesis *Damarchus workmanii* dan spesies tarantula yang belum dikenalpasti dari genus *Psednocnemis* yang dijumpai dalam kajian ini. Kajian ini menunjukkan kepentingan menjaga kawasan tanah tinggi di Taman Negara ini yang masih banyak lagi belum diteroka.

Kata kunci: Araknida, kekayaan spesis, spesies tarantula, tinjauan pertemuan visual

INTRODUCTION

Gunung Ledang also known as Mount Ophir is one of the protected areas under Johor National Park, situated in Tangkak, Johor, Malaysia. The highest peak in this Gunung Ledang National Park stands at 4186 ft (1276 m) above sea level. Several studies have been conducted in this area, particularly study on mammals using camera traps (Bakri et al. 2020) that discovered the presence of mountain serow in Johor state, a study on stick insects (Rabihah et al. 2016), diversity of butterflies (Hasnizan et al. 2021), birds (Lim et al. 2012), and orchid (Nordin et al. 2021). Based on previous studies, showed that Gunung Ledang National Park is rich in flora and fauna biodiversity. Therefore, more studies need to be done in this National Park to discover and add more biodiversity information on the highland species.

Up to this date, there has been no record of studies on the diversity of arachnids in Gunung Ledang National Park. However, there were study on the taxonomy of tarantula found in the lowland area of Gunung Ledang (West & Nunn 2010) and bioacoustics study of a tarantula species that can also be found in Gunung Ledang (Razak et al. 2024). The study focuses mainly on the taxonomic of the spider, and not much information related to the

diversity and natural history of arachnids in the National Park. In addition to that, only one study was done in the past regarding a checklist of arachnids in highland areas in Malaysia, particularly at Fraser Hill, Pahang (Chooi et al. 2014b). Other past studies on arachnids in Malaysia were mostly in lowland forests (Nasir et al. 2014a; Rahim & Dasran 2021; Sundram & Joseph 2020) and natural lakes such as Lake Bera and Lake Chini (Chooi et al. 2014a; Razak et al. 2023). The scarcity of information related to spider diversity in the highland area becomes a concern since they provide crucial ecosystem services. Highland ecosystems offer valuable biological benefits to both humans and the natural environment. Preservation of the environment is critical to ensuring the sustainability of a region and preventing the dwindling of biodiversity (Razali et al. 2018).

Arachnids play an important role in the forest in maintaining a healthy ecosystem. Generally, arachnids play a big role in any ecosystem in which they live (Bennett 2001). For example, arachnids contribute to maintaining a balanced ecosystem through their role as predators for many species of prey such as insects (Raiz et al. 2018). Arachnids also can be treated as bioindicator predictors to assess ecosystem stability because Araneae taxon can be identified without difficulty and respond to disturbances in natural habitats differently (Pearce & Venier 2006). Besides that, arachnids are one of the arthropods that contribute to the sustainability of the ecosystem, not many studies have been done especially about conservational studies. One past study showed that tarantula species, named *Grammostola vachoni* was proven to be sensitive to environmental changes (Schwerdt et al. 2018). Thus, it showed the potential of spider species as bioindicator for the healthiness of the environment. Although arachnids are one of the arthropods that contribute to the sustainability of the ecosystem, not much research has been done, especially in terms of conservation (Pearce & Venier 2006). This study aims to determine the abundance of arachnids in the highland area of Gunung Ledang and to estimate the species richness of arachnids in the highlands of Gunung Ledang. The findings from this study will serve as a baseline study for future research on arachnid diversity and taxonomy, particularly in highland areas of Malaysia.

MATERIALS AND METHODS

Study Site

The study area consists of mostly upper dipterocarp forest covered with closed canopy at 900m-1200m elevation. Nearing the peak, the canopy cover slowly decreases, with the peak having an open canopy. The temperature ranges between 17°C-24°C and has 80% humidity. Both Batu Hampar Trail and Pendeta Trail are used by visitors as hiking trails whereas Telekom Trail is the only tarred road that can be used to go to the Telekom tower. The coordinate for the study site was 2°22'24.0"N 102°36'27.9"E.

