Jurnal Entomologi Indonesia
p-ISSN: 1829-7722 e-ISSN: 2089-0257
Terakreditasi Kemenristekdikti: 105/E/KPT/2022

Juli 2022, Vol. 19 No. 2, 164–173
Online version: https://jurnal.pei-pusat.org
DOI: https://dx.doi.org/10.5994/jei.19.2.164

Distribution mapping of smaller arachnid orders and Pseudoscorpiones in Malaysia

Pemetaan distribusi Ordo Arachnida kecil dan Pseudoscorpiones di Malaysia

Faris Adly[1*], Dzulhelmi Muhammad Nasir[2], Nur-Athirah Abdullah[3], Suriyanti Su[3], Nurul Fatihah Abd Latip[4], Madihah Halim[5], Faszly Rahim[3, 6]

[1]Centre for Insect Systematics, Department of Biological Science and Biotechnology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[2]Malaysian Palm Oil Board
6 Persiaran Institusi, Bandar Baru Bangi, 43000 Kajang, Selangor, Malaysia
[3]Department of Earth and Environmental Sciences, Faculty Science and Technology, Universiti Kebangsaan Malaysia, 43600 Bangi, Selangor, Malaysia
[4]Fakulti Perladangan dan Agroteknologi, Universiti Teknologi Mara Cawangan Perlis Kampus Arau, 02600 Arau, Perlis, Malaysia
[5]Faculty of Agroscience, University College of Agroscience Malaysia
Lot 2020, Ayer Pa'abas, 78000 Alor Gajah, Melaka, Malaysia
[6]Islamic Science Institute, Universiti Sains Islam Malaysia
71800 Bandar Baru Nilai, Negeri Sembilan, Malaysia

(diterima Januari 2021, disetujui Juli 2022)

ABSTRACT

This checklist serves as a basic information based on compilation from published literatures, internet database, and from specimens collection stored at Center of Insect Systematics Universiti Kebangsaan Malaysia. To date, this study compiled smaller arachnids (28 species) and Pseudoscorpiones (41 species) that had been recorded in Malaysia. Although smaller arachnid orders were concentrated at localities with average rainfall and humidity, Pseudoscorpiones can be found at both wet and dry environments. More work is needed to determine the species diversity and distribution of these cryptic group.

Key words: arthropods, biodiversity, distribution record, inventory

ABSTRAK

Daftar ini menyediakan informasi dasar berdasarkan pada informasi yang dikompilasi dari literatur yang telah diterbitkan, pangkalan data internet, dan koleksi spesimen yang disimpan di Pusat Sistematik Serangga Universiti Kebangsaan Malaysia. Hingga saat ini, kajian ini telah mengkompilasi arachnid kecil (28 spesies) dan Pseudoscorpiones (41 spesies) yang telah dicatat di Malaysia. Walaupun distribusi arachnid kecil lebih terkonsentrasi di daerah dengan curah hujan dan kelembapan sedang, Pseudoscorpiones dapat ditemukan di lingkungan basah dan kering. Studi lebih lanjut perlu dilakukan untuk menentukan keanekaragaman spesies dan distribusi kelompok ini.

Kata kunci: artropoda, distribution record, inventarisasi, keanekaragaman

*Penulis korespondensi: Centre for Insect Systematics, Department of Biological Science and Biotechnology, Universiti Kebangsaan Malaysia 43600 Bangi, Selangor, Malaysia, Email: malaysiafaszly@usim.edu.my

INTRODUCTION

Arachnida is a large class of organism having diverse distribution covering both terrestrial and aquatic environment. It includes 13 orders which are Aranae, Acariformes, Parasitiformes, Opiliones, Pseudoscorpiones, Scorpiones, Solifuge, Schizomidae, Amblypigy, Uropgy, Palpygradi, Ricinulei, and Opiliocariformes (Harvey 2002). Six orders (Amblypygi, Uropygi, Schizomida, Palpigradi, Ricinulei, and Solifugae) were classified into a group of smaller arachnids (Harvey 2003). Each of the order in this group does not have more than 210 described species except for Solifugae. Pseudoscorpions nonetheless recorded 3336 described species throughout the world (Harvey 2013; Jiménez & de los Santos 2020). The group of smaller arachnids and Pseudoscorpiones are commonly found in darker and damp area especially in tropical and subtropical region.

