Monaški skakavci (Orthoptera: Tetrigidae) Malezijskog poluotoka

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University of Zagreb
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Karmela Adžić

Pygmy Grasshoppers (Orthoptera: Tetrigidae) of Peninsular Malaysia

Master thesis

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Ovaj rad je izrađen u Laboratoriju za evoluciju na Zoologijskom zavodu Prirodoslovno-matematičkog fakulteta u Zagrebu, pod voditeljstvom prof. dr. Bsc. Nurul Ashikin Abdullah, suvoditeljstvom izv. prof. dr. sc. Damjana Franjevića, neposrednim voditeljstvom asistenta Josipa Skeje, mag. biol. exp. Rad je predan na ocjenu Biološkom odsjeku Prirodoslovno-matematičkog fakulteta Sveučilišta u Zagrebu radi zvanja magistar eksperimentalne biologije.

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I dedicate this thesis to my friend and colleague Amira Aqilah Muhammad, a passionate entomologist who continuously contributes to the knowledge of fauna of Peninsular Malaysia.

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Monaški skakavci (Orthoptera: Tetrigidae) Malezijskog poluotoka

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Rooseveltov trg 6, 10000 Zagreb, Hrvatska

Ovaj je diplomski rad sveobuhvatni faunistički pregled monaških skakavaca (Orthoptera: Tetrigidae) poluotočnog dijela Malezije. Do sada je ta regija službeno brojala samo 15 vrsta i jednu podvrstu ove porodice, što je vrlo nizak broj u usporedbi s okolnim zemljama. Nakon proučavanja sve dostupne literature značajne za ovu temu i dostupnih uzoraka jedinki iz kolekcija i pronađenih na terenskim istraživanjima, pronađeno je sveukupno 54 vrsta za poluotočnu Maleziju. Od toga su 33 vrste podržane uzorcima koji se nalaze u kolekcijama tamošnjih fakulteta, dok se preostala 21 vrsta treba dodatno proučiti kako bi se ustanovio njihov status. U radu su sve proučene vrste predstavljene fotografijama uzoraka i dodatno detaljno opisane te se daje usporedba sa srodnim vrstama. Za svaku su proučenu vrstu dani dodatni komentari o staništu, ekologiji, rasprostranjenosti, mogućim pogreškama u determinaciji i nedostacima u kolekcijama uzoraka koji služe kao temelj za daljnja istraživanja ove porodice u regiji.

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Master Thesis

Pygmy Grasshoppers (Orthoptera: Tetrigidae) of Peninsular Malaysia

Karmela Adžić

Rooseveltov trg 6, 10000 Zagreb, Hrvatska

This thesis is a comprehensive faunistic overview on pygmy grasshoppers (Orthoptera: Tetrigidae) fauna of Peninsular Malaysia. Until now, the region officially counted only 15 species and 1 subspecies of this family, a very small number when compared to neighbouring countries. By examining all available literature, existing specimens collections, and additional fieldwork research, a total of 54 species is listed for Peninsular Malaysia. Out of those, specimens of 33 species are deposited at local universities, while remaining 21 species need additional research for confirmation of their current status. All examined species are represented with specimen photographs and described in detail along with comparison to morphologically close species. Additional comments are given for each examined species on the subject of its habitat, ecology, distribution, possible misidentifications, and insufficiencies in specimen collections, all serving as basis for future research of this family in the region.

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Abbreviations

e.g.— exempli gratia, meaning „for example”

et al.— meaning „and others“

Fig.—figure

FM—frontomedial

HT—holotype

ID—identification

Isl—island

IUCN—International Union for Conservation of Nature

MM1— first metamedial

MM2—second metamedial

mm—millimeters

nr.—species near

OSF—Orthoptera Species File

sp.—species

spp.—several species

UKM— Universiti Kebangsaan Malaysia

UM—Universiti Malaya

VL—ventrolateral

1. INTRODUCTION

Malaysia is a tropical country in the subregion of Southeast Asia. Located just north of the Equator, it represents the southernmost continental part of Asia. The country is divided into two regions—Peninsular Malaysia, located on mainland, and East Malaysia, a part of Borneo island (Fig. 1). Peninsular Malaysia occupies majority of Malay Peninsula, covering the total surface of 132, 265 km^2. Malaysia's population is over 32 million, mostly inhabiting the peninsular part of the country (Marshall 2007).

1.1. GEOGRAPHY AND CLIMATE

Located in the tropics, both Peninsular and East Malaysia share similar weather conditions. Malaysia has Equatorial climate, with a small northernmost part of Peninsular Malaysia belonging to Monsoon climate region. Temperature is therefore warm and uniformed throughout the year, with small annual and daily oscillations. Mountain chains play a significant role in the shaping of country's climate. Temperatures in those areas are a bit cooler due to limited maritime influence, with larger oscillations, and they create the difference between eastern and western coastline weather (Marshall 2007).

Four seasons can be defined in a year—two intermonsoonal periods around March and October, and two monsoon periods in between. First comes the northeast monsoon (November–March), originating from the area around PR China, usually bringing a large amount of rain, especially to the east coast. The second monsoon is the southwest monsoon (May–September), originating from Australia and bringing less rainfall than northeast monsoon. Humidity is very high in all areas, with a lot of rainfall throughout the year. This, combined with the topology of mountains, creates a rich water chain of rivers and streams, shaping the very complex karst landscape of the area (Marshall 2007). This all results in a very rich diversity of habitats found in Malaysia.

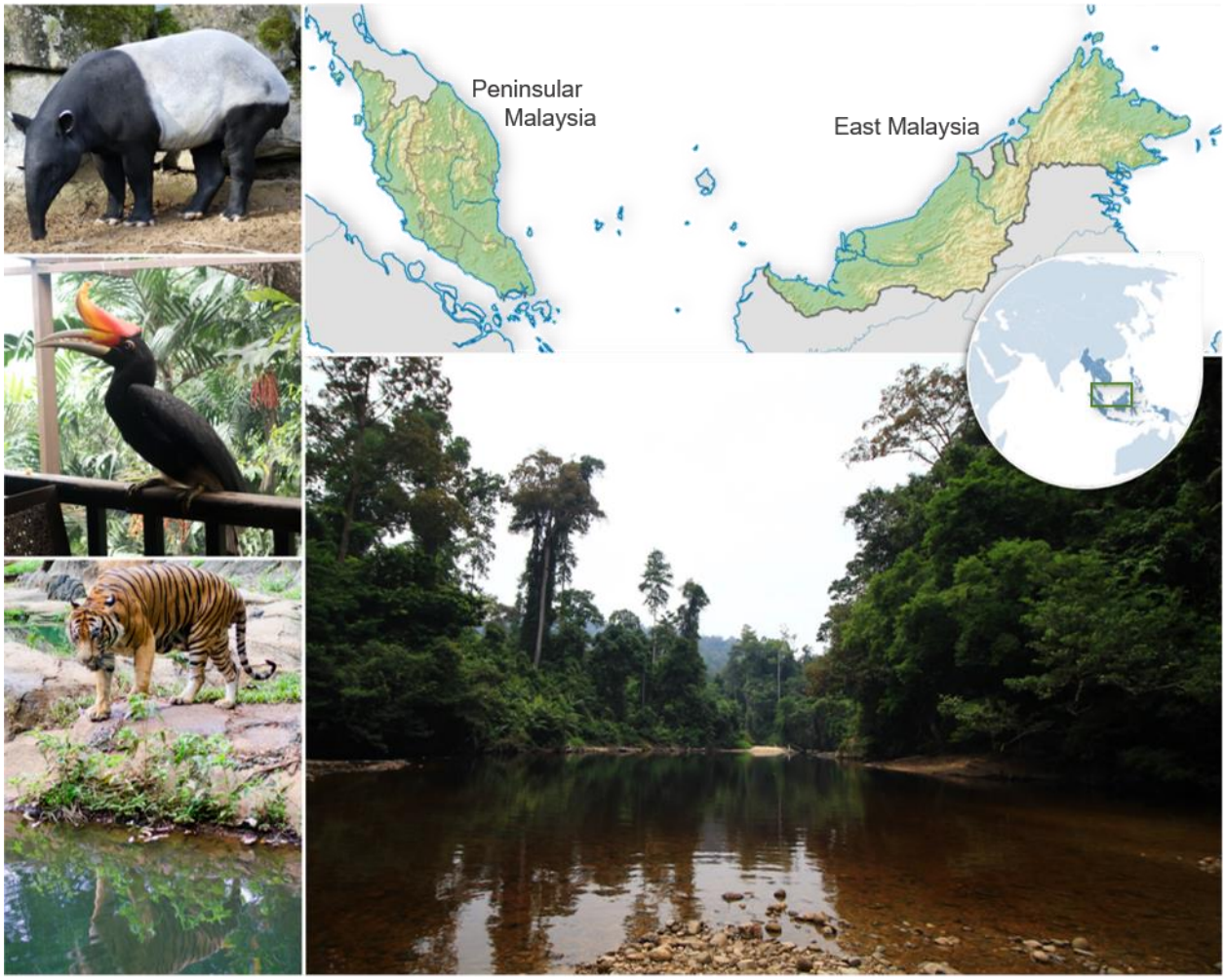

Figure 1. Map of Malaysia with added country placement in Southeast Asia (images reworked by the author). Some of the typical animals for Malaysian fauna are Malayan tapir—*Tapirus indicus* (top left; author: Allie Caulfield, image under cc-by-2.0 license), rhinoceros hornbill—*Buceros rhinoceros* (middle left; author: Thomas Quine, image under cc-by-2.0 license), and Malayan tiger—*Panthera tigris tigris* (bottom left, author: Angah hfz, image under attribution-share alike 4.0 license), national symbols and typical animals for this biogeographic region. Habitat where all these animals can be found are primary forests, such as Taman Negara National Park (bottom right; author's photography) (all photos downloaded from Wikimedia Commons under public domain license, unless noted otherwise).

1.2. BIOGEOGRAPHY OF PENINSULAR MALAYSIA

Due to the diversity of plants of the area, a distinct floristic region which includes Malaysia was defined—Malesia. It includes Peninsular Malaysia, Sumatra Isl, Java Isl, Borneo Isl, Philippines, and many surrounding islands. It previously included New Guinea and Bismarck Archipelago, but it was later shown that this area is in fact a biologically distinct region called Papuasia (Brummitt et al. 2001, Weigend 2003). Largely thanks to its biodiversity, biogeography of the area was thoroughly studied in the past, and it represents one of the most notable areas for the island biogeography theory (MacArthur & Wilson 2001).

Peninsular Malaysia was historically connected with its surrounding islands, all belonging to the same continental shelf, by a landmass known as Sunda. Islands of Borneo, Sumatra, and Java were connected with Peninsular Malaysia during the last glacial period (approximately 115–12 thousand years ago) when the sea level was much lower than today. Likewise, Australia was connected with its surrounding islands as well, including New Guinea, creating a landmass known as Sahul. These landmasses enabled animal and plant migrations between these otherwise isolated areas. A boundary can be drawn today, roughly corresponding to the boundary between Sunda and Sahul, showing how far species have migrated during the glacial period (Harrison, Krigbaum & Manser 2006, MacArthur & Wilson 2001). The most famous of such lines is Wallace's line, drawn between islands of Bali and Lombok and Borneo and Sulawesi. The line was created based on fauna of the area, and is hence a good reference for birds and mammals dispersal, but does not translate well to the dispersion of flora. It is important to note that the Philippines were not connected to the Asian mainland during the glacial period, though the islands had a rather narrow land connection to today's Borneo island, so they biologically represent quite a distinct region. This is reflected by Huxley's line, which separates Philippines from the rest of Sunda (Mayr 1944).

According to the modern biogeographic division of regions, Peninsular Malaysia belongs to the Oriental region, including land from India to Sulawesi (Holt et al. 2013). This supports Weber's line rather than Wallace's. The biogeographical analyses were mostly done on groups of animals

for which sufficient data was available, mostly birds, mammals, and amphibians. If not on animals, then conclusions were made based on plant species, which sometimes greatly differ from patterns of dispersal observed in animals, resulting in completely unique floristic regions (Takhtajan, Crovello & Cronquist 1986, Holt et al. 2013).

Biogeographical borders of the region were often put to test, and one recent study focused on flora of the region showed that Java might be more similar to Lesser Sundan islands and Sulawesi than it is to Sundan's shelf. This is probably the result of a special climate found on Java, which tends to have stronger seasonal fluctuations in climate than surrounding areas, similar to the conditions present on the land which connected it to the rest of Sunda during the glacial period. That area was covered in savannah-like biome, limiting species migration from Java to Borneo and vice versa. Similarly, because such a boundary was not present between Java and Sumatra and Peninsular Malaysia, migration was much more common in this area. As a result, Java has more similarities to islands to the south than to Borneo (Van Welzen, Parnell & Slik 2011).

However, the explanation as to why Java seems so different from the rest of Sundaland is still a matter of debate, as theories disproving the savannah-like flora exists. This just further shows complexity of both the historical and ecological biogeography of Malaysia. Historical biogeography must be taken into account for this region since today's geography of Sundaland islands is a poor representation of its historical geological, climatic, and environmental changes, especially since the Miocene, therefore leading to more problems with interpretation of the results (Cannon, Morley & Bush 2009, Webb & Ree 2012, Mason, Helgen & Murphy 2019).

Since entomology is a wide field of biology, dealing with more than 80% of all known species, zoogeography of the group is still mostly unknown. Since it was already shown that not all vertebrate species share the same dispersion patterns and might be classified in different biogeographical regions, it is possible such results might come from the more thorough study of biogeography in entomology (Morrone 2006, Holt et al. 2013). Also, insects are often dependent on flora of their habitat, so some groups might correspond to phytobiogeographic regions better

than to zoogeographic regions (Gressitt 1961). It is important to always consider biogeography of the region when its fauna is being studied because it tells which surrounding areas and countries might have similar or even the same species, and only by comparing those areas a complete and well-defined picture of fauna of the area can be created.

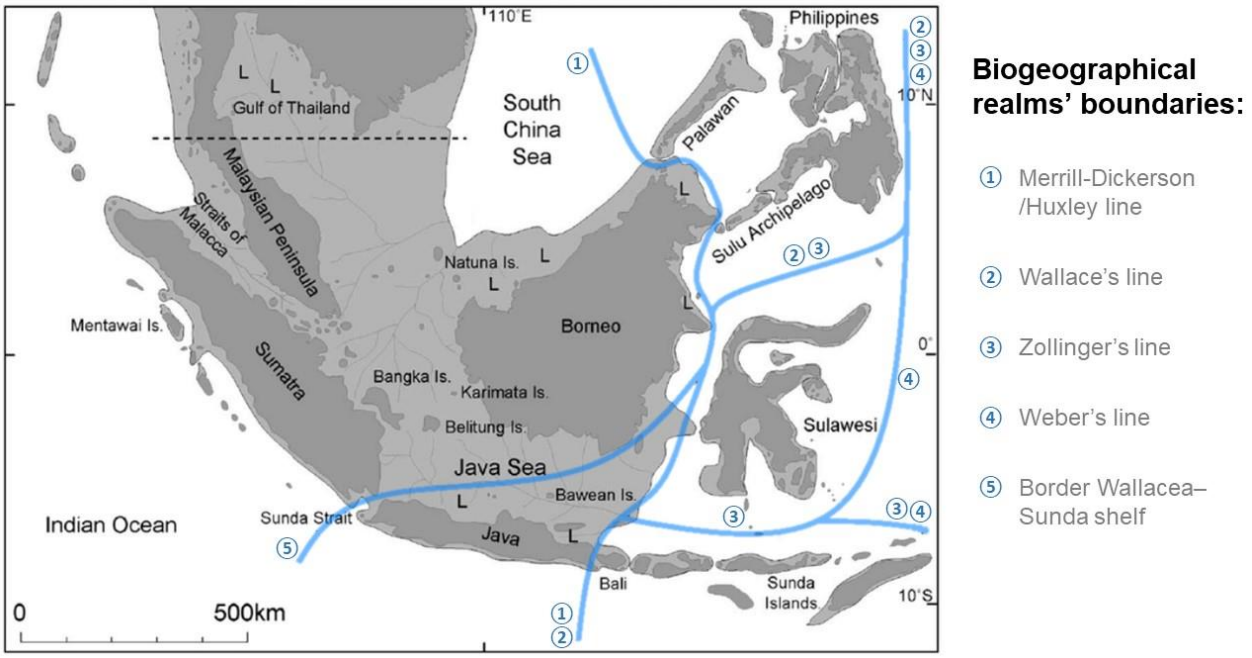

Figure 2. Map of Sundaland (downloaded from Wikimedia commons, author: S. Miron) with drawings of most significant boundaries of biogeographical realms (redrawn by the author after Van Welzen, Parnell & Slik (2011)).