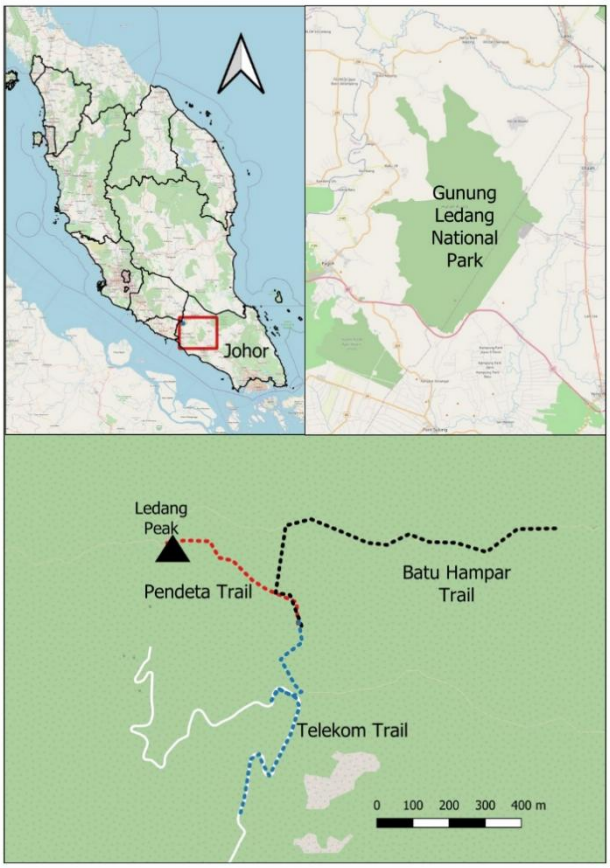


Figure 1. Study was conducted between 900-1200 meters above sea level in the highland area

Data Collection

The sampling was carried out for five consecutive days (21st August 2023 to 25th August 2023), in both daylight and night-time. The visual encounter survey (VES) method was employed during the survey by four people, starting from 0900-1700 hours, and 2000-2300 hours. Torchlight was used to detect the arachnids at night. The samples were collected bare-handed or with forceps depending on the arachnid species. The search areas focused on tarred roads, ridges, riverbanks, forest trails, and hiking trails. Liftable boulders, rocks, woods, or any other possible place for an arachnid's hiding places were flipped to maximize the probability of collecting the arachnids. For burrowing spiders, the entrance of the burrow was searched by looking at burrows that have web lining on the wall of the burrow. Specimens collected were photographed on-site to avoid any discoloration or faded pattern due to the stress.

Species Identification

The voucher specimens were preserved in containers with 70% ethanol solution for long-term preservation. All species were identified up to species or genus level following Nasir & Su (2015), Koh & Bay (2019), and World Spider Catalogue (2023). All specimens were deposited at the Nature Education and Research Centre (NERC) depository center that is located in Endau Rompin National Park under the administration of Johor National Parks Corporation (JNPC)

Data Analysis

The similarity of spider assemblages among the three study sites was assessed through a clustering analysis which used a dendrogram constructed via the Unweighted Pair Group Method with Arithmetic Mean (UPGMA) algorithm using Bray-Curtis method using Paleontological Statistics Software (PAST version 4.03) (Hammer 2001). The species accumulation curve (SAC) was constructed based on the spider abundance for each trail to determine the sampling adequacy in Ecosim2004 software (Christensen & Walters 2004), and the curves were plotted using WPS Office 2021. To further determine the sampling adequacy, the extrapolation of the species accumulation curve was done using iNEXT online software (Chao et al. 2016) by combining all data from three study trials. The spider species richness was also estimated using nine non-parametric species richness estimators namely ACE (Abundance Coverage Estimator), ICE (Incidence Coverage Estimator), Chao 1, Chao 2, Jack 1 (Jackknife), Jack 2 (Jackknife), Bootstrap, and Means (Michelis-Menten), using EstimateS 9.1 software (Colwell et al. 2012). The parameters used were set to the default values.

RESULTS

From the total of 27 Arachnid species collected (377 individuals), 26 spider species from 14 families belong to the order of Araneae and one species belongs to the order of Opiliones. The family Araneidae is the dominant family with six species, followed by Tetragnathidae (four species), Salticidae (three species), Theridiidae (three species), Theridiidae (two species), while other families are represented only by single species (Table 1). The clustering analysis shows spider communities in both Pendeta and Batu Hampar trails shared about 70% similar species composition while the Telekom trail differed from the other trails at 37.5% similarity (Figure 2). As for the diversity index, the Simpson_1-D index for Trail Telekom was 0.8894, Trail Pendeta was 0.8918 and Trail Batu Hampar was 0.8864. The index for Shannon (H') was 2.409 for Trail Telekom, 2.407 for Trail Pendeta and 2.392 for Trail Batu Hampar. According to the diversity index result, individual counts were highest for Trail Pendeta with 165 individuals, followed by Trail Batu Hampar (115 individuals) and Trail Telekom (97 individuals). Nonetheless, species recorded in each trail are similar among the three trails which were 16 species for each trail.