Order Amblypygi (whip-spider) bears a flattened body, spiky raptorial pedipalp with cleaner organ on its tarsus (Coddington et al. 2004). The Amblypygi recorded 160 species in 17 genera with five genera found in Asia and Australiasia. The five genera were from Family Charidinae, Charontidae, and Phrynichidae (Rahmadi et al. 2011). Order Uropygi (whip-scorpion) supports a large, sclerotized body compared to other arachnids. To date, there are 103 described species in 16 genera within four sub-family (Coddington et al. 2004). Sub-family Hypoctinae can be found in west Africa and Southeast Asia, Mastigoproctinae in America and Southeast Asia, Thelyponinae in Asia as well as Typopeltinae in East Asia (Coddington 2005).

The short tail whip- scorpion, Order Schizomida is small, less sclerotized and lacking a true eye. It has two families worldwide (Protoschizomidae Rowland 1975; Hubbardiidae Cook 1899). While Protoschizomidae limit its distribution to Central Africa, the Hubbardiidae can be found throughout the world including Southeast Asia (Coddington et al. 2004; Cokendolpher et al. 2010). The Palpigradi is small in size in comparison to Schizomida. It has two families (Eukoeneniidae Petrunkevitch, 1955; Prokoeneniidae Condé, 1996) of which sixteen species recorded to be found in Southeast Asia. Pseudoscorpions are also widely distributed around Southeast Asia. This organism varies from scorpion by lacking in telson and metasome. The order consists of seven superfamily (Chthonioidea, Feaelloidea, Neobisioidea, Cheliferoidea, Sternophoroidea, Garypoidea, dan Olpioidea) (Harvey 1992).

A fauna checklist through scientific documentation requires extensive compilation of comprehensive data sets. It contains the valid new scientific names accompanied with guideline to species identification (e.g. key to species, photographs, illustrations) (Chou & Goh 1996; Bruno et al. 2005), revised taxonomy group (Wells 2007) and report on new taxa found (Lee 2010). A checklist contributes to the knowledge on biodiversity which are a global issue (Taheri et al. 2012) and serves as a starting point for other scientific disciplines (Majka & Sikes 2009). The species checklist data are also used in understanding the ecological phenomena such as speciation (Emerson 2005) and biogeography (Almeida & Coelho 2008). Moreover, the discipline in conservation biology needs information and understanding through these data sets (Graening et al. 2007). Thus, checklists can be used as a basic data in monitoring and establishments of environmental policies, namely the changes in composition of local fauna and monitoring invasive species.

Malaysia is the 67th largest country in the world with a land mass of 329,847 km^2, the peninsular and two large states located on the Island of Borneo that are separated by the South China Sea. It is known as the mega-diversity country, richness in number of species with high amount of endemism. However, the biodiversity found in the tropical rainforest is currently under threat with logging activities twice the world rate (Laurance 1999; Achard et al. 2002). Many species have become extinct due to habitat loss and alteration (Harvey 2002). The comprehensive checklists are the main component in environmental management to determine the adequate strategy in protecting the species at national and international scale (Majka & Sikes 2009). A comprehensive checklist and distributional mapping are very important in monitoring the composition pattern of the local fauna. Knowledge about the diversity and distribution of targeted species can help strategize conservation and environmental management.

From the invertebrate's group, the Arachnida represent the second largest after Insecta, but the least studied group (Russell-Smith 1999). The Arachnida plays an important role as predators in the ecosystem, especially in controlling the abundance of insects and other invertebrates. Inventorying the Order Arachnida and Pseudoscorpiones species are as basic guideline for future studies of this group in Malaysia. The aim of this study is documenting the species list and provides the distribution mapping the smaller arachnid orders and Pseudoscorpiones in Malaysia.

MATERIALS AND METHODS

The checklist presented was based on published literatures, catalogues of smaller arachnids order (Harvey 2003; Harvey 2013) and Pseudoscorpiones (Harvey 2013), online database and examination of available specimens in the Centre for Insect Systematics (CIS) laboratory, Universiti Kebangsaan Malaysia. Available specimens were photographed using the USB Dinolite digital microscope. Species identifications were mostly done using the following references, Amblypygi (Harvey 2003), Uropygi (Cooke & Rowland 1973), Schizomida (Cokendolpher et al. 2010), and Pseudoscorpiones (Harvey 2013).

RESULTS

A total of 69 species of smaller arachnid order and pseudoscorpiones have been recorded in this study (Table 1). This includes 9 species from the Order Amblypygi, 13 species from the Order Uropygi, 5 species from the Order Schizomida, 1 species from the Order Palpigradi, and 41 species from the Order Pseudoscorpiones.

A total of nine Amblypygi species with three endemic species (i.e., *Stygophrynus longispina*, *S. berkeleyi*, and *Sarax rimosus*) had been recorded in Malaysia (Figure 1). The Amblypygi were commonly found at the area with high annual temperature (27.8 °C and 28.8 °C) though it tends to be restricted to localities with high annual humidity (76.9% and 81.40%) or rainfall (1830.6 mm and 3220.5 mm).