In order to fully understand the fauna of Peninsular Malaysia, even if a single family of insects is in the focus of research, all of these things must be taken into account. We know that the country belongs to the region Malesia, which had three major origins of ancestral species dispersal: (1) Laurasian, (2) Gondwanan west route with clades arriving via the Indian raft, originating in Africa, and (3) Gondwanan east route with clades arriving via the Australian raft (Webb & Ree 2012). Today, Peninsular Malaysia shows the most similarity to the rest of the countries found on Malay Peninsula, as well as to Sumatra and Borneo. However, it seems to be more closely related to the west and north part of Borneo, which is no surprise since Peninsular Malaysia was connected to this area with the same type of forests, and migrations from the north-west of the Borneo were likely limited to its south-east due to high mountain chains with specific climate and plant coverage in the middle of the island (Cannon, Morley & Bush 2009, Mason, Helgen & Murphy 2019). Also,

the last historically important thing to note is that Peninsular Malaysia represents geologically rather old and volcanically inactive area. This is important because there is no evidence that historical large volcanic eruptions burned and destroyed large forest areas, which was the case for surrounding islands (Marshall 2007). As a result, Malaysia has old, so-called virgin rainforests, some of which truly are 130 million years old. Although their appearance likely greatly changed during the past due to climate changes, the area was nevertheless covered in forests all this time (Cannon, Morley & Bush 2009). The two largest areas of primary forests cover the Titiwangsa mountains and the East Coast Range in the states of Kelantan and Terengganu (Estoque et al. 2019).

1.3. BIODIVERSITY AND CONSERVATION

Despite its relatively small size, Malaysia's tropical climate and special topography are reflected in its diversity of habitats and ecosystems found both on land and its marine area, as well as in between those two habitats in mangrove forests. This diversity hosts an exceptionally large number of species, which has led to its placement on the list of megadiverse countries (Myers et al. 2000). On land, almost half the surface is covered in different kinds of rainforests, with complex stratigraphy and tallest trees, such as *Koompassia excelsa*, reaching up to 80 meters in height (Latiff 2018). Peninsular Malaysia has a higher number of species than East Malaysia, though endemism is higher on Borneo thanks to its isolation (Marshall 2007, Saw et al. 2010).

However, the country is facing some conservation issues. Malaysia lost half of its forest coverage in the last century alone, and it is estimated that Sundaland, which includes Peninsular Malaysia, now has around 8% original extent of its primary vegetation, making deforestation and habitat loss one of the main conservation issues of the country (Myers et al. 2000, Kawanishi & Sunquist 2004, Estoque et al. 2019). Remaining large forest areas are isolated and hard to access, contributing to their protection but at the same time making the research of the area even harder (Kawanishi & Sunquist 2004). One of the largest National Parks in Southeast Asia is Taman Negara, a primary forest located in Peninsular Malaysia (Ibrahim & Hassan 2011).

1.4. TETRIGIDAE—THE PYGMY GRASSHOPPERS

Insects represent the most diverse group of animals on the planet, and Peninsular Malaysia is no exception to this rule. Even though thousands of insect species have been reported in Malaysia, the group still lacks enough research and available data. Not all groups of insects have been studied to the same extent in Peninsular Malaysia, with orders of Lepidoptera and Phasmatodea being relatively well-studied, and Orthoptera falling on the list of understudied animals (Cheng & Kirton 2007). Among Orthoptera, order comprised of almost 29 thousand species, 40 families are known today—Tetrigidae being one of them (Cigliano et al. 2021). Tetrigidae are the oldest family within the suborder of Caelifera, with the estimated time of divergence during the Triassic around 230 mya (Song et al. 2015). Counting over 2000 species, this family of grasshoppers is a very diverse and distinctive group of animals, with many unique morphological characters (Fig. 3) (based on: Shishodia 1991b, Storozhenko & Paik 2007, Tumbrinck 2014).

Tetrigidae have cosmopolitan distribution, being absent only on Antarctica and New Zealand (Cigliano et al. 2021). They depend on moist habitats rich with mosses and detritus—their primary source of food—and can therefore be found along the rivers and streams, but also living on barks of trees in rainforests of tropical and subtropical belt, something we are just beginning to understand (IUCN 2021, Tan, Yeo & Hwang 2017).

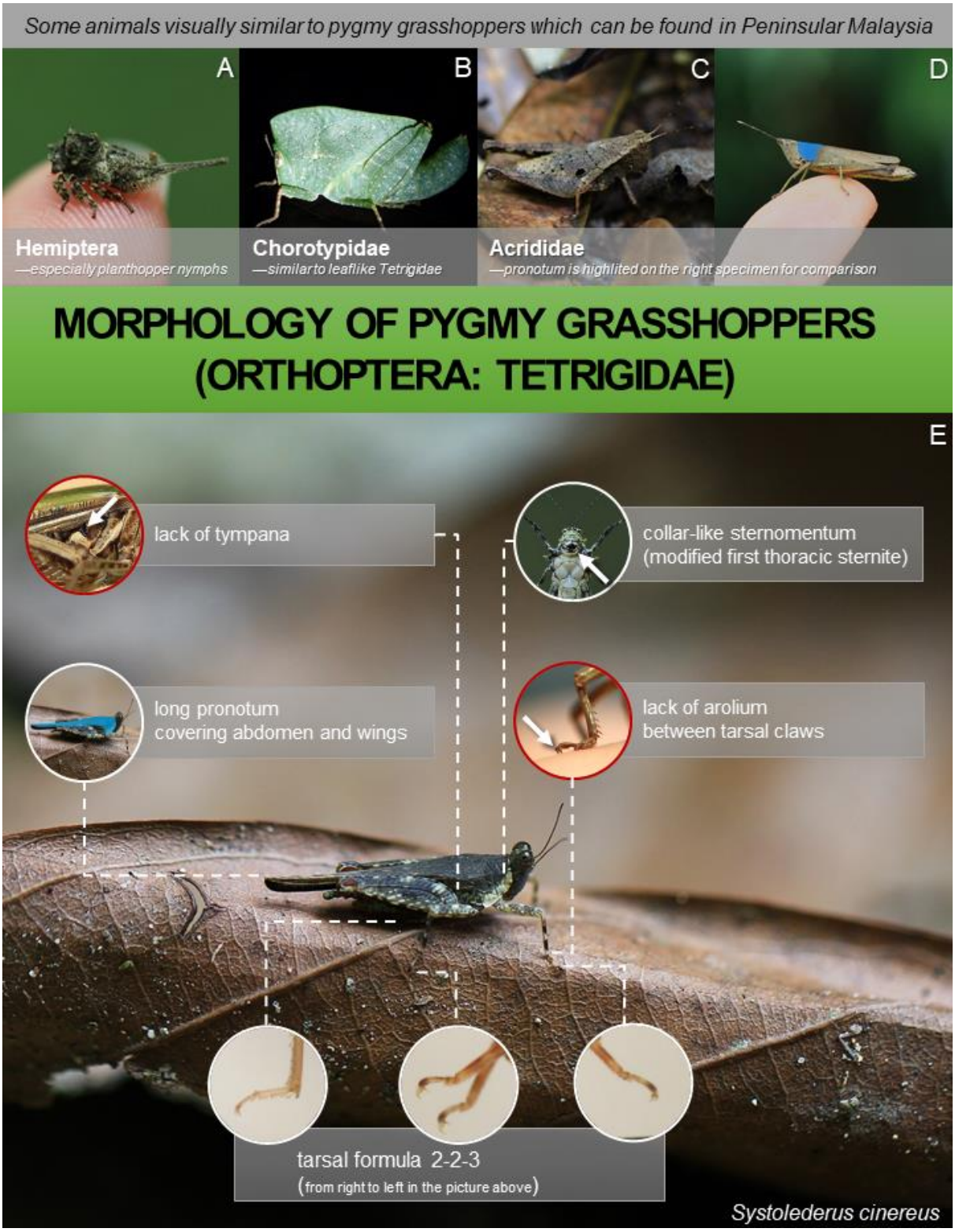

Figure 3. Morphology of Tetrigidae (E) and animals they most often get mixed with (A–D). Characters they lack are represented with images of other grasshoppers (Chorotypidae photograph (B) downloaded from Wikimedia Commons, author: L. Shyamal, under attribution-share alike 3.0 licence; all other images are author's).

The behaviour of Tetrigidae is not well-studied, although some aspects of their behaviour are known. One of the most interesting things they do is that they jump in the water when threatened, and can stay underwater for longer periods of time. Members of Scelimeninae are even known to swim rather well thanks to their widened and flattened hind tarsi, but this is again the subject that deserves more research in the future (Cigliano et al. 2021, Hancock 1907, Muhammad et al. 2018, Naskrecki 2013, *personal observations*). When not using such drastic measures of escaping, most of the species rely on their camouflage. Cladonotinae are probably best at demonstrating this, with species such as *Hymenotes triangularis* resembling parts of leaves or bark and *Potua coronata* fitting rather well among chunks of soil or decomposing wood. Although probably less obvious, other pygmy grasshoppers rely on cryptic appearance as well, even species that seem rather colourful when photographed out of their environment (Cigliano et al. 2021). This is not to say that there are species which might in fact use their colour in the aposemantic way, but these discoveries are still fresh—for example a rather curious case of discovery of photographs of living specimens of genus *Notocerus* which have bright purple and yellow coloration when alive, something we did not know previously (Mathieu, Pavlović & Skejo 2021). Probably the most important morphological character for pygmy grasshoppers is their pronotum, which serves a protective role for covering their developed hind wings used for flying (if present, since some groups do not have wings and cannot fly) (Cigliano et al. 2021, Hancock 1907, Shishodia 1991a, Tumbrinck 2014). Tetrigidae count 7 subfamilies, with rather dynamic taxonomic past and many changes still happening today (Cigliano et al. 2021).

Their diversity is highest in the Tropics, with Oriental region counting 126 genera with 1043 species (Cigliano et al. 2021). Peninsular Malaysia officially counts 15 species and 1 subspecies, a rather low number for the region. For comparison, Borneo counts 63 species and 2 subspecies, Sumatra 43 species and 4 subspecies, and there are 58 species and 1 subspecies in Thailand according to OSF (Cigliano et al. 2021).

2. RESEARCH GOALS

This thesis is a contribution to the knowledge of Tetrigidae fauna of Peninsular Malaysia. Since Tetrigidae fauna of Peninsular Malaysia is understudied, this thesis should be a step towards the resolution of that issue. By examining specimens deposited at various collections, and in combination with fieldwork observations made by the author, it should become more clear which species of pygmy grasshoppers actually inhabit the country. The thesis is primarily of taxonomic nature, but fieldwork observations concerning species ecology and behaviour will also be added, even if they are simple and basic, as this should help with future research of taxonomically unstable species. Also, this thesis aims to encourage future research of this region by making available data of the subject easily accessible for future researchers.

This thesis was inspired by the observation that Peninsular Malaysia counts a small number of species (according to OSF (Cigliano et al. 2019)) and has a lot of species with not too much literature data. The hypothesis was created that proposes that Peninsular Malaysia in fact has more pygmy grasshoppers species than was reported, with potential of some species being new for science. This was backed by the comparison with the neighbouring countries and regions. Another hypothesis is that Peninsular Malaysia has numerous misidentified species, along with before mentioned unreported species.

3. MATERIAL AND METHODS

3.1. STUDY AREA

As a part of this research, I was a part of the research team that conducted fieldwork focused on Tetrigidae during the summer of 2019. The fieldwork was conducted on numerous locations, as shown on the map (Fig. 4). The primary goal of the fieldwork was to observe living specimens in their natural habitat and photograph them. The part of research where I was personally present lasted 28 days, but colleagues from Malaysia were kind enough to share additional information they have gathered over a longer period. Living specimens were identified by combining photographic evidence, examination of living specimens from hand, or examination of collected specimens for species with complex morphological characters important for identification (see specimen identification for more information). The collected specimens are deposited at the Universiti Malaya (UM) collection, and were collected at the following locations: (1) Ulu Gombak Forest Reserve and (2) Genting Tea Estate. During fieldwork on all the localities listed below (Fig. 4) we gathered notes on the species behaviour and ecology by observing living specimens in their natural habitat for a longer period. All the reported species in this thesis can be found in Peninsular Malaysia and all photographs are of specimens documented in the region.

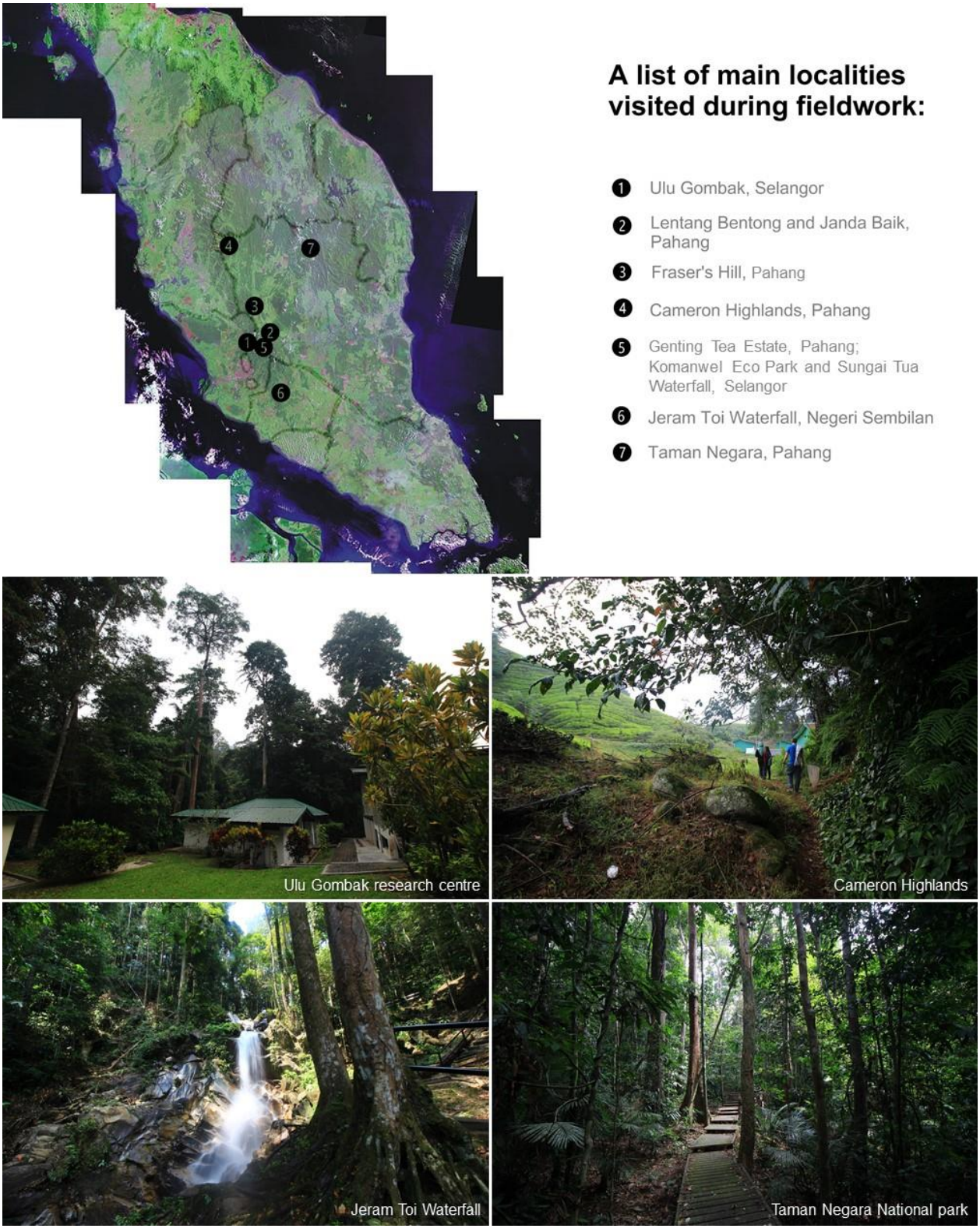

Figure 4. Research area localities shown on map, numbered in order as we visited them, with photographs of different habitats found in Peninsular Malaysia (map of the country is in public domain, reworked by the author; other photographs are author's).

3.2. SPECIMEN COLLECTIONS

I have examined two entomological collections with Tetrigidae specimens: (1) entomological collection deposited at Museum of Zoology, Institute of Biological Sciences, Faculty of Science, Universiti Malaya, 50603 Kuala Lumpur (Muzium Zoologi Universiti Malaya, Institut Sains Biologi, Fakulti Sains, Universiti Malaya, 50603 Kuala Lumpur, Malaysia) and (2) Tetrigidae collection deposited at the Centre for Insect Systematics, Biological Sciences Building, Faculty of Science and Technology, The National University of Malaysia (UKM), 43600 UKM Bangi, Selangor, Malaysia (Pusat Sistematik Serangga, Bangunan Sains Biologi, Fakulti Sains dan Teknologi, Universiti Kebangsaan Malaysia, 43600 UKM Bangi, Selangor, Malaysia) (Fig. 5). Since I had limited time in Malaysia, I was not able to examine all the specimens deposited there, so additional research would be needed to check if more species can be confirmed in these collections. I primarily focused on the specimens which were mentioned in the literature. For simplicity of reading and connecting specimens with justification of specimen identification, I list exact specimens under results, separately for each species.