Species accumulation for all trails shows no sign of reaching asymptote (Figure 3). All curves are still increasing proportionally between species richness and spider abundance, where the sampling efforts are still considered insufficient to document arachnid species richness in the study site. The extrapolation of species accumulation curves also shows that more additional spider species can be recorded if the sampling effort (number of individuals) is multiplied (Figure 4). Based on the nine species richness estimators, spider species richness was estimated to be at a minimum of 32 species (bootstrap), and a maximum of 47 species (MMRuns), with an additional 5 to 20 spider species.

Table 1. List of arachnid species found in the highland area of Gunung Ledang. All spiders recorded in this study are Not Evaluated (NE) in the IUCN Red List of Threatened Species

Order: Araneae
Family: Araneidae
Species
Araneus nox (Simon, 1877)
Neoscona (Simon, 1895)
Argiope aemula (Walckenaer, 1841)
Argiope reinwardtii (Doleschall, 1859)
Gasteracantha diardi (Lucas, 1835)
Thelacantha sp.
Family: Bemmeridae
Species
Damarchus sp.
Family: Clubionidae
Species:
Nusatidia borneensis (Deeleman-Reinhold 2001)
Family: Ctenidae
Species:
Bowie sp.
Family: Hersiliidae
Species:
Hersilia sp.
Family: Lycosidae
Species:
Pardosa pursiola (Thorell 1891)
Family: Nephilidae
Species:
Nephila pilipes (Fabricius 1793)
Family: Salticidae
Species:
Phintella sp.
Salticidae sp. 1
Pancorius sp.
Family: Scytodidae
Species:
Scytodes sp.
Family: Sparassidae
Species:
Heteropoda sp.
Family: Tetragnathidae
Species:
Orsinome vethi (van Hasselt 1882)
Leucauge celebesiana (Walckenaer 1841)

Mesida sp. Tetragnathidae sp.1
Family: Theraphosidae **Species:** *Psednocnemis* sp. 'Ledang'
Family: Theridiidae **Species:** Theridiidae sp. *Phoroncidia lygeana* (Walckenaer 1842) *Dipoenura* sp.
Family: Zodariidae **Species:** *Mallinella annulipes* (Thorell 1893)
Order: Opiliones
Family: Scleromastidae **Species:** Scelormastidae sp.

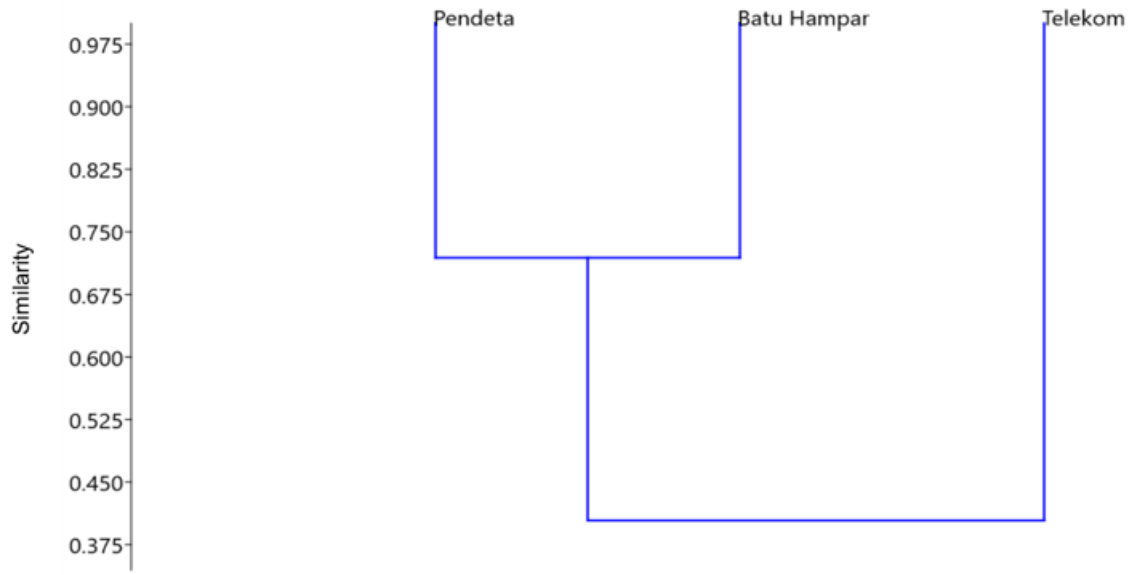


Figure 2. Clustering analysis on the spider composition with a 0.999 cophenetic coefficient value