A total of 13 Uropygi species with three endemic species (i.e., *Thelyphonus anthrachinus*, *T. doriae hosei*, and *T. kinabaluensis*) were recorded in Malaysia (Table 1). The distribution mapping showed localities with recorded Uropygi species pointed on areas with low annual rainfall (1711.2 mm and 3936.8 mm). The result showed that Uropygi were restricted to areas with intermediate average temperature (27.4°C and 28.2 °C) and high humidity (80.5% and 85.60%).

Malaysia also recorded five Schizomida species with two endemic species (i.e., *Apozomus termitarium*, and *Bamazomus pileti*). The distribution mapping showed Schizomida species were restricted to localities with average high temperature (27.7 °C and 28.6 °C), rainfall (2082.3 and 3220.5 mm) or humidity (76.90% and 85.10%).

This study also recorded 41 Pseudoscorpiones species in Malaysia (Table 1). However, only 25 species have a description on its locality (Figure 2). The pseudoscorpiones occurred in areas with average intermediate to high average annual rainfall (1711.2 to 3396.6 mm) temperature (18.9 °C to 28.6 °C) and humidity (76.90% to 89.70%).

DISCUSSIONS

Most smaller arachnids orders are confined inside caves, under rocks, underneath logs and few species can be found in termite's'nest'. On the other hand, the Order Pseudoscorpiones have wider habitat from caves, bird's nest, decay woods, wood skin and underneath logs. While Malaysia have recorded at least 18% from the total species of smaller Order Arachnids and Pseudoscorpiones in Southeast Asia, this study successfully recorded an increment of up to 23% of the total species.

To date, there are 28 species of smaller Order Arachnids including the 10 endemic species recorded in Malaysia. Most smaller arachnid orders are light-sensitive, nocturnal and tend to live in dark and moist places such as caves, underneath stones and logs. In this study, the distributional mapping indicates that the Amblypygi prefers living at places with high average temperature, rainfall, and humidity. About 165 species of Amblypygi