Figure 5. Boxes containing mostly *Scelimena gombakensis* Muhammad, Tan & Skejo, 2018 specimens, the left one from UKM collection and the right one from UM collection, with some labels from UM collection.

3.3. SOCIAL MEDIA

Additional information was found on social media platforms and is listed in this thesis as well. One of the platforms I examined is iNaturalist (www.inaturalist.org)—a social network of naturalists, citizen scientists, and biologists built on the concept of mapping and sharing observations of biodiversity across the globe. If photographs of specimens were sufficient for identification to species level, they are listed among examined material later in results. Some photographs found on this platform were used in the thesis, with author's permission, and some people even shared their own observations concerning the documented specimens. Another platform I examined is Facebook (www.facebook.com)—online social media and social networking service, not necessarily meant for scientists but several special interest pages can be found, such as „SIGTET - Special Interest Group Tetrigidae“, „Orthopterists' Society“, and „Entomology“. I also included observations from Flickr, a platform used for photography sharing, which was examined by Marko Pavlović who shared the list of observations from Peninsular Malaysia with me. For social media I list the specimens I was able to identify to species level, following explanations presented in this thesis.

3.4. SPECIMEN IDENTIFICATION

Examined specimens were identified using a wide array of literature, which is later listed in every paragraph dedicated to given species. The main database used for finding literature citations was Orthoptera Species File (http://orthoptera.speciesfile.org/). Since even OSF lacks data about Peninsular Malaysia, all literature listed on it was additionally examined, and references were checked as possible additional information sources. All the specimens were compared to available type specimens, original species descriptions, and type specimen photographs available on OSF (only name-bearing specimens were considered). Terms used to describe morphology of pygmy grasshoppers follow Devriese (1999), Tumbrinck (2014), and Skejo (2017) (most important morphological characters which are used in this thesis are represented in Fig. 6). Taxonomy follows Cigliano et al. (2021).

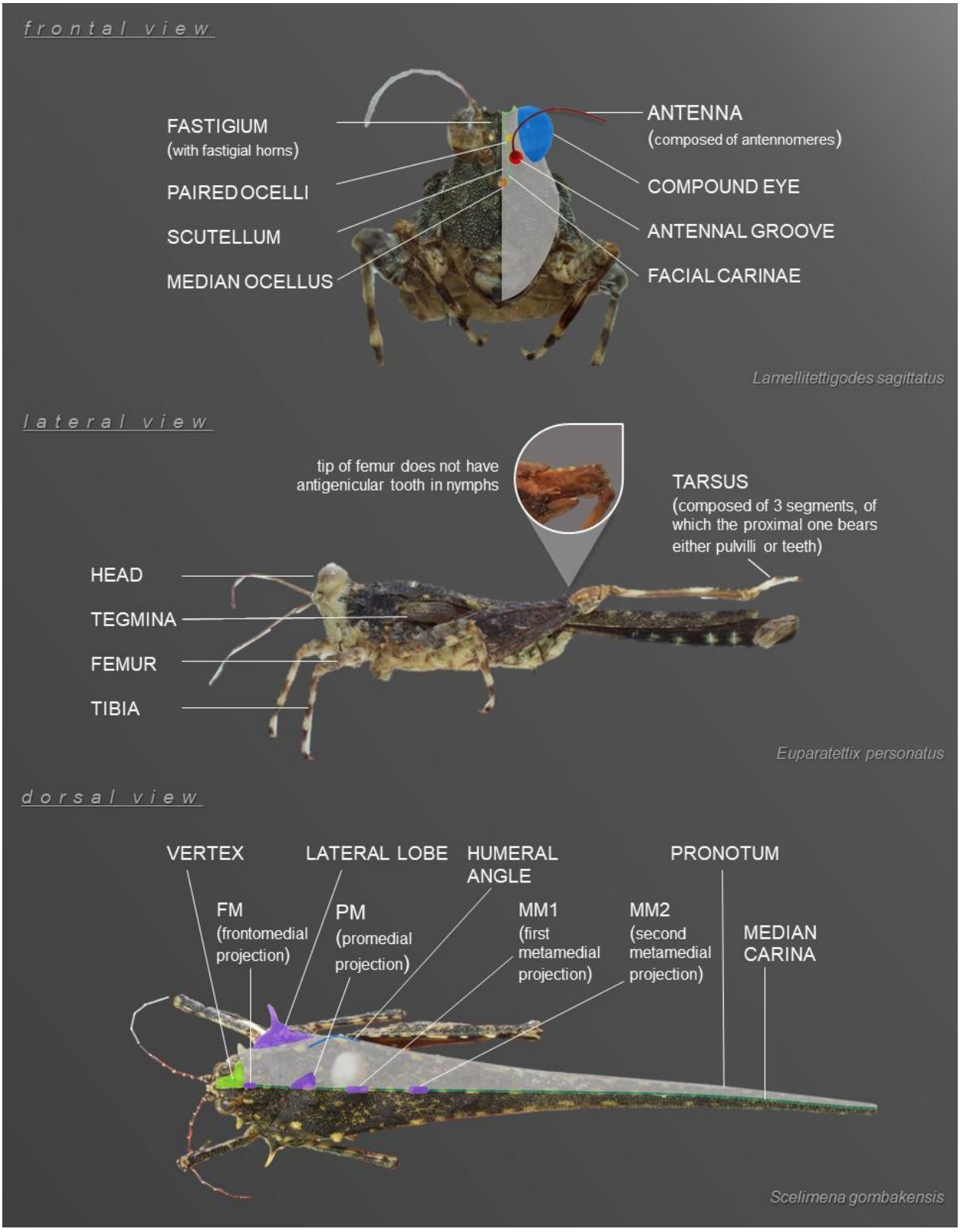

Figure 6. Morphology of pygmy grasshoppers (Tetrigidae) used in this thesis (photographs by Amira Aqilah Muhammad; drawings and figure made by the author).

Specimen paragraphs explanation

Species name. First, species name is given, following the taxonomy as accepted on OSF (Cigliano et al. 2021).

References. Below the species name, I list all the literature references for the given species that mention it for Peninsular Malaysia. This includes both synonyms, literature that mentions the species under the same name, and literature that lists misidentified specimens. I list all the references where authors have examined specimens from Peninsular Malaysia, as well as references where authors list that the species is present in Peninsular Malaysia, because that means that they agree with previous authors and think that given species inhabits the region. I list only the references which were available to me for examination, either publicly available online or sent to me by other researchers. Additional information may be available in some papers and books that were unavailable to me.

Examined material. All the specimens I personally examined are listed here. In this section I give information about locality of the specimens at the level of state, which serves both as information about distribution and to show which states lack research the most.

Morphology. This paragraph is supposed to give simple explanation of species morphology and should be simple enough so that most people can understand it. This segment is tightly linked to specimen photographs given at the end of each species' paragraph.

Similar species. This segment effectively replaces species key. Comparison is given for each species with species I personally found to be similar as well as with species people have previously misidentified it for. This segment mostly focuses on other species found in Peninsular Malaysia, but is not strictly limited to the region, since a lot of species have unknown distribution and can potentially be found in other countries as well.

History of identification. Here I list historical identifications given to specimens of the species from the region. I also use this segment to justify my own identification. This part serves as a starting point for future reidentifications of specimens.

Type locality. Type locality as listed on OSF and in the original description. The locality is listed based on holotype, multiple localities are listed for syntypes, and single localities are listed

for lectotypes if they were additionally designated. In this part I write the locality from the most precise location up to the country level. Country names follow the currently generally accepted terms.

Distribution. Here I list the countries in which given species can be found. This segment is thus written in the opposite way compared to the previous, where localities are mostly written at country level and precise locations are given in brackets for large countries only. For this part I combined both OSF specimen records (Cigliano et al. 2021) and literature data.

Ecology and behaviour notes. Here I list my personal observations, observations made by other colleagues, or information people from social media have agreed to share. This part serves to help future researchers find the species in their natural habitat, since pygmy grasshoppers' habitat preference can vary greatly and some species are hard to find without information of their ecology.

Specimen photography. I give photographic evidence to serve both as reference for future reidentifications and as a guide for recognition of given species—following instructions given by Lehmann et al. (2017). If possible, I give living specimen photographs, in addition to pinned specimens. All the pinned specimens are from Peninsular Malaysia, as well as living specimens. Some living specimen photographs are taken from social media, with author's permision, and some pinned specimen photographs were taken by Amira Aqilah Muhammad. All photo credits are given in the description of the figures and I take no credits for them.

Not all species found in literature were discovered during fieldwork and specimen collection examination, thus I cannot write about them in such detail as I was able to write about species I examined. For this reason, such species have simplified paragraphs and a note that states „*species presence should be confirmed*“. These species need additional research to confirm their taxonomic status, in addition to the needed confirmation of their presence in the region.

4. RESULTS

4.1. TETRIGIDAE CHECKLIST OF PENINSULAR MALAYSIA

4.1.1. Batrachideinae Bolívar, 1887

***Saussurella cornuta* (Haan, 1843)**

Saussurella cornuta (Mahmood, Idris & Salmah 2007)

Examined material. UKM: 1 ♀ from Pahang, Peninsular Malaysia.

Morphology. (Fig. 7) Pronotum longer than hind femora, extending in front of head with its anterior process. The pronotum process blunt and straight, not curved in any part, following a straight line from anterior to the posterior end of pronotum. Tegmina large, with dark spot in the middle surrounded by lightly colored outline (explained in detail in Grant 1966).

Similar species. Similar to *S. decurva* Brunner von Wattenwyl, 1893, but that species has larger and longer pronotal projection at the anterior part of pronotum, visibly elevated above head (opposed to following dorsal line of pronotum as in *S. cornuta*), lateral lobes of pronotum longer and bending outwards, away from the body.

History of identification. Reported for Peninsular Malaysia for the first time by Mahmood, Idris & Salmah (2007) and that is currently the only known specimen belonging to this species from the region. I agree that the specimen belongs to this species when compared to holotype photographs available on OSF (Cigliano et al. 2021) and species description (Grant 1966).

Type locality. Java.

Distribution. India (Assam), China (South), Myanmar, Vietnam, Thailand, Peninsular Malaysia, Java (Mahmood, Idris & Salmah 2007, Cigliano et al. 2021).

Ecology and behaviour notes. We did not find any specimens of the species in its natural habitat. Ecology is likely similar to *Saussurella* sp. specimen we observed resting on tree bark (listed under *S. decurva* section), same as one specimen that was photographed on Java, its type

locality (observation made on iNaturalist). The species is rarer than *S. decurva*, as observed by Mahmood, Idris & Salmah (2007).

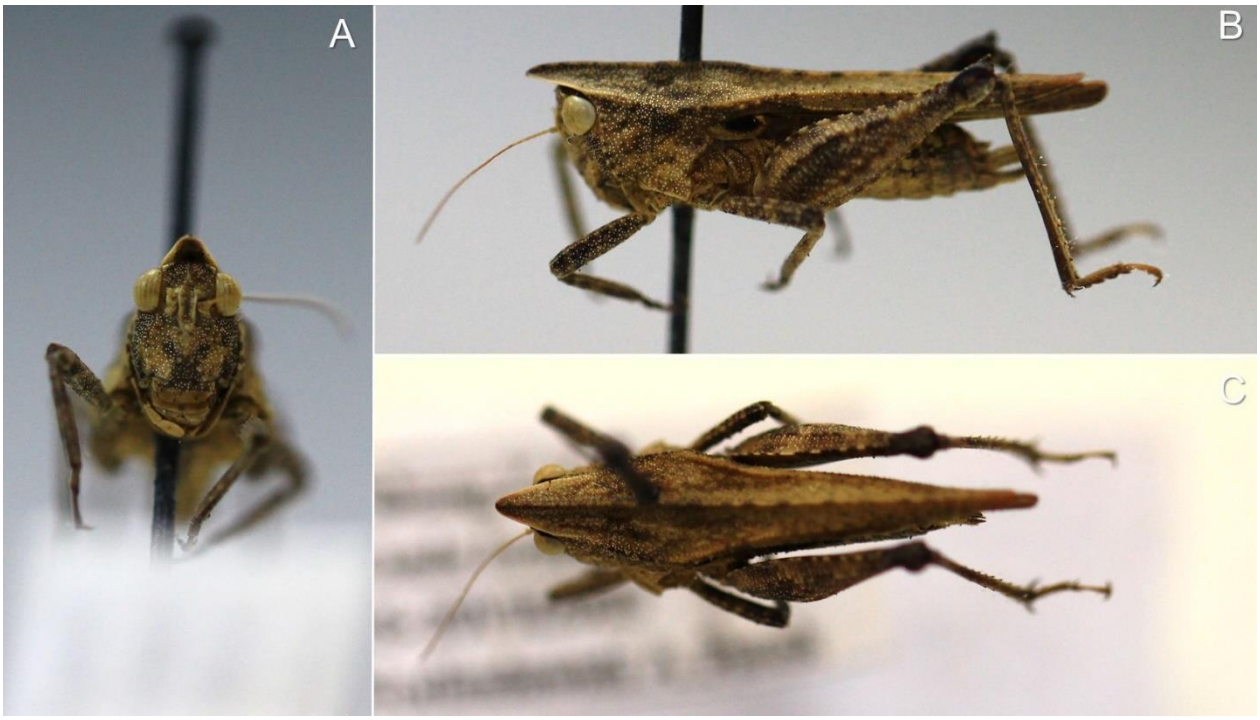

Figure 7. Morphology of *Saussurella cornuta* (Haan, 1843) specimen from UKM collection (A–C) (author's photographs).

***Saussurella decurva* Brunner von Wattenwyl, 1893**

Saussurella decurva (Grant 1966, Blackith 1992, Mahmood, Idris & Salmah 2007, Shishodia, Chandra & Gupta 2010, Storozhenko & Dawwrueng 2015, Deng 2016)

Examined material. UM: 1 ♂ from Selangor, Peninsular Malaysia; 3 ♀ from Selangor, Peninsular Malaysia. UKM: 6 individuals from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Pahang, Peninsular Malaysia (ID: 60746660). Facebook: 1 ♀ from Selangor, Peninsular Malaysia (https://www.facebook.com/groups/TheEntomologyGroup/posts/10152559204163393/); 1

nymph from Selangor, Peninsular Malaysia (https://www.facebook.com/groups/115824701779919/posts/1074920952536951/). Flickr: 1 ♂ from Selangor, Peninsular Malaysia (https://www.flickr.com/photos/99613800@N02/16334518402).

Morphology. (Fig. 8) Tegmina large, with dark spot in the middle surrounded by lightly colored outline, pronotum longer than hind femora, extending in front of head with its anterior process (same as *S. cornuta*). The pronotum process suddenly curves outwards and forwards roughly at the shoulder area, creating a long process extending significantly in front of head (explained in detail in Grant 1966).

Similar species. Similar to *S. cornuta*—as explained above. Also compared to *S. brevifrons* Zha, 2020 in the original description of latter species (Zha et al. 2020), from which it differs by morphology of pronotum process (curved in *S. decurva*), morphology of lateral lobes (obtusely angled in *S. decurva* and acutely angeled in *S. brevifrons*), and some other morphological characters, as explained in the said paper.

History of identification. Reported for Peninsular Malaysia by Grant (1966). There are numerous specimens of the species deposited at both UKM and UM, and they were either left unidentified or identified correctly. The species otherwise has synonyms, but as far as I know no specimens from Peninsular Malaysia belong to those species. The species is very similar to *S. brevifrons*, and can easily be mistaken for it, as was noted by Zha et al. (2020). I find species key provided by the authors to be unclear, and even though my specimens agree with *S. decurva*, this should be additionally discussed in the future.

Type locality. Palon, Pegu, Myanmar.

Distribution. India (Assam), Nepal, Vietnam, Laos, Myanmar, Thailand, Borneo, Peninsular Malaysia, Sumatra, Java (Shishodia, Chandra & Gupta 2010, Storozhenko & Dawwrueng 2015, Cigliano et al. 2021).

Ecology and behaviour notes. We encountered a single specimen of the genus in its natural habitat, and its ecology will be described here because I consider it to be closest to *S. decurva* in morphology. The specimen was observed on a tree, over two meters above the ground, not close to any water source. Because of its habitat preference so high of the ground the specimen

was hard to spot, and it is very likely we missed a lot of other specimens simply because we did not expect to find them at such place at the time.

Figure 8. Morphology of *Saussurella decurva* Brunner von Wattenwyl, 1893 specimen from UKM collection (A–C) and photography of a living specimen of *Saussurella* sp. specimen in its natural habitat (D). Note the living specimens' deformed anterior part of pronotum (author's photographs).

4.1.2. Cladonotinae Bolívar, 1887

***Potua coronata coronata* Bolívar, 1887**

Potua coronata coronata (Bolívar 1887, Hancock 1907, Willemse 1930, Günther 1938, Blackith 1992, Tumbrinck 2014)

Examined material. UM: 1 ♀ from Pahang, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Selangor, Peninsular Malaysia (ID: 33405916).