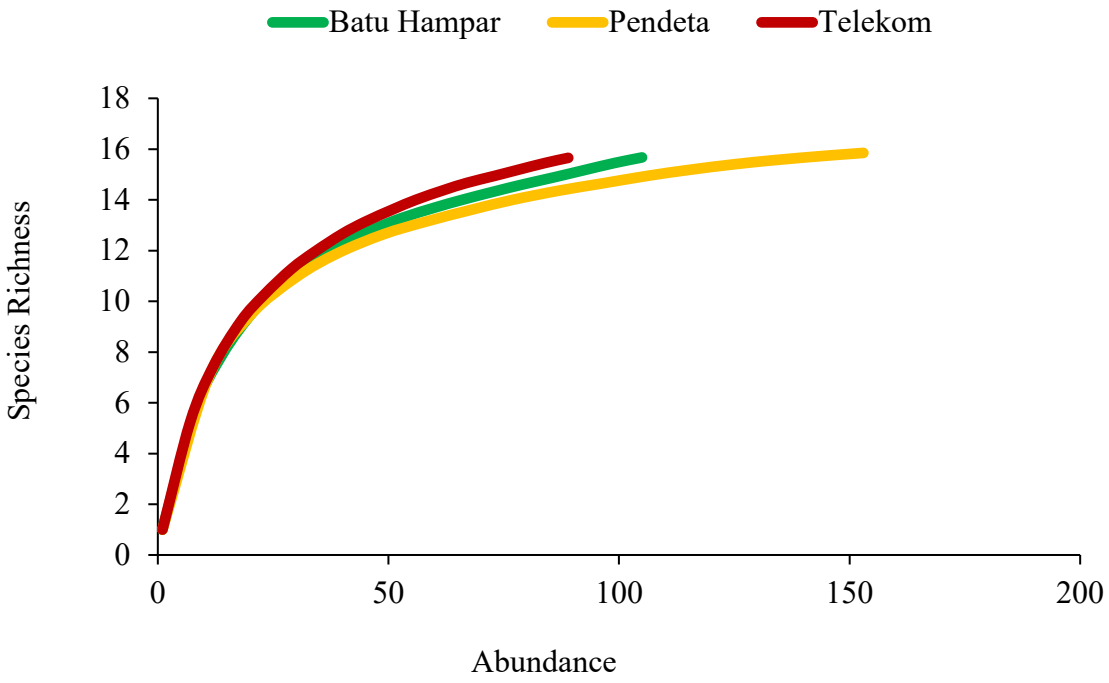


Figure 3. Species accumulation curve for all trails studied in Gunung Ledang