Table 1. List of smaller Order Arachnids and Pseudoscorpiones in Malaysia

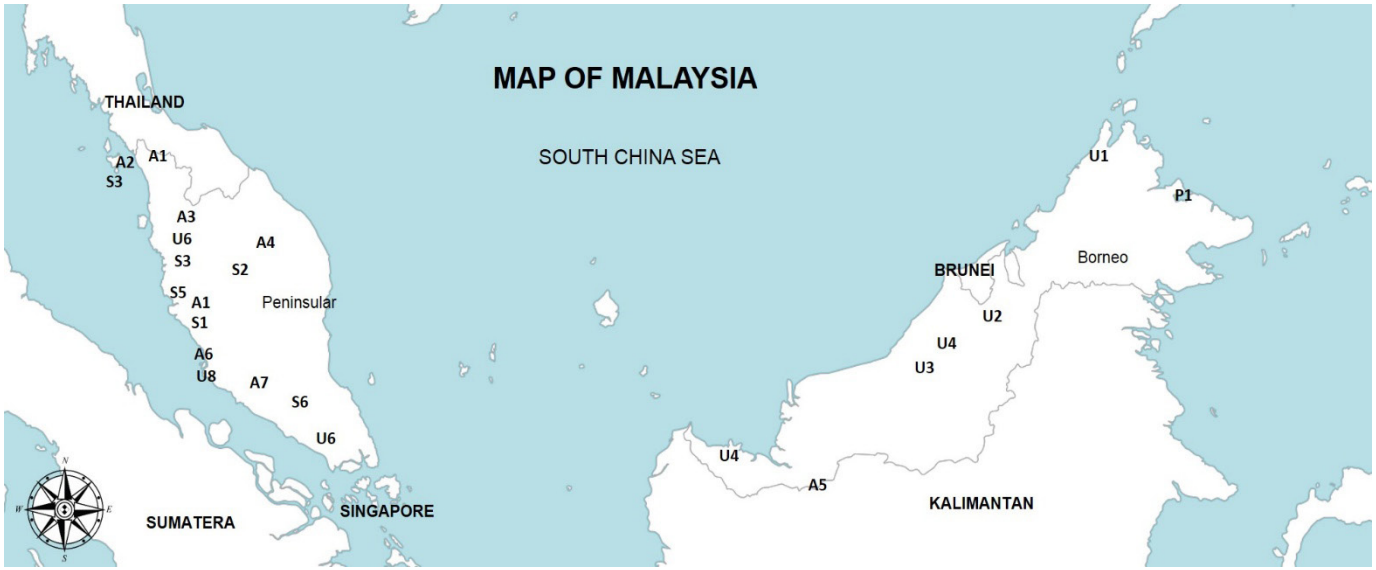
Order	Species	Habitat	Distribution
Amblypygi	*Stygophrynus longispina* Gravely, 1915	Cave	Pulau Langkawi, Kedah
	Stygophrynus (Stygophrynus) berkeleyi Gravely, 1915*	Cave	Lenggong, Perak
	Sarax buxtoni (Gravely, 1915)*	Cave	Gua Kubang Tiga, Perlis & Batu Caves, Selangor
	Sarax brachydactylus Simon, 1892	Cave	na
	Sarax rimosus (Simon, 1901)*	Under the rock	Kuala Aring, Kelantan
	Sarax sarawakensis (Thorell, 1888)*	Under the rock	Gng. Klingkang, Sarawak
	Sarax singaporae Gravely, 1911	Under the bricks	na
	Charon grayi (Gervais, 1842)*	Limestone cave	na
	Phrynichus orientalis Weygoldt, 1998	Limestone cave	na
Uropygi	*Ginosigma schimkewitschi* (Tarnani, 1894)*	na	na
	Hypoctonus gastritictus Kraepelin, 1897*	na	na
	Tetrabalius borneensis Speijer, 1933	na	na
	Thelyphonus anthracinus Pocock, 1894	na	Batu Song, Sarawak
	Thelyphonus borneensis Kraepelin, 1897	na	na
	Thelyphonus doriae Thorell, 1888	na	Bukit Dulit/Kuching, Sarawak
	Thelyphonus doriae doriae Thorell, 1888	na	Sarawak
	Thelyphonus doriae hosei Pocock, 1894	na	Bukit Dulit, Sarawak
	Thelyphonus grandis Speijer, 1931	na	na
	Thelyphonus kinabaluensis Speijer, 1933	na	Kenokok, Gunung Kinabalu, Sabah
	Thelyphonus linganus C.L.Koch, 1843	Cave	Gunung Pulai, Johor & Lenggong, Perak
	Thelyphonus lucanoides Butler, 1872	na	na
	Thelyphonus suckii Kraepelin, 1897	na	na
Schizomida	*Apozomus termitarium* Harvey 1992	Anai's nest	Bukit Tersik, Taman Negara, Malaysia
	Bamazomus pileti (Brignoli, 1974)*	Cave	Batu Caves
	Clavizomus claviger (Hansen, 1905)*	na	na
	Schizomus modestus (Hansen, 1905)*	na	Pulau Langkawi, Kedah & Lenggong, Perak
	Zomus bagnallii (Jackson, 1908)*	na	Sarawak
Palpigradi	*Koeneniodes berndi* Condé, 1988	Cave	Sandakan, Sabah
Pseudoscorpiones	*Alocobisium malaccense* Beier, 1952	na	Sungai Buluh, Selangor
	Anatemnus angustus Redikorzev, 1938	na	na
	Anatemnus orites (Thorell, 1889)*	Bird's nest, rotten wood	Rantau Panjang, Selangor
	Anatemnus orites major Beier, 1963	Bird's nest	na
	Anatemnus javanus (Thorell, 1883)*	Underwood logs	na
	Apocheiridium minutissimum Beier, 1964	Bird's nest	Subang, Selangor
	Beierolpium clarum (Beier, 1952)*	na	Sungai Buluh, Selangor
	Catatemnus thorelli (Balzan, 1891)*	na	na
	Cryptocheiridium lucifugum Beier, 1963	Cave	Batu Caves, Selangor
	Dhanus doveri Bristowe, 1952	Cave	Batu Caves, Selangor
	Dhanus sumatranus (Redikorzev, 1922)*	na	na

*Specimens of smaller arachnids and Pseudoscorpiones in Centre for Insect Systematics (CIS) laboratory, Universiti Kebangsaan Malaysia; na: not available.

Table 1. List of smaller Order Arachnida and Pseudoscorpiones in Malaysia (*Continue...*)