Morphology. (Fig. 9) The species can be recognized by its rugose general appearance, numerous warts and humps on its body, large hump in the area of its shoulders (to a variable degree), short pronotum, and thick and heavily serrated femora.

Similar species. There are no species of very similar morphology in Peninsular Malaysia.

History of identification. There are no historical records of misidentifications of this species. However, we found some evidence that Peninsular Malaysia might in fact have two (sub)species, which is something we will discuss in future paper after additional examination of type material.

Type locality. Sarawak, Borneo (2 syntypes) and Melaka, Peninsular Malaysia (1 syntype).

Distribution. Borneo, Peninsular Malaysia, Singapore (Cigliano et al. 2021).

Ecology and behaviour notes. We encountered one specimen in the wild, at the primary forest edge, in the bushes.

Figure 9. Morphology of *Potua coronata coronata* Bolívar, 1887 specimen from Ulu Gombak (Peninsular Malaysia) deposited at UM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

4.1.3. Criotettigini Kevan, 1966

***Criotettix bispinosus* (Dalman, 1818)**

Criotettix bispinosus (Shishodia 1991a, 1991b, Ingrisch 2006, Mahmood, Idris & Salmah 2007, Shishodia, Chandra & Gupta 2010, Gupta & Chandra 2017)

Criotettix tricarinatus (Mahmood, Idris & Salmah 2007)

Criotettix sp. (Tan & Kamaruddin 2014)

Eucriotettix tricarinatus (? Li et al. 2014)

Eucriotettix sp. (Tan & Kamaruddin 2016)

Examined material. UM: 1 ♂ from Kelantan, Peninsular Malaysia; 6 ♂ from Pahang, Peninsular Malaysia; 5 ♀ from Pahang, Peninsular Malaysia; 2 ♂ from Selangor, Peninsular Malaysia; 2 ♀ from Selangor, Peninsular Malaysia; 2 ♂ from Negeri Sembilan, Peninsular Malaysia. UKM: 1 ♂ from Selangor, Peninsular Malaysia (labeled as *Criotettix tricarinatus*).

Social media. iNaturalist: 1 individual from Kedah, Peninsular Malaysia (ID: 19251964); 1 ♂ from Pulau Pinang, Peninsular Malaysia (ID: 66182929); 3 ♀ from Pulau Pinang, Peninsular Malaysia (ID: 61557192, 36773540, 60296620); 4 individuals from Pulau Pinang, Peninsular Malaysia (ID: 23588883, 23599902, 20724004, 38133400); 1 ♂ from Pahang, Peninsular Malaysia (ID: 24201955); 1 ♀ from Pahang, Peninsular Malaysia (ID: 18555370); 1 individual from Pahang, Peninsular Malaysia (ID: 35706888); 1 ♂ from Selangor, Peninsular Malaysia (ID: 30300949); 1 individual from Selangor, Peninsular Malaysia (ID: 37190414); 1 individual from Negeri Sembilan, Peninsular Malaysia (ID: 27918421).

Facebook: 1 ♀ from Peninsular Malaysia (https://www.facebook.com/photo/?fbid=10153443477051429&set=pcb.935915553151299). Flickr: 2 individuals from Selangor, Peninsular Malaysia (https://www.flickr.com/photos/apitphoto/15633714564); 1 individual from Pahang, Peninsular Malaysia (https://www.flickr.com/photos/artour_a/5648527626).

Morphology. (Fig. 10) The species has large and straight, outwards pointing spines of lateral lobes of pronotum. Eyes partially protrude above the level of pronotum in lateral view. Long pronotum exceeds hind femora in length. In frontal view distance between compound eyes is smaller than width of one eye. Head is bright orange in living specimens, but this coloration quickly gets lost in pinned specimens. General body coloration is brown, and there are two seemingly equally common coloration varieties in the region, one with smaller and simpler darker markings and one with more prominent markings. Nymphs are more cryptic in coloration, with brown and green coloration, making them much harder to spot in natural habitat.

Similar species. In Peninsular Malaysia, if living specimens are observed, there is no other species with such head coloration and thus this species can be easily recognized. However, the genus is in a bit of a chaotic state, and numerous other species in the wider region are similar to this one. It will probably be satisfactory to identify them all as *C. bispinosus* (Dalman, 1818) until detailed study is done in Peninsular Malaysia and modern species key gets provided.

History of identification. Specimen Mahmood, Idris & Salmah (2007) labeled as „*Criotettix tricarinatus*“ concurs with this species. In the key they provided they state that *Eucriotettix tricarinatus* (Bolívar, 1887) has straight outwards directing spines of lateral lobes of pronotum, unlike in *C. bispinosus* which has spines directed either to front or back. This is not true as *C. bispinosus* holotype has directly outwards projecting spines (photographs available on OSF). Also, *C. bispinosus* is much more robust than *C. tricarinatus*, and since *C. tricarinatus* is only found in India (Cigliano et al. 2021) I think that the species is not present in Peninsular Malaysia. I placed specimen from UM collection, identified as *Eucriotettix oculatus oculatus* by D.K.McE. Kevan, in this species as I consider all my specimens to belong to the same species (some additional information in *E. oculatus oculatus* section below). I assume specimens Tan & Kamaruddin (2014) report under *Criotettix* sp. belong to the same species as the specimens considered here, same as specimens Tan & Kamaruddin (2016) report under *Eucriotettix* sp. I agree with the authors that genus is in a chaotic state and needs detailed revision to resolve status of numerous species, as well as the two genera themselves, but I think it is better to identify specimens to species level in this paper, even if proven wrong at some point, because in this way it is easier to reference to the specimens later. Li et al. (2014) mention that *Eucriotettix tricarinatus* is found in Malaysia, and I am not sure if they examined any specimens personally or if they used literature data, since I could not find this information in their paper, so I assume they used OSF as reference, meaning data about Peninsular Malaysia came from Mahmood, Idris & Salmah (2007). If I am correct, their paper is correctly listed is this section. As I find no important differences among our specimens and holotype photographs available at OSF (Cigliano et al. 2021) I report all my specimens and the listed literature specimens under this species.

Type locality. Unknown.

Distribution. China, India, Myanmar, Taiwan, Vietnam, Thailand, Borneo, Peninsular Malaysia, Celebes, Java (Gupta & Chandra 2017, Cigliano et al. 2021).

Ecology and behaviour notes. The species is rather common locally, near rivers and streams. It can be easily found resting on larger vertical rocks next to the water, especially if there is grass nearby. They are usually seen in larger numbers.

Figure 10. Photographs of living specimens of *Criotettix bispinosus* (Dalman, 1818) from Peninsular Malaysia (B, C), and a frontal photograph of pinned specimen's head (A) (note how living specimens have more vividly coloured head contrasting general body coloration, while entire body coloration is unifromed in pinned specimen) (author's photographs).

***Criotettix robustus* (Hancock, 1907)**

Examined material. UM: 1 individual from Negeri Sembilan, Peninsular Malaysia.

Social media. iNaturalist: 1 ♀ from Selangor, Peninsular Malaysia (ID: 75745200); 1 individual from Selangor, Peninsular Malaysia (ID: 77340179).

Morphology. (Fig. 11) Rather robust build, with somewhat elevated anterior part of pronotum. Lateral lobes of pronotum extending away from the body, relatively large, acutely ending. Distance between the compound eyes similar to the width of one eye in frontal view.

Antennal grooves placed in level with lower margin of compound eyes. Pronotum slightly longer than hind femora.

Similar species. Due to its robust build and humped prozona the species may look like *Paratettix obesus* Bolívar, 1887 which is also found in Peninsular Malaysia, but can easily be distinguished from it by its lateral lobes of pronotum (in *C. robustus* lobes extend significantly away from the body and end with acutely pointing distal lobes—not seen in *P. obesus*). Otherwise similar to other *Hyboella* species, especially *Hyboella perakensis* Günther, 1939, from which it can again be told apart by morphology of lateral lobes of pronotum. Species is close to some other *Criotettix* Bolívar, 1887 members from surrounding countries, namely *C. fuscus* (Hancock, 1907) (described from Borneo), *C. nexuosus* Bolívar, 1887 (described from Borneo) and *C. handschini* Günther, 1937 (described from Java), and these species are so similar that it is best to discern them just by their distribution now. Just to give some differences, *C. nexuosus* and *C. fuscus* have longer pronotum, and *C. handschini* has larger lateral lobes, thicker hind femora and more elevated anterior part of pronotum.

History of identification. The specimen from UM collection was not identified previously (it was collected in 1966), and the species was not previously recorded for the region, but specimens identified as *Criotettix* nr. *robustus* were reported for Singapore by Tan (2012). I place my specimen here because it concurs with type specimens' photographs from OSF (Cigliano et al. 2021). Further research is needed to see if specimens from Peninsular Malaysia perhaps belong to a separate subspecies. Above mentioned morphology of lateral lobes of pronotum is something that was already noted as variable by Günther (1937a, 1938), and Tumbrinck commented in 2020 on OSF that *C. fuscus*, *C. robustus*, and *C. nexuosus* are very closely related species (Cigliano et al. 2021), probably forming species complex. Also, its relationship with *Hyboella perakensis* needs to be resolved (see that species' section for further information).

Type locality. Kuching, Sarawak, Borneo.

Distribution. Peninsular Malaysia, Borneo (Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We did not observe any living specimens in their natural habitat.

Figure 11. Different specimens of *Criotettix robustus* (Hancock, 1907) from Peninsular Malaysia, both living ones in their natural habitat (B, C) (photographs provided provided by courtesy of Dr. Masatoshi Sone, Universiti Malaya, Kuala Lumpur) and a pinned specimen from UM museum (A, D) (author's photographs).

***Criotettix saginatus* Bolívar, 1887**

Eucriotettix exsertus (Mahmood, Idris & Salmah 2007)

Examined material. UKM: 1 individual from Terengganu, Peninsular Malaysia; 2 individuals from Selangor, Peninsular Malaysia; 1 ♀ from Negeri Sembilan, Peninsular Malaysia.

Morphology. (Fig. 12) Long pronotum and wings, clearly longer than hind femora. Large spines of lateral lobes of pronotum that extend away from the body, slightly turned backwards (as mentioned in the species key by Mahmood, Idris & Salmah (2007) for *E. exsertus*). Distance

between compound eyes in frontal view roughly the same as width of one eye. Vertex in dorsal view much wider than width of one eye.

Similar species. In Peninsular Malaysia it is close in morphology to *Criotettix bispinosus*, from which it can easily be separated by head morphology (distance between compound eyes much smaller in *C. bispinosus*, and head is coloured read or orange in living specimens of *C. bispinosus*), and *C. robustus* from which it differs by having spines of lateral lobes of pronotum. Otherwise similar to some other congeners from nearby countries (e.g. *Criotettix borrei* Bolívar, 1887 and *Criotettix inornatus* (Walker, 1871)) from which if differs by its flat pronotum in lateral view.

History of identification. The species was previously identified as *Eucriotettix exsertus* (Bolívar, 1902) by Mahmood, Idris & Salmah (2007), but this species has eyes above pronotum and narrow vertex, so it does not agree with their specimens. I place listed specimens here because they agree well with morphology of type specimens from OSF (Cigliano et al. 2021) and original description, but the species was not recorded in nearby regions so further research is needed to see if it is perhaps a separate species.

Type locality. Java.

Distribution. Peninsular Malaysia, Java, Lesser Sundan Islands, New Guinea (Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We encountered specimens only in well preserved habitats (e.g. in Taman Negara, specimen shown in Fig. 14 D), in near proximity to rivers.

Figure 12. Morphology of *Criotettix saginatus* Bolívar, 1887 specimen from UKM collection (A–C) and a living specimen resting on a rock in its natural habitat (D) (author's photographs).

4.1.4. Metrodorinae Bolívar, 1887

***Bermania daniili* Storozhenko, 2012**

Examined material. UM: 1 ♀ from Selangor, Peninsular Malaysia.

Morphology. (Fig. 13) Median carina of pronotum extremely elevated in anterior half of pronotum, with additional projection at the apex which creates a flattened spine that extends above the head. Pronotum otherwise flattened with wide humeral angles. Front and mid femora smooth, without any decorations.

Similar species. There are no similar species currently known from Peninsular Malaysia.

History of identification. The species was described from Borneo and discovering a specimen from Peninsular Malaysia was surprising. At the moment, I do not know if our specimen belongs to a separate subspecies than *B. daniili* described by Storozhenko (2012), but morphology overlaps, and they are certainly very closely related. Unfortunately, specimen was collected at University Campus, which expanded until then, so presently its natural habitat cannot be found anywhere nearby (thanks to Amira Aqilah Muhammad for clarification of specimen labels which were written in abbreviations). Because specimen's habitat is lost and because this is the single specimen and single record for the region that is almost 50 years old, I consider that this species could be locally extinct.

Type locality. Borneo.

Distribution. Peninsular Malaysia (*possibly locally extinct*), Borneo (Storozhenko 2012, Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We did not encounter any living specimens in their natural habitat and original habitat of the specimen is no longer present at the site.

Figure 13. Morphology of *Bermania daniili* Storozhenko, 2012 specimen from UM collection, with labels (A–D) (author's photographs).

***Bolivaritettix convergens* (Brunner von Wattenwyl, 1893)**

Macromotettix spp. (Tan & Kamaruddin 2014)

Bolivaritettix convergens (Tan & Kamaruddin 2016)

Examined material. UM: 1 ♂ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia; 3 ♀ from Pahang, Peninsular Malaysia. UKM: 1 individual from Pahang, Peninsular Malaysia.

Social media. iNaturalist: 1 ♂ from Selangor, Peninsular Malaysia (ID: 67518962, 85390541); 2 individuals from Selangor, Peninsular Malaysia (ID: 67518962).

Facebook: 1 individual from Selangor, Peninsular Malaysia
(https://www.facebook.com/groups/TheEntomologyGroup/posts/10151761946548393/);
2 ♀ from Peninsular Malaysia
(https://www.facebook.com/photo?fbid=10153443476876429&set=pcb.935915553151299,
https://www.facebook.com/photo?fbid=10153443477056429&set=pcb.935915553151299);
1 individual from Peninsular Malaysia
(https://www.facebook.com/photo?fbid=10153443476861429&set=pcb.935915553151299).

Morphology. (Fig. 14) Species has long pronotum, clearly surpassing hind femora. In frontal view, distance between compound eyes is similar to width of one eye, frontal costa bifurcates above the paired ocelli, antennae are placed at the lower level of compound eyes, and concave vertex with prominent ridge alongside its median carina. In dorsal view vertex is wider than width of a compound eye. In lateral view, eyes do not at all protrude above the level of pronotum. Pronotum is usually slightly elevated in two humps (at the place of MM1 and MM2), but otherwise generally flat. Prozonal carinae converge posteriorly—not extremely, but obviously) (prozona is pronotum area anterior to shoulders). Lateral lobes of pronotum extend away from the body and are obliquely truncated. Body coloration is generally brown but variability is quite high and specimens can have multiple colors and patterns on them.

Similar species. The genus currently counts 102 valid species (Cigliano et al. 2021). Recently there have been some genus revisions and new reports in the wider region, with a lot of newly described species, but almost nothing is known of the genus in Peninsular Malaysia. Historically, specimens from Peninsular Malaysia were collected and identified only to a genus level due to the complexity of this genus (e.g. Buzzetti & Devriese 2008). I compared our specimens to other species of the genus, mostly focusing on species for which I considered to possibly be present in the region (e.g. excluding species endemic to isolated regions such as the Philippines). Genus was redescribed by Deng et al. (2018) and is generally recognized by (1) width of vertex usually wider than the compound eye, (2) posterior angles of lateral lobes of pronotum obliquely truncated and produced outwards, (3) head and eyes not protruding above the level of pronotum. It is similar to numerous other genera, but since detailed explanations and descriptions have been given by Deng et al. (2018) and Storozhenko (2018) I recommend those as further literature on the matter. The species differs from *Bolivaritettix javanicus* (Bolívar, 1909) (described

from Java) by morphology of head in frontal view (*B. javanicus* has wider scutellum and straight vertex, not ridged as in *B. convergens*), from *Bolivaritettix lativertex* (Brunner von Wattenwyl, 1893) (described from Myanmar) by morphology of lateral lobes and vertex (in *B. lativertex* vertex is clearly wider than the compound eye, almost leveled in frontal view, and lateral lobes of pronotum protruding further away from the body in *B. convergens*, giving *B. lativertex* generally more slender appearance in dorsal view), from *Bolivaritettix sculptus* (Bolívar, 1887) (described from Myanmar) by morphology of head and prozonal carinae (*B. sculptus* has more protruded lateral carinae of vertex in frontal view and almost parallel prozonal carinae). Numerous other species are close in morphology, but these are the ones that look like examined specimens the most.