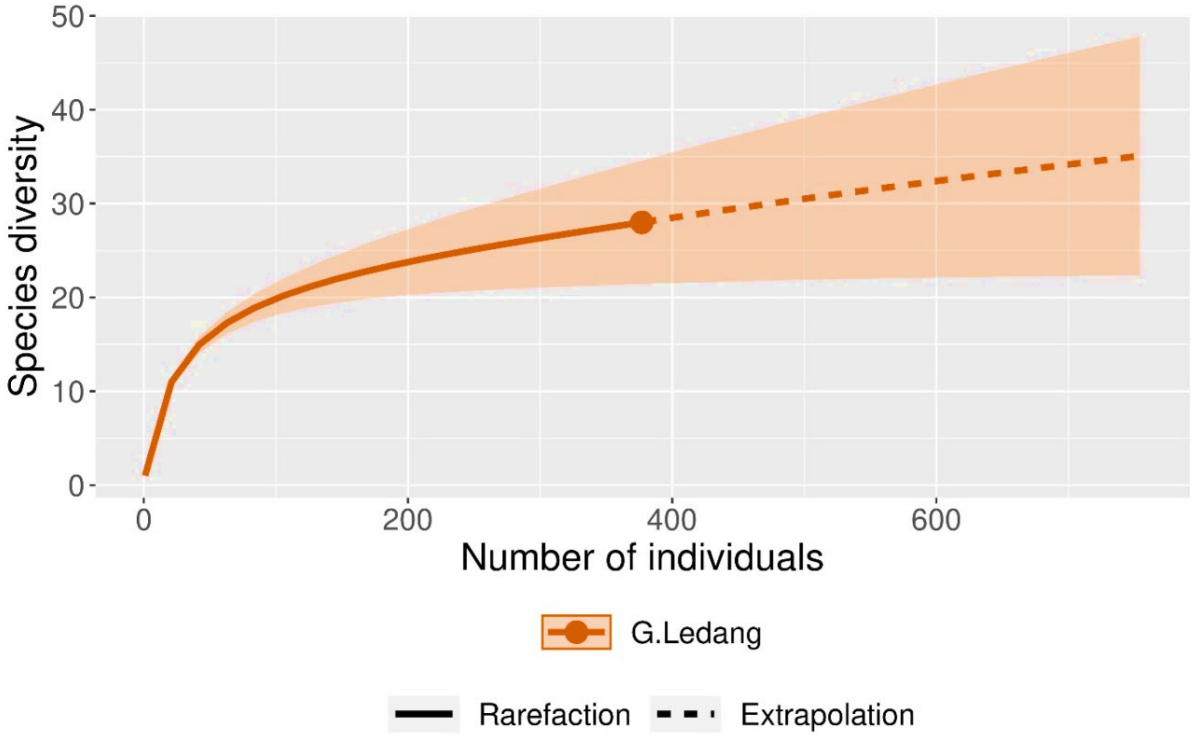


Figure 4. Extrapolation of species accumulation curve of spider