Order	Species	Habitat	Distribution
	Ditha pahangica Beier, 1955*	na	Telom Valley, Cameron Highlands, Pahang
	Geogarypus albus Beier, 1963	Bird's nest	Rantau Panjang, Selangor
	Geogarypus longidigitatus (Rainbow, 1897)*	Bird's nest	Kuala Lumpur
	Geogarypus elegans (With, 1906)*	Bird's nest,	Kuala Aring, Kelantan
	Hya minuta (Tullgren, 1905)*	na	na
	Lagynochthonius exiguous (Beier, 1952)*	na	Sungai Buluh, Selangor
	Lagynochthonius guasirih (Mahnert, 1988)*	Cave	Gua Sireh, Daerah Serian-Bau, Sarawak
	Lagynochthonius paucedentatus (Beier, 1955)*	na	Terlom Valley, Camron Highlands, Pahang
	Lophochernes balzanii (Thorell, 1890)*	na	Pinang, Pulau Pinang
	Lopochernes hians (Thorell, 1890)*	na	Pinang, Pulau Pinang
	Megachernes grandis (Beier, 1930)*	na	na
	Metatemnus heterodentatus Beier, 1952	na	na
	Metawithius (*Metawithius*) *spiniventer* Redikorzev, 1938	na	na
	Metawithius spiniventer spiniventer Redikorzev, 1938	na	na
	Metatemnus superior Muchmore, 1972	Under bark	Cameron Highlands, Pahang
	Metawithius tweediei Beier, 1955*	na	Terlom Valley, Cameron Highlands, Pahang
	Oratemnus navigator (With, 1906)*	Bird's nest, wood bark	na
	Oratemnus saigonensis (Beier, 1930)*	na	na
	Parachernes cocophilus (Simon, 1901)	na	Kuala Aring, Kelantan
	Paratemnoides borneoensis Beier, 1932	na	na
	Paratemnoides pallidus (Balzan, 1892)*	Under bark	na
	Paratemnoides plebejus (With, 1906)*	Under bark	na
	Pseudochiridium clavigerum (Thorell, 1889)*	na	na
	Stenatemnus sundaicus (Beier, 1930)*	na	na
	Stygiochelifer cavernae (Tullgren, 1912)*	Cave	na
	Sundochernes malayanus Beier, 1963	Bird's nest	Rantau Panjang, Selangor
	Sundochernes modiglianii (Ellingsen, 1911)*	na	na
	Sundowithius sumatranus (Thorell, 1889)*	na	na
	Tyrannochthonius terribilis (With, 1906)*	na	Sungai Buluh, Selangor
	Tyrannochthonius terribilis malaccensis Beier, 1952	na	na

*Specimens of smaller arachnids and Pseudoscorpiones in Centre for Insect Systematics (CIS) laboratory, Universiti Kebangsaan Malaysia; na: not available.



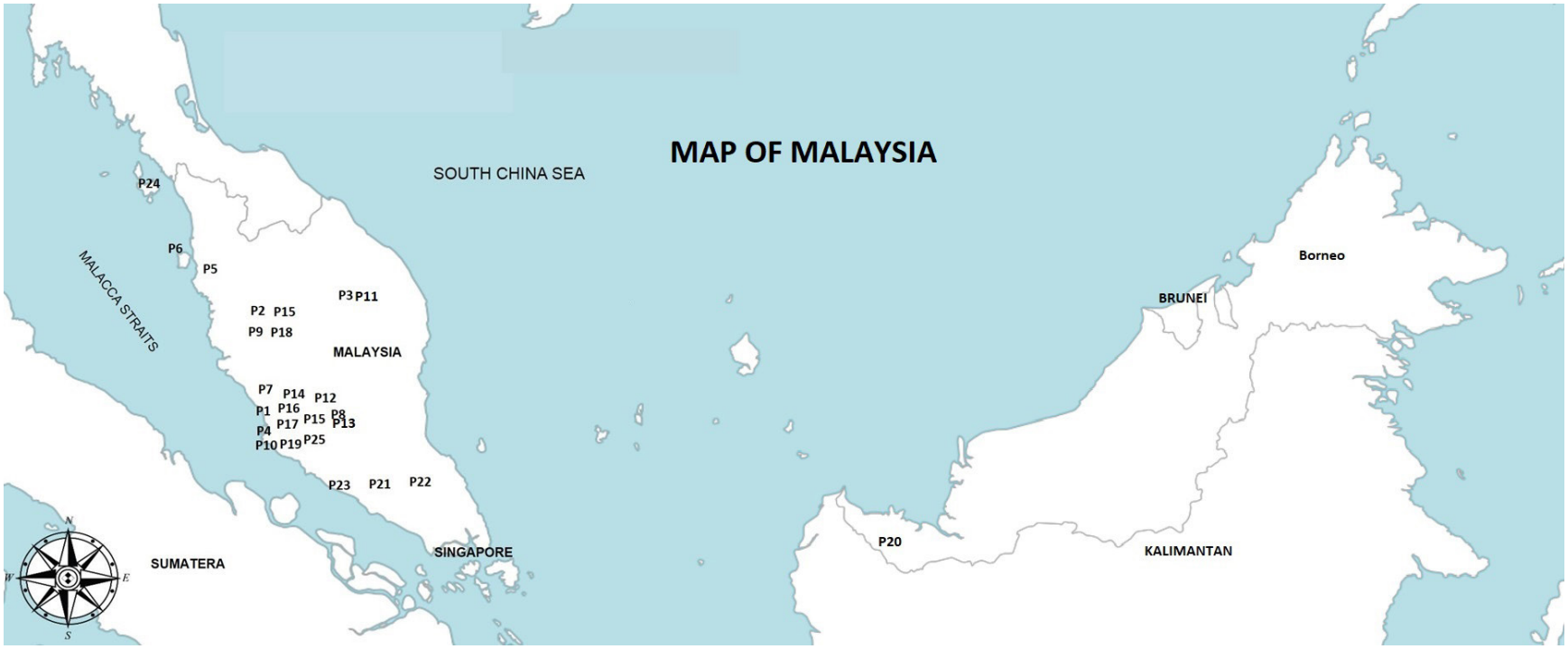
Amblypygi
A1: *Sarax buxtoni*
A2: *Stygophrynus longispina*
A3: *Stygophrynus (stygophrynus) berkelevi*
A4: *Sarax rimosus*
A5: *Sarax sarawakensis*
A6: Unidentified species (NR)