History of identification. No species of the genus is described from Peninsular Malaysia, so the identification of the reported specimens was complicated and should be revisited after examination of type material. Based on type material photographs available on OSF (Cigliano et al. 2021), original descriptions, and additional descriptions (Deng et al. 2018, Storozhenko 2018), I have narrowed down the list of possible species to only a few with the help of Maks Deranja and those species are the ones I discussed in the text above. I think specimens Tan & Kamaruddin (2014) placed in *Macromotettix* Günther, 1939, recognizing three distinct species, all in fact belong to this species. My reasoning is simple, given that morphology of specimens shown in their photographs agrees better with *Bolivaritettix* than *Macromotettix*, which has very narrow area between compound eyes on its head in frontal view (e.g. in *Macromotettix tonkinensis* Günther, 1939 from Vietnam, or *Macromotettix quadricarinatus* (Bolívar, 1898) from Java—type species of the genus), which is important morphological character in Tetrigidae. I think specimens reported by Tan & Kamaruddin (2016) likely belong to the same species as my specimens, since they also identified it as *B. convergens*. Specimens found at UM collection were identified by D.K.McE. Kevan to genus level only (labeled „*Bolivaritettix* sp.“). Genus needs complete revision, along with other related genera (Storozhenko 2018).

Type locality. Carin Cheba, Myanmar (3 syntypes) and Tagata, Tenassarim, Myanmar (1 syntype).

Distribution. Myanmar, Peninsular Malaysia (Cigliano et al. 2021).

Ecology and behaviour notes. We normally encountered specimens of this species in the tall grass or in the bushes, during daytime.

Figure 14. *Bolivaritettix convergens* (Brunner von Wattenwyl, 1893) specimen from UM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

***Bolivaritettix javanicus* (Bolívar, 1909)**

Bolivaritettix javanicus (Günther 1955, Shishodia, Chandra & Gupta 2010, Deng et al. 2018)

Examined material. We did not find any specimens of this species from Peninsular Malaysia.

The species is very close to *B. convergens* and I am not completely sure which species is correct identification for the region, if any of these two. I explained my identification of specimens above (see *B. convergens* paragraph). Since I placed no examined specimens under this species, its

presence should be confirmed. After complete genus revision, all the specimens should be revisited and re-identified.

Type locality. Java.

Distribution. China, India, Nepal, Thailand, Peninsular Malaysia, Java (Shishodia, Chandra & Gupta 2010, Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Bolivaritettix lativertex* (Brunner von Wattenwyl, 1893)**

Bolivaritettix lativertex (Günther 1939, Shishodia 1991b, Deng 2016)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Very close in morphology to *B. convergens*, and I explained in that species' section why I placed all my specimens in the latter species. As I found no specimens I would place in *B. lativertex*, for now I consider species presence remains to be confirmed.

Type locality. Carin Asciuii Ghecu, Myanmar.

Distribution. India, Nepal, China (south), Myanmar, Vietnam, Thailand, Peninsular Malaysia, Indonesia (Deng 2016, Storozhenko 2018).

Note. Species presence should be confirmed.

***Hyboella dilatata* (Haan, 1843)**

Hyboella dilatata (Shishodia, Chandra & Gupta 2010)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Given that the species is described from Java and was reported in numerous surrounding countries it is possible that the species can be found in Peninsular Malaysia. However, I did not discover any specimens belonging to this species and therefore consider that species presence should be additionally confirmed and verified.

Type locality. Java.

Distribution. China, Tibet, India, Myanmar, Thailand, Peninsular Malaysia, Sumatra, Java, Indonesia (Kai islands) (Shishodia, Chandra & Gupta 2010).

Note. Species presence should be confirmed.

***Hyboella perakensis* Günther, 1939**

Hyboella perakensis (Günther 1939, Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

This poorly known species was reported for the region by Blackith (1992). Günther (1939) stated that the species is very similar to *Hyboella dilatata* (species that I commented in a section above) so both species should be considered as possible identification for *Hyboella* specimens from Peninsular Malaysia found in the future. The species is very close in morphology to *Criotettix robustus*, and only strong difference is morphology of lateral lobes of pronotum. Since holotype of *H. perakensis* has deformed end of pronotum, it cannot be ruled out at this point that the specimen is in fact simply a slightly deformed specimen of *C. robustus*. If not, then the species is likely very localised (conclusions made in personal communication with Maks Deranja and Josip Skejo).

Type locality. Malacca: watershed between Perak and Pahang, Peninsular Malaysia (as written on holotype label).

Distribution. Peninsular Malaysia (Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Hyboella similis* Günther, 1939**

Hyboella similis (Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

This poorly known species was reported for the region by Blackith (1992). Günther (1939) stated that the species is very similar to *Hyboella dilatata* (species that I commented in the section above) so both species should be considered as possible identification for *Hyboella* specimens from Peninsular Malaysia found in the future. Currently, no specimens are available to me, and species presence needs to be confirmed.

Type locality. Java.

Distribution. Philippines, Peninsular Malaysia, Java (Blackith 1992, Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Orthotettix obliquifrons* Hancock, 1909**

Orthotettix obliquifrons (Günther 1939, Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Species was reported for the region based on one female specimen identified by Günther. Little is known of the species, and only a few specimens exist, so further research and analysis of the species is needed to confirm its presence in the region.

Type locality. Sarawak, Borneo.

Distribution. Borneo, Peninsular Malaysia, Sumatra (Günther 1939, Blackith 1992).

Note. Species presence should be confirmed.

***Rostella processus* (Hancock, 1907)**

Examined material. UM: 1 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia.

Morphology. (Fig. 15) Slender species in dorsal view, with pronotum clearly longer than legs, and with brown coloration with irregular darker markings. The most noticeable feature of the species is the projection on its vertex, which is one of the deterministic characters of the genus (though it is not exclusive to this genus) used for species identification.

Similar species. At this point, this is the only *Rostella* species I report for the region, so it is the only species with projection on its vertex and thus not similar to any other species in the region. For other species found in the wider region, see Storozhenko (2016) as recent species key.

History of identification. I identify the two examined specimens as *R. processus*, though the male specimen does not fit the species perfectly. Female specimen corresponds to species key given by Storozhenko (2016). The male specimen appears to have deformed vertex projection, where left and right side would not belong to the same species if Storozhenko's (2016) key was considered. To further the confusion, neither half of the projection fits drawings presented in that paper, so it would be possible to consider the specimen a certain member of new species if I was to strictly follow Storozhenko's (2016) species key. So, to avoid any future confusion, I have checked other characters and report both specimens as same species because they fit species description and look similar (apart from small deformation on male's head).

Type locality. Kuching, Sarawak, Borneo.

Distribution. Borneo, Peninsular Malaysia (Storozhenko 2016, *this thesis*).

Ecology and behaviour notes. We did not find any specimen of the species in its natural habitat.

Figure 15. Morphology of *Rostella processus* (Hancock, 1907) specimens from Peninsular Malaysia, from UM collection. Male specimen projection is shown in one picture (B), and all other photographs are of the female specimen (A, C, D) (author's photographs).

***Systolederus cinereus* Brunner von Wattenwyl, 1893**

Systolederus cinereus (Günther 1938, Günther 1939, Shishodia 1991b, Blackith 1992, Mahmood, Idris & Salmah 2007, Shishodia, Chandra & Gupta 2010, Storozhenko & Dawwrueng 2015)

Examined material. UM: 10 ♂ from Pahang, Peninsular Malaysia; 10 ♀ from Pagang, Peninsular Malaysia; 20 ♂ from Selangor, Peninsular Malaysia; 20 ♀ from Selangor, Peninsular Malaysia; 3 individuals from Negeri Sembilan, Peninsular Malaysia. UKM: 1 ♀ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 ♂ from Pahang, Peninsular Malaysia (ID: 35706825); 1 ♀ from Selangor, Peninsular Malaysia (ID: 12635432); 3 individuals from Selangor, Peninsular Malaysia (ID: 80102465, 31171565, 31333727).

Facebook: 1 individual from Selangor, Peninsular Malaysia (https://www.facebook.com/groups/115824701779919/posts/1144963865532659/). Flickr: 1 individual from Selangor, Peninsular Malaysia (https://www.flickr.com/photos/liewwk/2463716187).

Morphology.(Fig. 16) Extremely narrow vertex, with large eyes that are almost touching. Pronotum smooth, without any noticeable decorations or projections. Pronotum longer than hind femora, similar in length to wings, which are black in coloration. Legs also smooth, without any decorations. General body coloration usually uniformed gray or brown, but high variability of coloration was observed in specimens from Peninsular Malaysia.

Similar species. *Systolederus* Bolívar, 1887 is morphologically close to *Teredorus* Hancock, 1907, but there are no species of the latter genus in Peninsular Malaysia, and *Teredorus* species that inhabit Indochina are not similar to *Systolederus* species found in Peninsular Malaysia. The species is otherwise very close in morphology to *S. ridleyi* Hancock, 1909. The two species can be told apart by the fact that *S. ridleyi* has distal pulvili of hind tarsi slightly longer than the proximal two (all same size in *S. cinereus*) (Hancock 1909), shorter prozona (pronotum area anterior to shoulders) of *S. ridleyi*, wart on its fore femora (observations by Josip Skejo), lateral lobes almost not at all protruding outwards (while they clearly bend outwards in *S. cinereus*—most easily visible in frontal view), coloration of hind tibiae (distinct interchanging white and black stripes of equal width in *S. ridleyi*, with proximal part completely lightly coloured, while in *S. cinereus* coloration varies, but it always has smaller and less distinct light stripes and proximal part is never without black coloration mixed in). The species is also very close to *S. injucundus* Günther, 1937 and after comparing the holotype specimen available on OSF (Cigliano et al. 2021) I found no strong morphological characters to separate the two species. *S. injucundus* inhabits Java (its type locality) and Sumatra, so it is unlikely, though not impossible, that it inhabits Peninsular Malaysia as well. I was not able to find any differences among the two species and this is something that should be discussed in the future.

History of identification. The species was recorded for Peninsular Malaysia by Günther (1938) and has been known ever since, but I assume there were numerous misidentifications as *S. ridleyi* due to their similarity. Such misidentification was common on iNaturalist as well, where numerous *S. cinereus* specimens from Peninsular Malaysia had been identified as *S. ridleyi*, and only recently correctly identified by Josip Skejo.

Type locality. Carin Cheba, Myanmar.

Distribution. Myanmar, Thailand, Peninsular Malaysia (Storozhenko & Dawwrueng 2015).

Ecology and behaviour notes. I believe this to be the most common species in Peninsular Malaysia. It can be found near water and appears to be less sensitive to habitat quality than most other species, so it can be found on almost any locality near water. It prefers rocky shores, and even pebbles, but we never found them on parts of rivers and streams with sandy shores. It is common to find this species in larger groups.

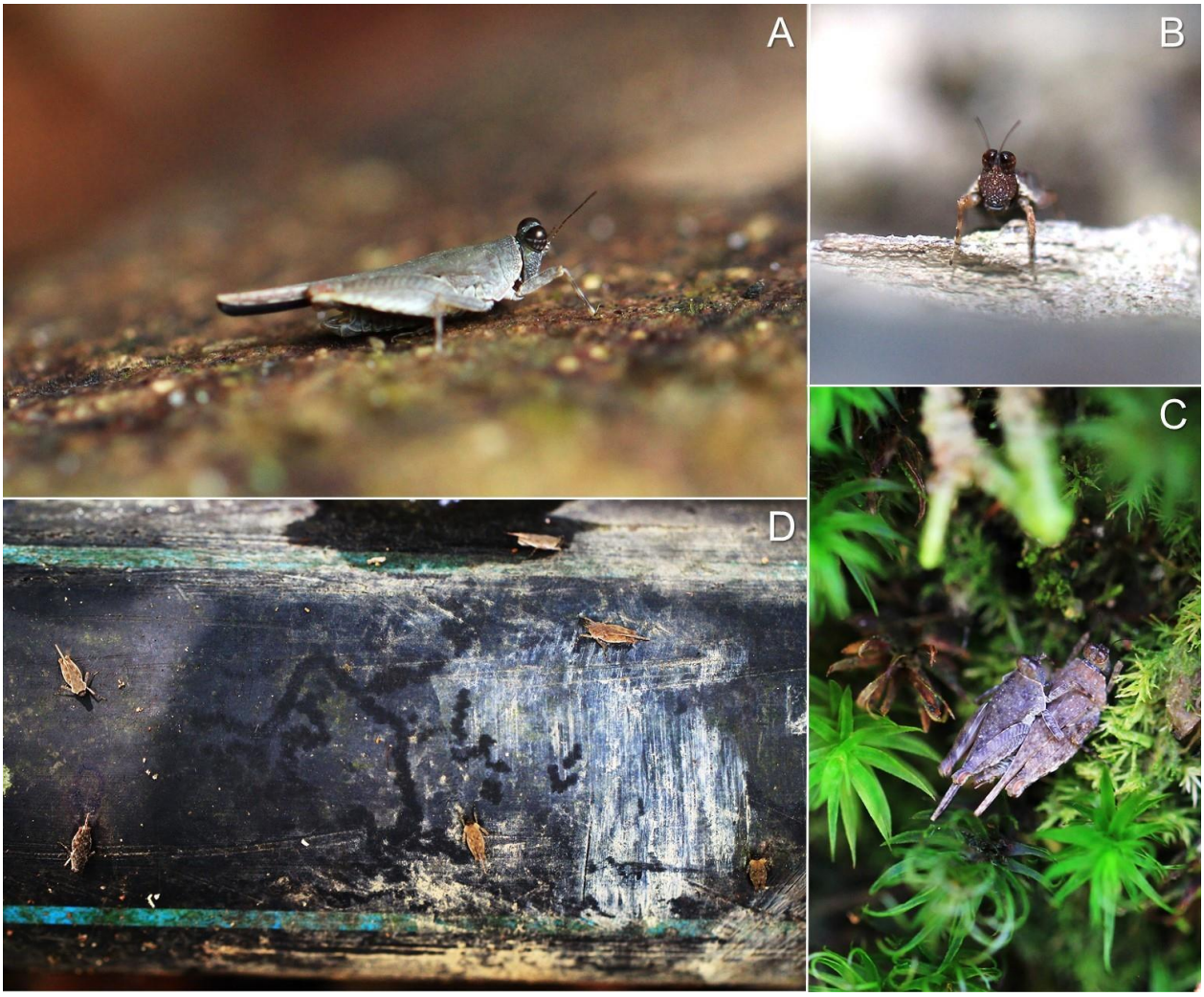

Figure 16. Morphology of *Systolederus cinereus* Brunner von Wattenwyl, 1893 living specimens (A, B) and one mating couple (C). The species can often be found in larger groups, as shown in this example where individuals had gathered on a large water pipe near river (D) (author's photographs).

***Systolederus parvus* Hancock, 1907**

Systolederus parvus (Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

The species was reported for Peninsular Malaysia by Blackith (1992), but it is very likely that either location is wrong or the specimen is misidentified.

Type locality. Mount Matang, Borneo.

Distribution. Borneo, Peninsular Malaysia (Hancock 1907, Blackith 1992).

Note. Species presence should be confirmed.

***Systolederus ridleyi* Hancock, 1909**

Systolederus ridleyi (Günther 1939, Blackith 1992)

Examined material. UKM: 1 ♀ from Terengannu, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Pulau Pinang, Peninsular Malaysia (ID: 89285465); 1 ♀ from Perak, Peninsular Malaysia (ID: 24203633); 1 ♀ from Selangor, Peninsular Malaysia (ID: 85450945).

Facebook: 1 ♀ from Selangor, Peninsular Malaysia (https://www.facebook.com/photo/?fbid=10212389741770475&set=pcb.969360039920913).

Morphology. (Fig. 17) Very large eyes and extremely narrow vertex, with eyes that are almost touching. Generally smooth pronotum without any humps or projections, but slightly rugose. Somewhat robust build. On front femora this species has visible wart on its bottom side.

Similar species. Very similar to *S. cinereus*, as explained previously. The species generally has stouter appearance, is larger than *S. cinereus*, with wider shoulders and thicker legs, and lateral lobes generally following ouline of the body and not bending outwards in frontal view.

History of identification. Most of the specimens from literature data are from Singapore, only Günther 1939 reports specimens from Peninsular Malaysia. No specimen of this species were discovered in UM collection (as confirmed by Amira Aqilah Muhammad), and only one was found in UKM.

Type locality. Singapore Botanical Garden, Singapore.

Distribution. Peninsular Malaysia, Singapore (Hancock 1909).

Ecology and behaviour notes. We did not encounter any specimen of the species in natural habitat, but one of the observers from iNaturalist, Dr. Masatoshi Sone, was kind enough to share his observations. He found both specimens in grass, on regularly mowed areas and relatively close to cultivated areas. They were not close to any larger water sources, maybe even preferring such dryer habitats. Both specimens were found alone (opposed to *S. cinereus* which is regularly found in larger groups of animals).

Figure 17. Morphology of *Systolederus ridleyi* Hancock, 1909 living specimens from iNaturalist (A: photograph provided by David Kohl; B: photograph provided by courtesy of Dr. Masatoshi Sone, Universiti Malaya, Kuala Lumpur). The arrow at the upper photography (A) points to the wart on fore femur as one of the easiest morphological characters by which the species differs from its cogenre *S. cinereus*.