species richness in Gunung Ledang

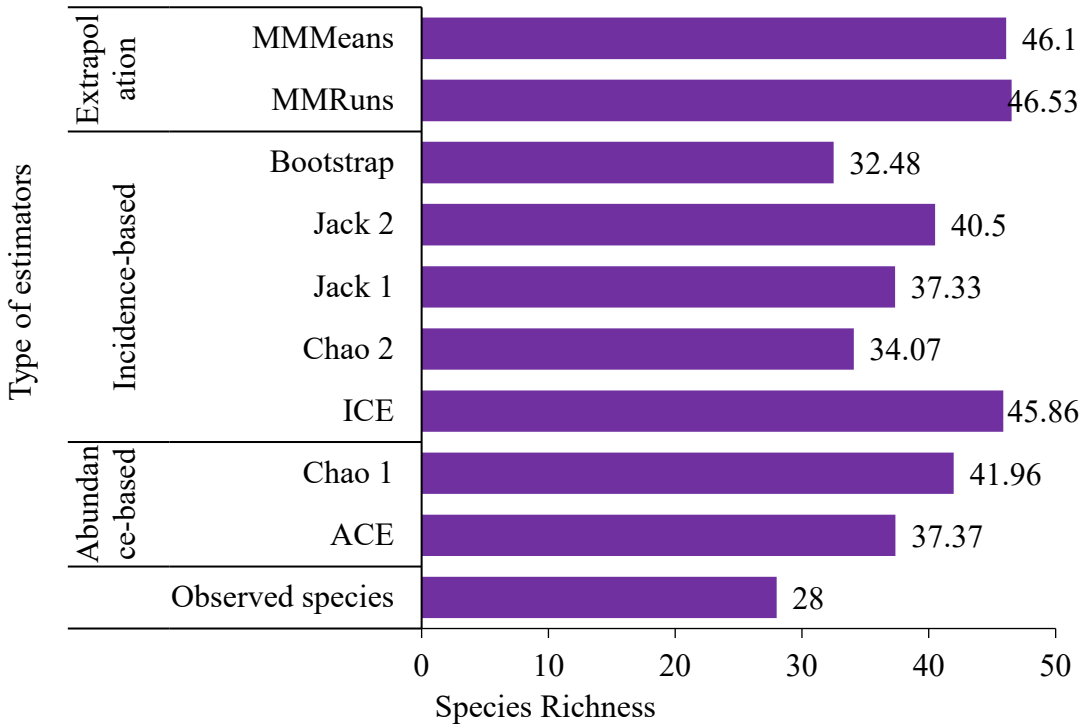
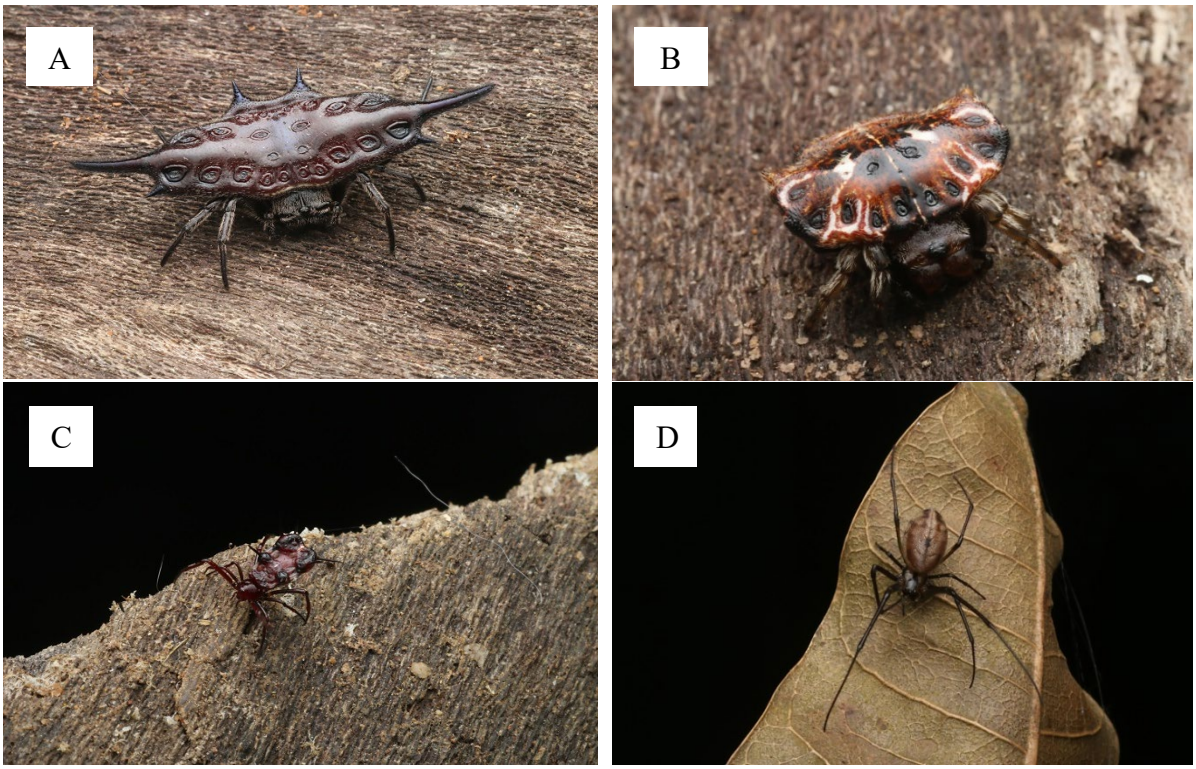