Uropygi
U1: *Thelyphonus kinabaluensis*
U2: *Thelyphonus anthracinus*
U3: *Thelyphonus doriae hosei*
U4: *Thelyphonus doriae*
U5: *Thelyphonus doriae doriae**
U6: *Thelyphonus linganus*
U7: Unidentified species (NR)
U8: Unidentified species (NR)

Schizomida
S1: *Bamazomous pileti*
S2: *Apozomus termitarium*
S3: *Schizomus modestus*
S4: *Zomus bagnallii**
S5: Unidentified species (NR)
S6: Unidentified species (NR)

Palpigradi
P1: *Koeneniodes berndi*

Figure 1. Species distribution mapping of smaller arachnid order in Malaysia. *Information on specific locality is not available.



Pseudoscorpion

P1: *Anatemnus orites major*
P2: *Metatemnus superior*
P3: *Parachernes cocophilus*
P4: *Sundochernes malayanus*
P5: *Lopochernes balzanii*
P6: *Lopochernes hians*
P7: *Apocheiridium minutissimum*
P8: *Cryptocheiridium lucifugum*
P9: *Metawithius tweediei*
P10: *Geogarypus albus*
P11: *Geogarypus elegans*
P12: *Geogarypus longidigitatus*
P13: *Danus doveri*
P14: *Alocobisium malaccense*
P15: *Ditha pahangica*
P16: *Beierolpium clarum*
P17: *Lagynochthonius exiguous*
P18: *Lagynochthonius paucadentatus*
P19: *Tyrannochthonius terribilis malaccensis*
P20: *Lagynochthonius guasirih*
P21: Unidentified species (NR)
P22: Unidentified species (NR)
P23: Unidentified species (NR)
P24: Unidentified species (NR)
P25: Unidentified species (NR)

Figure 2. Species distribution mapping of Pseudoscorpiones in Malaysia.

have been recognized throughout the world with 25 species have been recorded in Southeast Asia. The distribution mapping showed localities with recorded Amblypygi species pointed on areas with intermediate soil humidity. Coddington et al. (2004) stated that most of Amblypygi species are restricted to moist habitat, with several species that is capable to live in drier areas. The Amblypygi have been reported as nocturnal creatures that inhabit dark and moist places (Coddington et al. 2004).

The results of this study showed that the Uropgygi may tolerate areas with low average rainfall, moderate temperature, and humidity. A total of 106 species of Uropygi are known in the world, with 73 species have been recorded in Southeast Asia. In comparison to other arachnids, the Uropygi have very sclerotized body helping in water retention (Coddingtion et al. 2004). Therefore, the Uropygi may survive under moderate temperature and humidity with lower average of rainfall. However, there is one locality record (i.e., Kinabalu National Park) the presence of Uropygi in an area with high soil humidity.

There were at least 236 species of Schizomida around the world, with only 15 species that have been recorded from Southeast Asia. Palpigradi on the other hand is the least studied group among the small group of arachnids, with only about 80 known species throughout the world and 20 species that occur in Southeast Asia. The Schizomida and Palpigradi however are restricted to areas with high rainfall and humidity. This is due to their poorly sclerotized body making them susceptible to losing water. Thus, the Schizomida and Papligradi tend to live in a humid places and protected from direct sunlight to avoid dehydration (Coddington et al. 2004; Kovac et al. 2002). The Schizomida species tend to live in habitat such as caves and termite's nest that support their survival needs. These nocturnal creatures spend their daytime in places including underneath stacks of leaves, stones, and logs or in humid soil with high humidity (Thompson 1958).