***Xistrella dohrni* Günther, 1939**

Examined material. UM: 2 ♀ from Selangor, Peninsular Malaysia. UKM: 1 ♂ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia; 1 ♂ from Terengganu, Peninsular Malaysia.

Morphology. (Fig. 18) The species has relatively large and visibly inflated shoulders which are somewhat wide when viewed in frontal view. Its pronotum is long and clearly surpasses its hind large and relatively thick femora. Its head in frontal view is narrow, with strongly curved fastigial horns and narrow vertex. Paired ocelli and antennal grooves are both placed below the lower margin of the eye. It does not have any noticeable projections and is generally rather smooth.

Similar species. This species, if characters mentioned in the morphology section are observed, does not resemble any other species in Peninsular Malaysia. There is another species of this genus reported for the region, but this is commented later in the text.

History of identification. The species was not previously recorded for the region. I place it under *X. dohrni* species, but do not identify it to subspecies level since I was not able to examine specimens from other localities.

Type locality. Soekaranda, Sumatra (for *X. dohrni dohrni* subspecies syntypes).

Distribution. India, Philippinnes, Myanmar, Borneo, Sumatra (Shishodia, Chandra & Gupta 2010, Xin & Deng. 2019, *this thesis*).

Ecology and behaviour notes. We have encountered one female in Selangor, in the forest of Rawang Komanwel Eco Park, on tree roots.

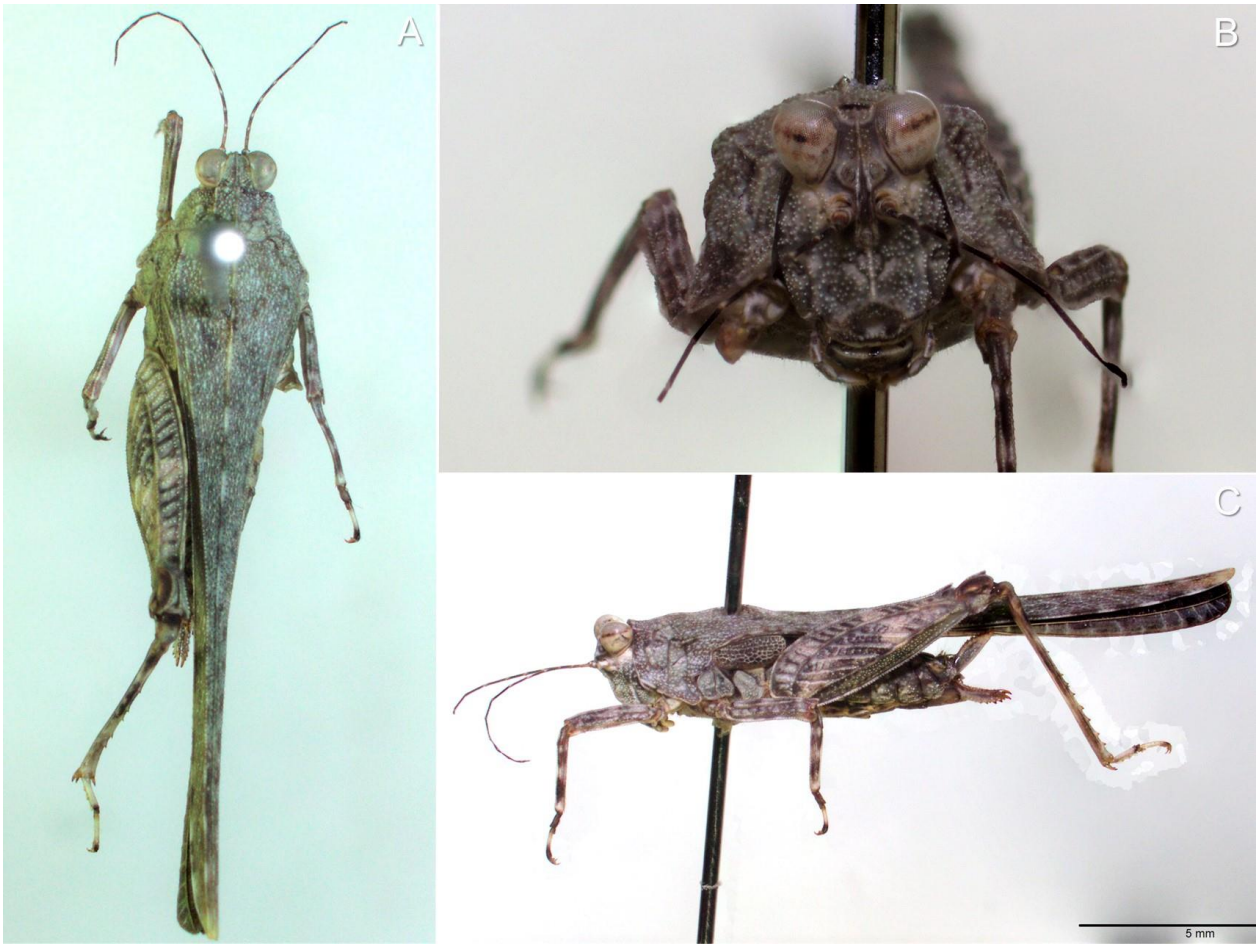

Figure 18. Specimen of *Xistrella dohrni* Günther, 1939 found at UM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

***Xistrella ophthalmica* (Bolívar, 1909)**

Xistrella ophthalmica (Shishodia, Chandra & Gupta 2010, Xin & Deng 2019)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Shishodia, Chandra & Gupta (2010) reported the species for Peninsular Malaysia. The species type locality is Upper Assam (India) and it is not widely distributed (Cigliano et al. 2021). Therefore, I find this identification unlikely, but it is only a speculation on my part and either reported specimen examination or species confirmation for the region is needed.

Type locality. Sibsagar, Assam, India.

Distribution. India (Assam), Peninsular Malaysia (Shishodia, Chandra & Gupta 2010).

Note. Species presence should be confirmed.

4.1.5. Scelimeninae Bolívar, 1887

***Amphibotettix hafizhaii* (Mahmood, Idris & Salmah, 2007)**

Scelimena hafizhaii (Mahmood, Idris & Salmah 2007)

Amphibotettix hafizhaii (Storozhenko & Dawwrueng 2015, Muhammad, Tan & Skejo 2018)

Examined material. *Type series*. UKM: 1 ♀ HT from Negeri Sembilan, Peninsular Malaysia.

Morphology. (Fig. 19) Species can easily be recognized by its long legs and large, straight and outwards pointing spines of lateral lobes, as well as large FM projection extending above the head. It has yellow ventral coloration, as well as coloration of face, with the rest of body being quite smooth, without any noticeable projections, colored with dark base and with numerous small yellow dots. Head in frontal view with large eyes protruding above the head, very narrow scutellum and antennal grooves placed just below the compound eyes. Morphology described in more detail in the original description (Mahmood, Idris & Salmah 2007).

Similar species. Although originally placed within the genus *Scelimena* Serville, 1838, members of *Amphibotettix* Hancock, 1906 can easily be recognized by their extremely (in the context of Tetrigidae) prolonged legs (front and mid femora), long and straight spines of lateral lobes, and FM forming a projection pointed forward and upwards. Another similar genus is *Paramphibotettix* Günther, 1938, but this genus has shorter femora when compared to shoulder width (Blackith 1992) and smaller and blunter VL. There are only three species currently in *Amphibotettix* (Cigliano et al. 2021), and since it was already hypothesised that *Amphibotettix abbotti* (Rehn, 1904) is in fact a member of *Scelimena* genus (Muhammad et al. 2018), the only

remaining similar species is *Amphibotettix longipes* Hancock, 1906 (described from Brunei, Borneo). After inspection of specimen photographs (Cigliano et al. 2021) of *A. longipes*, I find that *A. hafizhaii* has shorter femora than *A. longipes* (still longer than *Paramphibotettix* members, justifying genera placement) and shorter VL projection. There are no morphologically similar species in Peninsular Malaysia.

History of identification. The species was originally described as a member of genus *Scelimena*, and later transferred to genus *Amphibotettix* by Storozhenko & Dawwrueng (2015) based on a drawing given in the original description. Muhammad et al. (2018) agree that the species likely belongs to this genus, but make no further notes as they had not examined the type material at the time. After examination of type specimen I agree that the specimen is *Amphibotettix hafizhaii*.

Type locality. Negeri Sembilan, Peninsular Malaysia.

Distribution. Peninsular Malaysia (Negeri Sembilan) (holotype is the only known specimen of the species) (Mahmood, Idris & Salmah 2007).

Ecology and behaviour notes. There are no known notes on this subject for the species. Since a single specimen has ever been reported, the species likely has a very specific and narrow habitat. It also cannot be ruled out at this point that the individual was accidentally introduced to Peninsular Malaysia.

Figure 19. Morphology of *Amphibotettix hafizhaii* (Mahmood, Idris & Salmah, 2007) holotype from UKM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

***Discotettix selysi* Bolívar, 1887**

Discotettix selysi (Blackith 1992, Skejo et al. *in press*)

Discotettix selangori (Mahmood, Idris & Salmah 2007)

Examined material. UM: 1 ♂ from Pahang, Peninsular Malaysia. UKM: 1 ♂ from Selangor, Peninsular Malaysia; 2 ♀ from Selangor, Peninsular Malaysia.

Social media. Facebook. 1 individual from Selangor, Peninsular Malaysia (https://www.facebook.com/groups/TheEntomologyGroup/posts/10152672052313393/).

Morphology. (Fig. 20) Preapical antennomere broadly widened. Large lateral lobes, extending away from the body, acutely ending in distal part, with additional smaller spines and warts. FM projection long, extending above head. Other projections of pronotum visible, but not

as long, and flat rather than spiky. All femora with numerous warts. In frontal view antennae and paired ocelli placed rather low, very large distance between compound eyes.

Similar species. The species is similar to other congeners, but it is so far the only known species from Peninsular Malaysia in its genus (Skejo et al. (*in press*) will discuss entire genus in detail). Otherwise, it may be similar to *Eufalconius pendleburyi* Günther, 1938 in the region, from which it can easily be distinguished by completely different pronotal projections and flattened, *Phaesticus*-like preapical antennomeres.

History of identification. Specimen found at UM museum was identified by D.K.McE. Kevan as *D. selysi*. Here I follow the synonymy proposed by Skejo (2017) and Skejo et al. (*in press*) and treat the species Mahmood, Idris & Salmah (2007) described as *Discotettix selangori* as a synonym of *D. selysi*, since I agree that there are no morphological differences among examined material from Peninsular Malaysia and type specimens photographs available on OSF (Cigliano et al. 2021).

Type locality. Sumatra.

Distribution. Peninsular Malaysia, Sumatra (Skejo et al. *in press*).

Ecology and behaviour notes. We did not encounter any living specimens in their natural habitat. However, living specimens photographs available on OSF (Cigliano et al. 2021) all show specimens on dead tree logs, so the species is likely linked to that microhabitat.

Figure 20. Morphology of *Discotettix selysi* Bolívar, 1887 specimen from UKM collection (= *Discotettix selangori* holotype) (A–C) (photographs provided by Amira Aqilah Muhammad).

***Eufalconius pendleburyi* Günther, 1938**

Eufalconius pendleburyi (Günther 1938, Günther 1955, Blackith 1992, Skejo & Bertner 2017, Muhammad et al. 2018)

Gavialidium phangensum (Mahmood, Idris & Salmah 2007)

Examined material. UKM: 1 ♀ from Pahang, Peninsular Malaysia (holotype of junior synonym *Gavialidium phangensum*).

Social media. Facebook: 1 nymph from Pahang, Peninsular Malaysia (https://www.facebook.com/groups/TheEntomologyGroup/posts/10158332789233393/). Flickr: 2

individuals from Pahang, Peninsular Malaysia (https://www.flickr.com/photos/jameskoh/5993709239, https://www.flickr.com/photos/rainforests/3532987240).

Morphology. (Fig. 21) Very rugose body, with numerous visible projections along the pronotum and numerous teeth on all femora. Humeral angles very widened, creating large flat projections, making the species generally appear very flat. Vertex wider than the width of one compound eye (in dorsal view). Facial carinae extremely elevated and thus very well visible in lateral view.

Similar species. There are no similar species in Peninsular Malaysia, apart from maybe *Potua coronata* Bolívar, 1887 due to its rugose morphology, but that species has hump while this species has flat humeral angles projections, making them easy to tell apart. Could also look similar to *Discotettix selysi* Bolívar, 1887, but the latter species has widened preapical antennomeres (see *D. selysi* section for more information).

History of identification. The species was described from Peninsular Malaysia and did not have too many cases of misidentification, apart from the identification as a new species of genus *Gavialidium* Saussure, 1862 by Mahmood, Idris & Salmah (2007), which was resolved in Muhammad et al. (2018).

Type locality. Bukit Kutu, Selangor, Peninsular Malaysia.

Distribution. Peninsular Malaysia (Muhammad et al. 2018).

Ecology and behaviour notes. We did not observe any living specimens in their natural habitat and do not know the type of habitat in which the species can be encountered. One observation was recently made on Facebook where a living specimen was spotted on tree bark, probably on dead tree log (listed in observed specimens), so this may represent its niche.

Figure 21. Specimen of *Eufalconius pendleburyi* Günther, 1938 from UKM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

***Falconius bedoti* (Bolívar, 1909)**

Falconius bedoti (Günther 1938, Günther 1955)

Euriotettix spinilobus (Mahmood, Idris & Salmah 2007)

Examined material. UM: 2 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia. UKM: 1 individual from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia; 1 ♀ from Melacca, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Selangor, Peninsular Malaysia (ID: 11642070).

Morphology. (Fig. 22) Rugose body with numerous small warts and with elevated pronotal projections, but not too tall and very rounded. Pronotum is very long, same as wings. Lateral lobes of pronotum end with a forward-turning spine. Distal segment of hind tarsi is inflated in females. In frontal view, distance between compound eyes is larger than width of one eye, antennae are placed at lower margin of compound eyes, frontal costa bifurcates at the level of paired ocelli, and fastigial horns are well visible but do not noticeably extend above eyes.

Similar species. *F. bedoti* can be recognized by its lateral lobes which form a forward-facing spine, but is otherwise very similar to other *Falconius* Bolívar, 1898 species found in Peninsular Malaysia. Species of this genus found in Peninsular Malaysia can be told apart by combining characters of morphology of the lateral lobes and vertex. By morphology of lateral lobes the species can be told apart from *F. clavitarsis* (Bolívar, 1887) and *F. pseudoclavitarsis* Günther, 1938. From *F. dubius* Günther, 1938 it differs by head in frontal view (*F. dubius* has vertex as wide as an eye, while *F. bedoti* has clearly wider vertex), morphology of pronotum which is generally smooth in *F. dubius* and generally gibbous in *F. bedoti* (see figures), and morphology of front femora which are relatively smooth in *F. dubius* and clearly undulating and bearing teeth in *F. bedoti*.

History of identification. I place the examined specimens within this species based on the examination of available photographs of type specimen and drawings provided in Günther's paper (1938). In the original description, Günther describes the species from Java and reports a single specimen from Penang, Peninsular Malaysia. One year later he reports a specimen of this species from Annam, Vietnam (Günther 1939). *Falconius tschernovi* Storozhenko, 2014 is a species described from Bac Giang, Vietnam (Storozhenko 2014), and only drawings of female holotype are given in the description. Description of male specimen was given one year later (Storozhenko & Dawwrueng 2015) along with photographs of said specimen. Based on examination of the listed material I found no morphological differences among the two species, and since the authors (Storozhenko 2014, Storozhenko & Dawwrueng 2015) gave no notes on differences between *F. tschernovi* and *F. bedoti* I consider the former species dubious and report our specimens as *F. bedoti*. I do consider it unlikely that these two species are synonymous as the distribution would be very large when compared to other congeners, but further research and examination of type series is needed to resolve status of the species *T. tschernovi*. Both specimens at UKM previously

reported as *Eucriotettix spinilobus* (Hancock, 1904) (Mahmood, Idris & Salmah 2007) (specimen from Melaka labeled „*Criotettix spinilobus*“, probably accidentally) agree with *F. bedoti* and I treat them as members of this species.

Type locality. Pengalengan, Java.

Distribution. Vietnam, Thailand, Peninsular Malaysia, Java (joint records of *F. bedoti* and *F. tschernovi*—until their relationship is resolved) (Storozhenko & Dawwrueng 2015, Cigliano et al. 2021).

Ecology and behaviour notes. One living specimen was observed near river in Ulu Gombak (Selangor, Peninsular Malaysia) on large rock covered in moss right beside river.

Figure 22. Morphology of *Falconius bedoti* (Bolívar, 1909) represented by specimen found at UM collection (A–C) (photographs provided by Amira Aqilah Muhammad).

***Falconius clavitarsis* (Bolívar, 1887)**

Falconius clavitarsis (Günther 1938, Blackith 1992)

Criotettix subulatus (Mahmood, Idris & Salmah 2007)

Examined material. UM: 1 ♂ from Selangor, Peninsular Malaysia. UKM: 1 ♀ from Selangor, Peninsular Malaysia (labeled *Criotettix subulatus*).