Figure 5. Estimated spider species richness of the highland species at Gunung Ledang



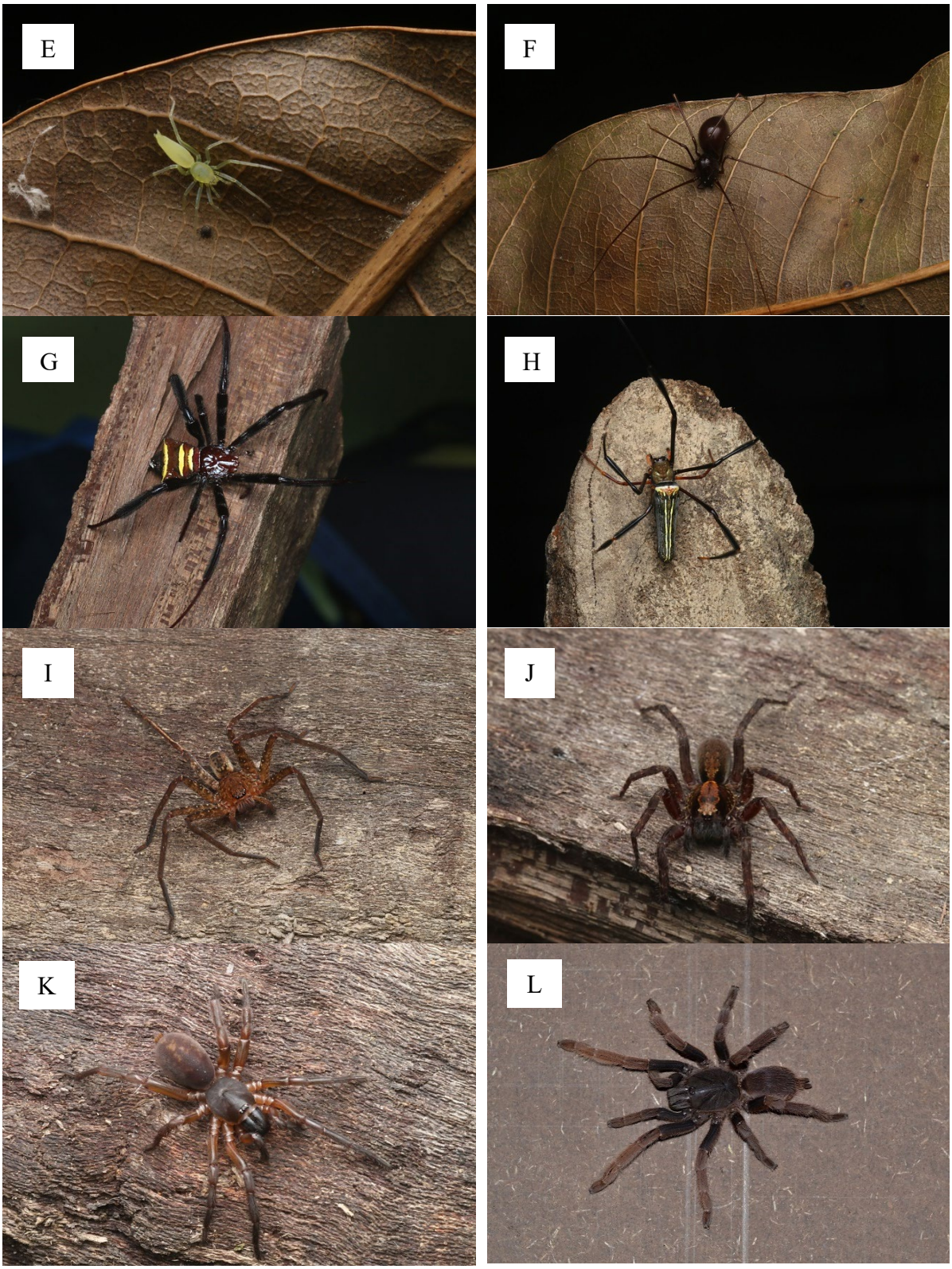


Figure 6. A = *Gasteracantha diardii*, B = *Thelacantha* sp., C = *Phoroncidia lygeana*, D = *Orsinome vethi*, E = *Nusatidia borneensis*, F = *Scytodes* sp., G = *Argiope reimwardtii*, H = *Nephila pilipes*, I = *Heteropoda* sp., J = *Bowie* sp., K = *Damarchus* sp. and L = *Psednocmenis* sp. "Ledang'

Figure 7. Unidentified tarantula, *Psednocnemis* sp. 'Ledang' from the highlands of Gunung Ledang National Park. It is a medium-sized tarantula that can be found at an elevation of 900m-1200m (Photo credit: Muhammad Khaidhir Arif)

DISCUSSION

Based on this study, showed that this forest reserve had a relatively high number of arachnid species that can be an indicator of a good forest ecosystem. A total of 14 families of spiders can be found in the highland area compared to a previous study done in Fraser Hill that found 13 families of spider species (Chooi et al. 2014b). Spiders are arthropods that are successful in a wide array of ecosystems (Dimitrov & Hormiga 2021) and are extensively treated as bioindicators of healthy ecosystems (De et al. 2021; Mader et al. 2016; Pearce & Venier 2006; Schwerdt et al. 2018). Not only that, tarantula species can be recorded at all trails, showing that the habitat is considered good as tarantula species are sensitive towards microclimate changes, quickly respond to disturbance, and are sensitive to forest ecosystem changes (Schwerdt et al. 2018). The study revealed that tarantula prefers undisturbed grassland, rather than grazed areas with human disturbance.

From this survey, some species only can be found at certain trails. The sightings of some of the spider species in this area tend to be specialized in certain areas. For example, web-building spiders such as *Nephilia pilipes* and *Argiope reimwardtii* were found particularly in tarred road trails. Some spiders can only be found at night, while some can only be detected during daylight for example jumping spiders (Rößler et al. 2021). Nonetheless, two of the trails share a similar type of habitat, which is undisturbed and natural habitat with no tarred road. The similarities of the two habitats might contribute to the similarities in species composition

for the two trails. Based on the cluster analysis, 70% of species from the two trails were similar, whereas Trail Telekom has fewer similarities. It was also noted that the majority of the species that were found particularly at Trail Telekom were not recorded at the other two undisturbed trails. This may be due to the changes in the natural environment setting of the habitat after the construction of the tarred road such as the openness of the canopy and changes in temperature and humidity due to the existence of the tarred road. Other than that, the species accumulation curve and extrapolation of the accumulation curve showed that the sampling effort was not enough for this study.