In this study, only a single species of Palpigradi was recorded. The *Koeneniodes berndi* is an endemic species that was taken from a cave at Sandakan, Sabah. This species is found at a locality with average temperature (27.9 ^{o}C), rainfall (3417.8 mm) and humidity (82.90%). Most species from the order Palpigradi does not have respiratory organ and breathe directly through cuticle (Barnes 1987). The respiratory system of the Palpigradi has been one of the reasons to which it is restricted to areas with high humidity such as in caves and endogen ecosystem throughout the world (Condé 1996). However, since this data is a singleton, there is not much can be said on its distribution in Malaysia.

There have been 41 species of Pseudoscorpiones with 14 endemic species have also been recorded in the country. These include Pseudoscorpiones which consists of six families (Atemnidae, Chernetidae, Neobisidae, Ideoroncidae, Garypinidae and Tridentchthoniidae), Uropygi (*Mimbosius* and *Mimoscorpius*), Amblipygi (*Sarax*). The Pseudoscorpiones have wider distribution due to their high diversity and ability to tolerate various environment (Thompson 1958). In comparison to other smaller arachnid order, Pseudoscorpiones thrives in both dry and wet places. About 3336 Pseudoscorpiones species are recognized in the world, with at least 225 species that occur in Southeast Asia. Currently, no Pseudoscorpiones species have been recorded at an area with low soil humidity. The Pseudoscorpiones have the ability to live in various habitat types including caves, bird nests, decayed logs and underneath stacks of leaves and twigs. Bass on the distribution map of Pseudoscorpiones, it was shown to have the widest distribution. This is due to its species richness and diversity, the phoresy behavior and unique dispersal strategy. For instance, the mature females hold onto larger flying insects by using their pedipalps, which carry them from one place to another as they fly (Coddington & Colwell 2002). Nevertheless, there is little information on the distribution of Pseudoscorpiones in the two states located in the Island of Borneo due to the lack of studies for this group.

CONCLUSION

This checklist may serve as preliminary information based on compilation from published literatures, internet database and from specimens' collection stored at Center of Insect Systematics

Universiti Kebangsaan Malaysia. More work needs to be done in order to determine the diversity and distribution of these cryptic groups.

ACKNOWLEDGEMENTS

We acknowledged those who have directly and indirectly helped in making this study a success.

REFERENCES

Achard F, Eva HD, Gallego J, Mayaux P, Malingreau JP, Richards JT, Stibig HJ. 2002. Determination of deforestation rates of the world's humid tropical forest. *Science* 297:999–1002. DOI: https://doi.org/10.1126/science.1070656.

Almeida AO, Coelho PA. 2008. Estuarine and marine brachyuran crabs (Crustacea: Decapoda from Bahia, Brazil: Checklist and zoogeographical considerations. *Latin American Journal of Aquatic Research* 36:183–222. DOI: https://doi.org/10.3856/vol36-issue2-fulltext-4.

Barnes RD. 1987. *Invertebrate Zoology*. 5th Edition. Saunders. Philadelpia: College Publishing.

Bruno MC, Perry SA, Reid JW. 2005. A list and identification key for the freshwater free-living copepods of Florida (USA). *Journal of Crustasean Biology* 25:384–400. DOI: https://doi.org/10.1651/C-2538.

Chou LM, Goh NKC.1996. An annotated checklist of the gorgonians (Anthozoa: Octocorallia) of Singapore, with a discussion of gorgonian diversity in the Indo-West Pacific. *Raffles Bulletin Zoology* 44:435–459.

Coddington JA, Colwell RK. 2002. Arachnids. *Encylopedia of Biodiversity* 1:199–218. Academic Press. DOI: https://doi.org/10.1016/B0-12-226865-2/00016-X.

Coddington JA. 2005. Phylogeny and classification of spiders. In: Ubick D, Paquin P, Cushing PE, Roth V (Eds.), *Spiders of North America: an Identification Manual*. pp. 18–24. Keene, New Hampshire: American Arachnological Society.

Coddington JA, Giribet G, Harvey MS, Prendini L, Walter DE. 2004. Arachnida. In: Cracraft J, Donoghue MJ (Eds.), *Assembling the Tree of Life*. pp. 296–318. United Kingdom: Oxford University Press.

Cokendolpher JC, Reddell JR, Sissom WD. 2010. A new species of Apozomus (Arachnida: Schizomida: Hubbardiidae) from Peninsular Malaysia. *Occasional Papers, Museum of Texas Tech University* 298:1–8.