Morphology. (Fig. 23) Long pronotum and wings. Rugose body surface with visible pronotal projections (visible but not too tall and always rounded). Distal segment of tarsus inflated in females. Frontal costa bulging outwards, very well visible in lateral view. In frontal view distance between compound eyes larger than width of one eye, visible fastigial horns (but not taller than eyes), and antennae placed at the lower margin of compound eyes. Vertex much wider than width of one eye in dorsal view. It has unusual morphology of lateral lobes, which do not form a single spine but have indentation in the middle, seemingly creating two spines. The living specimens we observed had a bright yellow stripe along the median carina of pronotum, with lighter coloration at the places of its projections.

Similar species. The species is most similar to *F. pseudoclavitarsis* in Peninsular Malaysia, from which it differs by morphology of vertex (distance between compound eyes much larger in *F. clavitarsis*).

History of identification. These are, to my knowledge, the only two specimens of this species from Peninsular Malaysia. The specimen at UKM was originally identified as *Criotettix subulatus* Bolívar, 1887 by Mahmood, Idris & Salmah (2007), and since the authors already described the differences, I simply agree with them and place their specimens in *F. clavitarsis* instead. After examination of the holotype photographs (Cigliano et al. 2021) I found no visible morphological differences between that specimen and the specimens I examined in person, and thus conclude that they belong to the same species.

Type locality. Borneo.

Distribution. Peninsular Malaysia, Sumatra, Borneo, and Java (Cigliano et al. 2021).

Ecology and behaviour notes. We have observed only one living specimen. It was resting on a tree, not too close to any river, in Selangor. The individual was positioned very high on tree

bark, over 2 meters above the ground. It is likely that the species often goes undetected and has a small number of known specimens because of such secretive behavior.

Figure 23. Morphology of *Falconius clavitarsis* (Bolívar, 1887) specimen from Peninsular Malaysia found at UKM collection with enlarged photograph of lateral lobes of pronotum (A–C) and a display of a living specimen camouflage in its natural habitat on tree bark covered in moss (D) (author's photographs).

***Falconius dubius* Günther, 1938**

Examined material. UM: 4 ♂ from Selangor, Peninsular Malaysia; 5 ♀ from Selangor, Peninsular Malaysia. UKM: 1 ♂ from Selangor, Peninsular Malaysia.

Morphology. (Fig. 24) Very long pronotum and wings. Relatively slender, with generally smooth body without any specific decorations or pronotal projections, but slightly inflated in entire prozonal area. Lateral lobes of pronotum form a forward-facing spine. Distance between compound eyes in frontal view a bit smaller than width of one eye, vertex width close to width of one eye. Living specimens were all morphologically similar with no obvious variations. All specimens had uniformed brown coloration on smooth and rather shiny pronotum.

Similar species. The species is generally similar to all *Falconius* species found in Peninsular Malaysia, morphologically closest to *F. bedoti*. Differences are listed under *F. bedoti* chapter. The species is otherwise very similar in morphology to *F. clavatus* Bolívar, 1898 (described from Mentawai Islands) and there are actually no reliable deterministic characters to discern these two species (explained in Muhammad et al. 2018). The two species do have some differences in vertex width in dorsal view in its anterior part (in *F. clavatus* clearly narrower than width of the compound eye while it is similarly wide in *F. dubius*), length of tarsal segments of hind and front legs (in *F. clavatus* distal segment of hind tarsi is close to first tarsal segment in length, while distal segment is much shorter in *F. dubius*; tarsus of front legs longer in *F. clavatus* than in *F. dubius* when compared to tibia length), and placement of antennal grooves (clearly below compound eyes in *F. clavatus* while in *F. dubius* it seems that upper margin of antennal grooves is slightly above the bottom level of compound eyes) (note: all compared specimens for this part were females). Further comparison of type material is needed and reidentification should be done after genus revision.

History of identification. This species was not previously recorded from the region, even though existing specimens were discovered. I consider *S. razalii* to be synonymous with this species, but this will be discussed in more detail in the future. I justified my identification in the upper paragraph. I cannot be sure whether this identification is correct, because of the unclear relationship of the species with *F. clavatus*. I have compared our specimens to photographs of *F. clavatus* and *F. dubius* holotypes available on OSF and have discussed this question thoroughly

with Maks Deranja, and in the end we decided to place our specimens in this species for the reasons listed above.

Type locality. Middle East Borneo, Borneo.

Distribution. Borneo, Peninsular Malaysia (Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We saw many specimens of this species along riverbanks of secondary forests resting on larger rocks, seemingly preferring ones covered in moss. We often saw more of them on the same locality, but rarely too close one to another. Individuals blend well in their surroundings and rarely choose to escape, probably rather relying on their camouflage. It was often found on same localities as *Scelimena gombakensis*.

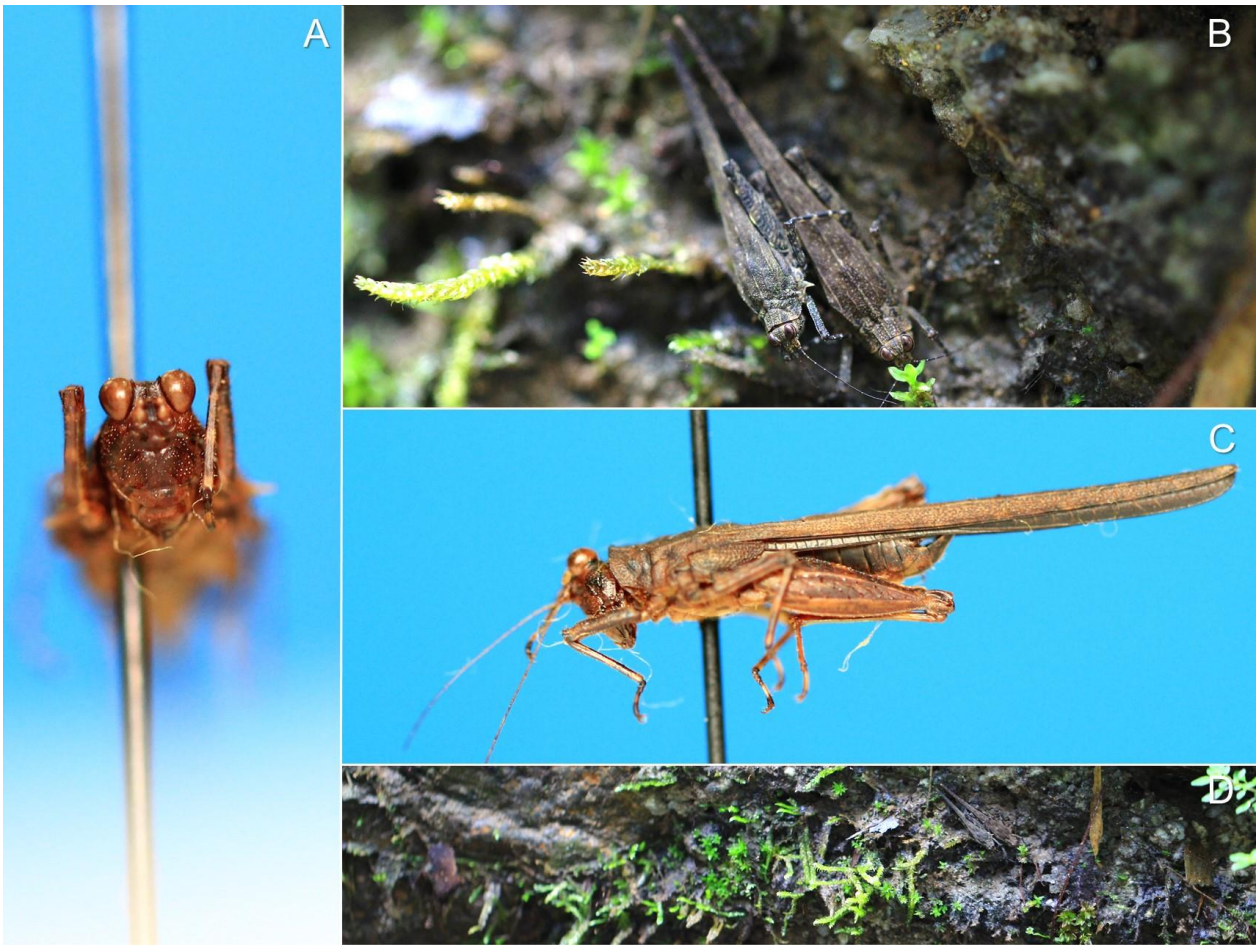

Figure 24. *Falconius dubius* Günther, 1938 morphology of pinned specimen (A, C), mating living specimens (B) and camouflage of said couple in their natural habitat (D) (author's photographs).

***Falconius pseudoclavitarsis* Günther, 1938**

Falconius pseudoclavitarsis (Günther 1938)

Criotettix vidali (Mahmood, Idris & Salmah 2007)

Examined material. *Type series*. We were hoping to examine one of the syntypes deposited in SMKM, Kuala Lumpur, Peninsular Malaysia (Cigliano et al. 2021), but it turned out that the museum is no longer functional and the collection status is unknown. Thus, depository of the specimen with following information is currently unknown: 1 ♀ syntype, Malesia, Malaya, Peninsular Malaysia: Selangor: Gombak Valley, 20.X.1921, leg. Pendlebury (Günther 1938). *Other specimens*. UM: 2 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Terengganu, Peninsular Malaysia (labeled „*Criotettix vidali*"); 1 ♀ from Selangor, Peninsular Malaysia. UKM: 2 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia.

Morphology. (Fig. 25) The species is relatively large, with variations in coloration. Specimens we found in collections all appeared to be of grey-brown coloration, all with patches of lighter coloration on hind femora. This light coloration varied from an indistinct patch to a clear white stripe almost parallel with transversal femora ridges. One living specimen was almost red in coloration, with large white spot on its anterior part of pronotum (Fig. 14 A). Pronotum is long, and wings are even longer than pronotum. It has some humped projections of pronotum, with most visible one being MM1, and some warts on its body especially on femora. Vertex width is similar to the width of an eye.

Similar species. In Peninsular Malaysia, this species most closely resembles *F. bedoti* and *F. clavitarsis* which have similar hump-like morphology of pronotum. It differs from *F. bedoti* in morphology of lateral lobes in dorsal view and from *F. clavitarsis* by head in frontal view (in *F. pseudoclavitarsis* distance between compound eyes similar to width of one eye).

History of identification. There are, to my knowledge, only a few specimens of this species reported from Peninsular Malaysia, and I know only two that have been identified. One is previously mentioned syntype identified by Günther (1938), on which I cannot give any comments as I did not examine the specimen. A number of specimens was discovered at the UKM collection, and one of them was identified as *Criotettix vidali*. Since remaining specimens here identified as *F. pseudoclavitarsis* correspond to specimens reported as *C. vidali* by Mahmood, Idris & Salmah

(2007), I report them all as *F. pseudoclavitarsis* (justification above). The species does not have many similarities with *Criotettix vidali* Bolívar, 1887, some of the most evident differences being morphology of lateral lobes, hump-like appearance of shoulders, inflated last tarsal segment of females, and head morphology in frontal view. I think we discovered all the specimens reported by Mahmood, Idris & Salmah (2007) as *C. vidali* but we only found one specimen from Terengganu, while the authors report two females from the locality. It is possible that the numbers were mistaken in their paper, but since only a single specimen had label with identification on it I cannot be sure of the identity of the fourth specimen, and this should be checked in the future. I treat this species as *F. pseudoclavitarsis* as I cannot find any strong morphological differences between specimens from Peninsular Malaysia and available photographs of type specimen (Cigliano et al. 2021).

Type locality. Middle East Borneo (5 syntypes) and Gombak Valley, Selangor, Peninsular Malaysia (1 syntype).

Distribution. India, Borneo, Peninsular Malaysia (Günther 1938, Blackith 1992, Muhammad et al. 2018, Cigliano et al. 2021).

Ecology and behaviour notes. We have observed three individuals in natural habitat, all from Pahang (Peninsular Malaysia). One was observed resting on a tree, at the height of about 1.5 meters, second specimen showed similar behaviour but I do not have notes of the height it was found on. Another specimen was observed flying over river and landing on a large rock in the middle of said river. All specimens were observed during daytime. It appears the species depends on rivers and large streams in the rainforest, spending time both on rocks of the river and on nearby trees, preferring preserved habitats of secondary forests.

Figure 25. Morphology of *Falconius pseudoclavitarsis* Günther, 1938 living specimen in its natural habitat (A) and pinned specimen (B, C, E), and labels of the pinned specimen from UM collection (D) (author's photographs).

***Scelimena gombakensis* Muhammad, Tan & Skejo, 2018**

Scelimena producta (Mahmood, Idris & Salmah 2007, Storozhenko & Dawwrueng 2015)

Scelimena gombakensis (Muhammad, Tan & Skejo 2018)

Examined material. UM: 3 ♂ from Pahang, Peninsular Malaysia; 1 ♀ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia. UKM: 1 ♂ from Pahang, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Pulau Pinang, Peninsular Malaysia (ID 20687721, 36773269); 1 individual from Kelantan, Peninsular Malaysia (ID: 84546541); 1 individual from Perak, Peninsular Malaysia (ID: 45968367); 1 individual from Selangor, Peninsular Malaysia (ID: 63194111); 1 individual from Negeri Sembilan, Peninsular Malaysia (ID: 35679667). Flickr: 1 individual from Perak, Peninsular Malaysia (https://www.flickr.com/photos/45763236@N02/5637267141).

Morphology. (Fig. 26) Large species (in terms of size in pygmy grasshoppers), with very long pronotum extending far beyond hind femora. Lateral lobes form outwards and slightly forwards pointing spine. General body coloration is dark, almost black, but projections are coloured bright yellow, making them well-noticeable. Projetions of pronotum are visible, but not too large, and generally rounded at the tip rather than pointed. Morphology and comparison to morphologically similar species is given in detail in Muhammad et al. (2018). Nymphs have morphology very similar to adults, with the most notable difference of significantly shorter pronotum. Adult specimens show obvious variation in size, something that is an interesting topic for future research. Only a single specimen has been observed that has general body coloration in shades of brown and red, with pronotum markings colored orange (Fig. 20 D, specimen on the left), as opposed to the common dark, almost black coloration with yellow markings (Fig. 20).

Similar species. There are no similar species in Peninsular Malaysia. Species otherwise similar to *S. gombakensis* are *S. discalis* (Hancock, 1915) (described from Upper Assam in India and Thailand) and *S. melli* Günther, 1938 (described from Southeast China). *S. gombakensis* differs from the former in morphology of head and deeper tegminal sinus and from the latter by size (Muhammad et al. 2018). As morphological differences are not too strong for these species (especially *S. melli*, as acknowledged in the original description of *S. gombakensis*), it is important to note that their distribution ranges do not overlap, at least to our current knowledge, and they can be divided by this fact at the moment. Comparison with type specimens would be the ideal option to avoid misidentification. Another similar species is *S. producta producta* (Serville, 1838) (described from Java), which is the identity most *S. gombakensis* specimens got during the past (see below). Just to give some differences, the two species can be told apart by tubercules of humeral angles being almost pointed in *S. producta producta* and more rounded in *S. gombakensis* and ventral side of hind femora having numerous clearly visible teeth in *S. producta producta*,

while *S. gombakensis* only has two teeth which are much smaller and less visible (Muhammad et al. 2018).

History of identification. Although *S. gombakensis* was described relatively recently, there are already new notes to be added about the species. The species was originally described as a species with rather narrow distribution, being endemic to Ulu Gombak (Selangor, Peninsular Malaysia) (Muhammad et al. 2018), and I therefore did not expect to find much, if any, specimens of this species in the existing collections collected prior to species description. However, numerous specimens belonging to this species were discovered at both UKM and UM specimen collections, all identified as *Scelimena producta* by both Mahmood, Idris & Salmah (2007) and D.K.McE. Kevan (note on specimen label). Here, I follow the recent revision of tribe Scelimenini (Muhammad et al. 2018) and after specimen examination report that all specimens belong to *S. gombakensis* (as confirmed by Amira Aqilah Muhammad).

Type locality. Peninsular Malaysia, Selangor, Ulu Gombak Field Studies Centre.

Distribution. Peninsular Malaysia (distribution update will be published in a separate paper) (Muhammad, Tan & Skejo 2018).

Ecology and behaviour notes. Specimens can be found resting on large rocks near rivers and streams. We never encountered *S. gombakensis* in a different habitat, not even on nearby trees. While resting, their coloration helps them blend rather well with their environment, making it unexpectedly hard to spot individuals. When disturbed, they can cover large distances with their jump, propelling themselves in the air, and can then start flying. While flying, they can easily cross from one side of the river to another. They can also maneuver quite well during flight. They can also swim, and while swimming they are able to control the direction of their swim. They also do not immediately come out of the water and can spend a considerable amount of time submerged underwater, resting.

Figure 26. Living specimen of *Scelimena gombakensis* Muhammad, Tan & Skejo, 2018 morphology (A–C) and position above the river in natural habitat (D) (author's photographs).