Moreover, species richness estimator analysis also predicted that the minimum species richness for the highland area is around 32 species, while species recorded during this study were only 27 species. Thus, more sampling effort needs to be done to maximize the study accuracy (Mérian et al. 2013), while also adding more sampling methods such as pitfall trap. Certain spiders require good forest areas, such as the Mygalomorph spiders, while some spiders prefer habitat near the river. The tarred road trail (Trail Telekom) showed that some spiders can live within human activity areas (cars moving up and down the hill). Most of the spider species that can be found on the tarred road trails were web-weaving spider species such as orb weaver spider (e.g *Nephilia pilipes* and *Argiope reimwardtii*). In contrast, the other two trails are hospitable towards several species where the spiders can be found even when the trails are active with hiking activity and tourism (e,g *Scytodes* sp. and *Hersilia* sp.). Certain arachnid species are very specific when it comes to prey selection, whereas other species are generalists, especially web-building spiders (Nentwig 1986). We observed that web-building spider species such as the orb weaver spider were recorded more often, compared to others. This is maybe due to the reason that the highland area is very windy, causing insect to be blown away by the wind that cause the insect to easily caught by the web build by web building spiders.

However, one past study showed that recreational trails affect insect diversity (Kamel 2020). Nonetheless, according to this study, certain species of spiders seem to have the capabilities to adapt to recreational trails. This is maybe due to the prey opportunities such as the bright light coming from the Telecommunication buildings near the peak of the mountain at night that attract insect on the trail, causing extra food supply for the arachnids. Although hiking trails affect negatively, proper and effective management of the National Park can be exercised to maintain a healthy ecosystem while promoting tourism. For example, Johor National Parks limits the number of visitors each day and this might contribute towards the relatively good species richness of arachnids on the hiking trails. Nonetheless, although the area has human activities, it was observed that the tarantula species can thrive at every trail although tarantula is not generalist in terms of its habitat selection due to their sedentary lifestyle and prone to localization (Raven 2010).

A spider survey from Fraser Hill has recorded 13 families of arachnids, whereas a study in a highland area of Gunung Ledang National Park discovered 14 families of arachnids. However, the past study only makes a spider checklist based on family. This was the first checklist of arachnids done in this area, so this information can serve as the baseline study for any study about arachnids that will be conducted in another area of Johor National Parks. Based on the IUCN 2022 red list status check, all the species recorded were not listed in the list. It means that more attention needs to be given to arachnid studies to ensure that more assessments will be done related to arachnids in the future. This study has also shown that the arachnids in

Malaysia are not well assessed in terms of arachnid biodiversity assessment (Nasir et al. 2014b).

CONCLUSIONS

More vigorous studies related to diversity, ecology, natural history, behavior, taxonomic and molecular of arachnids are needed to enhance our knowledge to ensure that the status of each species of arachnid in the area is being determined. Lastly, as this study only focuses on the highland area of Gunung Ledang, it can serve as a reference for other future studies related to highland arachnids in Malaysia and help to increase the conservation work in the future.

ACKNOWLEDGEMENTS

The authors wish to thank the Universiti Malaysia Terengganu and Johor National Park for the help and support of this research work. We also would like to thank Mohd Ilham Norhakim Lokman, Mushahril, Mohd and Ariff Khaidhir for helping this research during the pilot study.

AUTHORS DECLARATIONS

Funding Statement

Special thanks are given to Johor National Park for giving permission and assistance to conduct research and for the given research permit (TNJ 700-2/1/2 Bil. (15)). We would also like to thank The Habitat Foundation Grant for providing funding for this research.

Conflict of Interest

The authors declare that they have no conflict of interest.

Ethics Declarations

No ethical issue is required for this research.

Authors' Contributions

Irham Razak- IR conceived and designed the study, conducted fieldwork, collected and analyzed data, and wrote the manuscript.; Dzulhelmi Muhammad Nasir- DMN help in identifying the species checklist, wrote the manuscript and analysed the data; Macdey Jengkeng- MJ conducted fieldword and data collection; Aliff Ariff- AA conducted fieldwork and data collection; Danial Sallahuddin- DS conducted fieldwork and assist in data collection; Mohamad Aqmal-Naser- MAN assist in analysing the data; Ahmad Zafir Wahab- AZW finalized the manuscript and wrote the manuscript, and Amirrudin Ahmad- AA finalized the manuscript, analyzed and wrote the manuscript All authors read and approved the manuscript.

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