Condé B. 1996. Les Palpigrades, 1885–1995: acquisitions et lacunes. *Revue Suisse de Zoologie, Hors Série* 1:87–106.

Cooke JAL, Rowland JM. 1973. Systematics of the order Uropygida (=Thelyphonida). *Journal of Arachnology* 1:55–71.

Emerson BC. 2005. Species diversity can drive speciation. *Nature* 434:1015–1017. DOI: https://doi.org/10.1038/nature03450.

Graening GO, ME Slay, DB Fenolio, HW Robison. 2007. Annotated checklist of the Isopoda (Subphylum Crustacea: Class Malacostraca) of Arkansas and Oklahoma, with emphasis upon subterranean habitats. *Proceedings of the Oklahoma Academy of Science* 87:1–14.

Harvey MS. 1992. The phylogeny and classification of the Pseudoscorpionida (Chelicerata: Arachnida). *Invertebrate Taxonomy* 6:1373–1435. DOI: https://doi.org/10.1071/IT9921373.

Harvey MS. 2002. The Neglected Cousins: What do we know about smaller arachnid orders? *The Journal of Arachnology* 30:357–372. DOI: https://doi.org/10.1636/0161-8202(2002)030[0357:TNCWDW]2.0.CO;2.

Harvey MS. 2003. *Catalogue of The Smaller Arachnid Orders of the World: Amblypygi, Uropygi, Schizomida, Palpigradi, Ricinuler, and Solifugae.* Australia: CSIRO Publishing. DOI: https://doi.org/10.1071/9780643090071.

Harvey MS. 2013. Order Pseudoscorpiones. *Zootaxa* 3703:034–035. DOI: https://doi.org/10.11646/zootaxa.3703.1.8.

Jiménez SC, de los Santos G. 2020. An update checklist of the Pseudoscorpions. *Revista Ibérica de Aracnología* 37:225–230.

Kovac L, Luptacik P, Mock A, Palacios-Vargas JG. 2002. Distribution of *Eukoenenia spelaea* (Peyerimhoff, 1902) (Arachnida, Palpigradida) in the Western Carpathians with remarks on its biology and behaviour. In: Tajovsky K, Balik V, Pizl V (Eds.), *Studies on Soil Fauna in Central Europe, Proceedings of the 6th Central European Workshop on Soil Zoology (23–25 April 2021).* pp. 93–99. České Budějovice: Institute of Soil Biology AS ČR.

Laurance WF. 1999. *Logging and Wildlife Research in Australasia: Implications for Tropical Forest Management. Conserving Wildlife in Managed Tropical Forests*. New York: Columbia University Press.

Lee YJ. 2010. Checklist of cicadas (Hemiptera: Cicadidae) of Luzon, Philippines, with six new species and revised keys to the species of *Oncotympana* Stal and *Psithyristria* Stal. *Zootaxa* 2621:1–26. DOI: https://doi.org/10.11646/zootaxa.2621.1.1.

Majka CG, Sikes DS. 2009. Thomas L. Casey and Rohde Island's precinctive beetles: Taxonomic lessons and the utility of distributional checklists. *ZooKeys* 22:267–283. DOI: https://doi.org/10.3897/zookeys.22.93.

Rahmadi C, Harvey MS, Kojima J. 2011. The status of the whip-spider subgenus *Neocharon* (Amblypygi: Charontidae) and the distribution of the Genera *Charon* and *Stygophrynus*. *The Journal of Arachnology* 39:223–229. DOI: https://doi.org/10.1636/CA10-77.1.

Russell-Smith A. 1999. The spiders of Mkomazi Game Reserve. In: Coe M, McWilliam N, Stone NG, Packer M (Eds.), *Mkomazi: The Ecology, Biodiversity and Conservation of a Tanzanian Savanna*. pp. 197–222. London: Royal Geographical Society.

Taheri M, Foshtomi MY, Noranian M, Mira SS. 2012. Spatial distribution and biodiversity of macrofauna in the southeast of the Caspian Sea, Gorgan Bay in relation to environmental conditions. *Ocean Science Journal* 47:113–122. DOI: https://doi.org/10.1007/s12601-012-0012-8.

Thompson-Cloudsley JL. 1958. *Spiders, Scorpions, Centipedes and Mites; the Ecology and Natural Histories of Woodlice, 'Myriapods' and Arachnids.* New York: Pergamon Press.

Wells JBJ. 2007. An annotated checklist and keys to the species of *Copepoda harpacticoida* (Crustacea). *Zootaxa* 1568:1–872. DOI: https://doi.org/10.11646/zootaxa.1568.1.1.