***Scelimena razalii* Mahmood, Idris & Salmah, 2007**

Scelimena razalii (Mahmood, Idris & Salmah 2007, Muhammad et al. 2018)

Examined material. *Type series*. UKM: 1 ♀ HT from Pahang, Peninsular Malaysia; 1♂ AT from Pahang, Peninsular Malaysia; 1 ♀ PT from Pahang, Peninsular Malaysia.

This species was descibed from Peninsular Malaysia. I comment on this species in a simplified form because I do not think the species belongs to genus *Scelimena*, and I in fact think it might be a synonym. For now, the species is listed here but its validity needs to be discussed in the future.

Type locality. Kuala Lompat, Pahang, Peninsular Malaysia.

Distribution. Pakistan, Peninsular Malaysia (Muhammad et al. 2018, Maitlo & Panhwar 2021).

Note. Species presence should be confirmed.

4.1.6. Tetriginae Rambur, 1838

***Coptotettix nigrifemurus* Deng & Jiang, 2017**

Coptotettix capitatus (Mahmood, Idris & Salmah 2007)

Examined material. UM: 10 ♂ from Pahang, Peninsular Malaysia; 5 ♀ from Pahang, Peninsular Malaysia; 2 ♂ from Selangor, Peninsular Malaysia; 2 ♀ from Selangor, Peninsular Malaysia. UKM: 1 ♀ from Terengganu, Peninsular Malaysia; 1 ♀ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 individual from Pulau Pinang, Peninsular Malaysia (ID: 24169747); 1 individual from Pahang, Peninsular Malaysia (ID: 18838268); 1 ♂ from Selangor, Peninsular Malaysia (ID: 67460345); 2 individuals from Selangor, Peninsular Malaysia (ID: 20203301, 36463746); 1 ♀ from Negeri Sembilan, Peninsular Malaysia (ID: 49540404); 1 individual from Negeri Sembilan, Peninsular Malaysia (ID: 36311689).

Facebook: 1 individual from Pahang, Peninsular Malaysia (https://www.facebook.com/groups/TheEntomologyGroup/posts/10156978366888393/); 1 ♀ from Peninsular Malaysia (https://www.facebook.com/photo/?fbid=10153443477286429&set=pcb.935915553151299).

Morphology. (Fig. 27) Relatively small pygmy grasshopper, rather variable in coloration, but usually in shades of brown. Females and males look very different at first, and can even appear to be a different species, so this is something to be careful about when dealing with this species. Pronotum relatively flat in lateral view, with some subtle tubercules. Frontal costa bifurcates above the level of paired ocelli. Fastigium somewhat elevated, can be above the level of compound eyes in frontal view. In lateral view, vertex and fastigium are above the compound eyes, while frontal

costa is in front of eyes. Pronotum generally not extending beyond hind femora. Hind femora thick, often with dark coloration of ventral half.

Similar species. Similar to *C. rotundatus* in Peninsular Malaysia, and differences are explained under that species' section. Otherwise similar to numerous other *Coptotettix* species, which is explained in that section as well. Some specimens of the species from Peninsular Malaysia were previously identified as *C. capitatus* Bolívar, 1887 (described from Java) (see the next section), but since the genus is in need of revision and specimens are so close to *C. nigrifemurus* (described from Thailand), I think the only reliable way of telling those species apart is by geographic distribution (note: I only take type specimens in consideration because *C. nigrifemurus* is a recently described species and its actual distribution is unknown, as well if some *C. capitatus* specimen actually belong to this species).

History of identification. The genus is very problematic for identification due to its large number of species and numerous similar genera. Thus, it is very likely that this identification is wrong and that the genus has numerous synonyms, not even all from the genus. Since I was not able to discover any morphological differences between our specimen and *C. nigrifemurus* I decided to place them within the species in hopes of aiding future research. I think specimens Tan & Kamaruddin (2014) reported as *Coptotettix* sp. belong to this species as well. After personal examination I consider the specimen Mahmood, Idris & Salmah (2007) identified as *C. capitatus* members of this species as well.

Type locality. Phu Hin Rong Kla National Park, Loei Province, Thailand.

Distribution. Thailand, Peninsular Malaysia (Deng & Jiang, 2017, *this thesis*).

Ecology and behaviour notes. Probably the most common species in the grass, especially at forest edges. We have encountered specimens during daytime.

Figure 27. Morphology of *Coptotettix nigrifemurus* Deng & Jiang, 2017 living specimen from Peninsular Malaysia (B, C) and head morphology of pinned specimen (A) (A: provided by Amira Aqilah Muhammad; B, C: author's photographs).

***Coptotettix rotundatus* Hancock, 1907**

Coptotettix interruptus (Mahmood, Idris & Salmah 2007)

Paratettix scaber (Mahmood, Idris & Salmah 2007)

Examined material. UM: 1 ♂ from Pahang, Peninsular Malaysia; 2 ♀ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia; 1 ♀ from Selangor, Peninsular Malaysia. UKM: 2 ♂ from Selangor, Peninsular Malaysia; 2 ♀ from Selangor, Peninsular Malaysia; 1 ♀ from Negeri Sembilan, Peninsular Malaysia.

Morphology. (Fig. 28) Vertex straight in frontal view, can even seem a bit convex. Antennal grooves placed clearly above the lower margin of compound eyes, and frontal costa bifurcates almost at the very top of the head. In lateral view, vertex and fastigium are clearly above the compound eyes, while frontal costa is in front of eyes and very rounded. Pronotum is long in almost all observed specimens, but one specimen was discovered at UM that had short pronotum (Fig. 10 B), so this character seems to be variable within species. Pronotum rugose, with numerous decorations which are much more noticeable in older specimens. Elytrae are rounded but elongated. Hind femora are very thick.

Similar species. *Coptotettix* Bolívar, 1887 is a hard genus for identification. It has large number of species, many of which are probably synonyms. There are also probably many misplaced species, especially in the genus *Hyboella* Hancock, 1915. *Coptotettix* differs from *Hyboella* species by morphology of lateral lobes of pronotum (in *Hyboella* they are „*dilated or reflexed*"—compare type specimens of *H. tentata* Hancock, 1915 and *C. asperatus* Bolívar, 1887), by general appearance of *Hyboella* being of stouter stature, and position of antennae (antennal grooves positioned at the level or below the lower margin of compound eyes in *Hyboella*, while they are positioned clearly above the lower margin in *Coptotettix*) (further explanation in Hancock 1915). In Peninsular Malaysia, only other species of the genus I report is *C. nigrifemurus* Deng & Jiang, 2017, from which this species differs by morphology of its head in frontal view—*C. nigrifemurus* has more protruding eyes and vertex of examined specimens of *C. rotundatus* is almost completely straight. In Southeast Asia the species is similar to a number of its congeners, namely *C. asperatus* Bolívar, 1887 (described from Vietnam; elytrae in *C. rotundatus* have lower width to length ratio), *C. conspersus* Hancock, 1915 (described from India; morphologically very close); *C. ferrugineus* Bolívar, 1887 (described from Philippines; morphologically very similar to *C. rotundatus*), *Coptotettix fuliginosus fuliginosus* Bolívar, 1887 (imprecise type locality: Malesia; elytrae in *C. rotundatus* have lower width to length ratio), and *C. interruptus* Bolívar, 1887 (described from Java; this species has narrower vertex). Furthermore, this species can resemble certain members of genus *Paratettix* Bolívar, 1887, mostly *P. histricus* (Stål, 1861) (*C. rotundatus* has larger distance between compound eyes in frontal view).

History of identification. *Coptotettix* is a complicated genus in need of revision which probably has a lot of misidentified species. There are not many records of the genus for Peninsular

Malaysia, so species reported for the wider region were all considered as possible identifications for these specimens. After specimen examination, I correct identification presented in Mahmood, Idris & Salmah (2007) to this species, with easiest difference being head morphology in frontal view by which their specimens correspond to this species. I consider that specimens D.K.McE. Kevan identified as *Paratettix histricus* all belong to this species. Because this genus is in such a problematic state and the fact that specimens have already been misidentified as belonging to genus *Paratettix*, I think a lot more misidentified specimens will be discovered. I place our specimens in this species, though it is very close in morphology to a lot of its congeners and it is possible that it in fact belongs to some other species listed above. I think our specimens could belong to the same species as specimens from Thailand that had been identified as *C. conspersus* Hancock, 1915 by Storozhenko & Dawwrueng (2015).

Type locality. Borneo (see subspecies information in original descriptions for more precise localities).

Distribution. Borneo, Peninsular Malaysia (Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We have encountered a few specimens in their natural habitat, respectively in tall grass.

Figure 28. Two specimens of *Coptotettix rotundatus* Hancock, 1907 from UM collection, one with long pronotum (A–C) and one with short (D), for comparison (photographs provided by Amira Aqilah Muhammad).

***Ergatettix interruptus* (Brunner von Wattenwyl, 1893)**

Ergatettix interruptus (Mahmood, Idris & Salmah 2007, Storozhenko & Dawwrueng 2015)

Examined material. UKM: 1 ♀ from Pahang, Peninsular Malaysia.

Morphology. (Fig. 29) Long pronotum, with small but well visible projections on median carina, with posthumeral spots. Wings longer than pronotum. Compound eyes are large, mostly above the level of pronotum in lateral view. Antennae are placed below the compound eyes.

Distance between compound eyes is a bit smaller than width of one eye, narrower at the top than at the bottom.

Similar species. Close in morphology to *Ergatettix dorsiferus* (Walker, 1871) (described from India). I concluded with Josip Skejo that it appears those two species are closely related, with *E. interruptus* being eastern species while *E. dorsiferus* has western distribution range. Another similar species is *Euparatettix nodulosus* Hancock, 1912 (described from India), to which *E. interruptus* was compared in detail by Tumbrinck (2015). Other than that, I do not think there are other morphologically similar species which can be found in Peninsular Malaysia, thanks to the morphology of median carina of pronotum and eyes being above the level of pronotum.

History of identification. The species was reported for the region by Mahmood, Idris & Salmah (2007), Storozhenko & Dawwrueng (2015) followed this, and I agree with this identification after specimen examination at UKM museum.

Type locality. Carin Cheba, Myanmar.

Distribution. India, Myanmar, Laos, Thailand, Peninsular Malaysia (Cigliano et al. 2021).

Ecology and behaviour notes. We did not encounter any living specimens in their natural habitat.

Figure 29. Morphology of pinned specimen of *Ergatettix interruptus* (Brunner von Wattenwyl, 1893) from UKM museum (A–C) (photographs provided by Maks Deranja).

***Euparatettix mimus* (Bolívar, 1887)**

Euparatettix mimus (Hancock 1907, Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

This is a confusing species and I do not really know how to recognize it. Josef Tumbrinck (in 2018) added comment on OSF saying that „*after study of photos from the types* E. mimus *seems to be synonym with* Euparatettix personatus“ (Cigliano et al. 2021). Bolívar (1887) describes both species in the same work, but does not really explain how he tells the species apart and I found no strong morphological differences mentioned in the original descriptions. Thus, additional

examination of existing specimens from Peninsular Malaysia is needed to confirm species presence in the region. Also, examination of *E. mimus* type specimens is needed to check validity of the species.

Type locality. Philippines.

Distribution. Philippines, Peninsular Malaysia, Sulawesi, Java (Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Euparatettix personatus* Hancock, 1907**

Euparatettix scabripes (Mahmood, Idris & Salmah 2007)

Examined material. UM: 3 ♂ from Selangor, Peninsular Malaysia. UKM: 1 ♂ from Selangor, Peninsular; 1 ♀ from Selangor, Peninsular Malaysia (labeled as *Euparatettix scabripes*; note: unsure of the locality of specimens from UKM since label on specimen gives „UKMS“ as locality, which would refer to UKM Sabah (Borneo), but Mahmood, Idris & Salmah (2007) only report specimens from Selangor, so I follow published information here).

Social media. iNaturalist: 1 individual from Malacca, Peninsular Malaysia (ID: 50401148).

Morphology. (Fig. 30) This is the type species of genus *Euparatettix* Hancock, 1904, and as such has specific characteristics of the genus. Its pronotum and wings are long, longer than hind legs. It has relatively wide shoulders, but the pronotum looks tightened in the front part. Eyes are clearly above the level of pronotum in lateral view. This species always has distinct white band at the top of its hind tibia, that remains visible in pinned specimens, even if they are old (for example check lectotype photographs available on OSF (Cigliano et al. 2021)).

Similar species. The species is similar to *E. mimus*, but the validity of that species is questionable and this is discussed in the *E. mimus* paragraph above. The species is very similar to *E. scabripes* (Bolívar, 1898) from which it is easily separated by the presence of white band on top of hind tibiae, a character that *E. scabripes* lacks. Detailed species descriptions of genus *Euparatettix* and comparison to other species are given in Tumbrinck (2015).

History of identification. The validity of the species is currently questioned since Tumbrinck (in 2019) stated on OSF (Cigliano et al. 2021) it could be synonymous with *Euparatettix balteatus* (Walker, 1871). Specimens Mahmood, Idris & Salmah (2007) reported as *E. scabripes* agree with *E. personatus* because they have distinct white band on tibia.

Type locality. Philippines.

Distribution. Philippines, Sri Lanka, Borneo, Peninsular Malaysia, Java, Sulawesi (Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We encountered many specimens of the species in their natural habitat, mostly during night. They were common in habitats covered with low grass, often found along with *Hedotettix gracilis*, and often with nearby dead tree logs and branches. They also seemed to be attracted to light. The species seems to be rather common, but we always found individuals, never larger groups of these animals.

Figure 30. Pinned specimen of *Euparatettix personatus* Hancock, 1907 from UM collection (note the white stripe at the proximal part of hind tibia) (A–C) (photographs provided by Amira Aqilah Muhammad).

***Euparatettix tricarinatus* (Bolívar, 1887)**

Paratettix tricarinatus (Günther 1971, Shishodia 1991b, Shishodia 2007, Buzzetti & Devriese 2008)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

In newer papers, Shishodia, Chandra & Gupta (2010) and Deng (2016) do not list Malaysia as distribution area anymore. It is likely that specimens previously reported as *Euparatettix tricarinatus* belong to *E. personatus*.

Type locality. Philippines.

Distribution. India, China (southeast), Myanmar, Taiwan, Philippines, Peninsular Malayia, New Guinea, Sulawesi, Indonesia, Timor (Buzzetti & Devriese 2008, Shishodia, Chandra & Gupta 2010, Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Hedotettix costatus* Hancock, 1912**

Hedotettix costatus (Günther 1937b)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

As far as I was able to research, this species was mentioned for the region only by Günther (1937b). The author himself was unsure of this identification, and since no other authors agreed with this identification and species distribution, the species is unlikely to be present in Peninsular Malaysia. It is likely that those specimens in fact belong to *Hedotettix gracilis*.

Type locality. India.

Distribution. India, Nepal, Bangladesh, Sulawesi (Gupta & Chandra 2017).

Note. Species presence should be confirmed.

***Hedotettix gracilis* (Haan, 1843)**

Paratettix cingalensis (Mahmood, Idris & Salmah 2007)

Examined material. UM: 5 ♀ from Pahang, Peninsular Malaysia; 8 ♂ from Pahang, Peninsular Malaysia; 6 ♂ from Selangor, Peninsular Malaysia; 4 ♀ from Selangor, Peninsular Malaysia. UKM: 1 ♀ from Kedah, Peninsular Malaysia.

Social media. iNaturalist: 4 individuals from Selangor, Peninsular Malaysia (ID: 81443699, 84520397, 78862414, 77675875).

Morphology. (Fig. 31, 32) Two distinct varieties can be found, one with long pronotum and another with much shorter pronotum. The most recognizable feature of this species is its elevated and curved median carina of pronotum which is clearly above the level of head in lateral view. In the specimen with long pronotum we discovered from Kedah its wings are significantly longer than pronotum. Lateral carinae of vertex on head (in frontal view) are not higher than compound eye in any part, and its scutellum is wide and clearly visible in frontal view. Specimens with short pronotum were much more common, and only specimens from Pahang and Selangor states were discovered so far. They show high variability in coloration, with general coloration usually being brown, but having different kinds of patterns ranging in coloration from black, grey, green, and even to pink. Otherwise, morphology rather uniformed, with broadened fore femora (characteristic for the genus), pronotum crested in its anterior half (slightly, but very noticeable), pronotum not significantly surpassing hind femora (sometimes slightly shorter, sometimes reaching hind femora, and sometimes slightly surpassing hind femora; not significantly variable character in observed specimens), and non-protruding eyes (vertex and facial carinae in lateral view always above and in front of eyes).

Similar species. Specimens with short pronotum look very similar to *H. triangularis* Zha & Hyde, 2016, but according to comparison to *H. gracilis* given by Zha et al. (2016a) our specimens agree with *H. gracilis*. Specimens from Peninsular Malaysia are also close to *H. attenuatus* Hancock, 1904 (described from Sri Lanka), *H. quadriplagiatus* (Walker, 1871) (described from India), *H. rusticus* Bolívar, 1887 (described from Philippines), as well as description of *H. coactus* Bolívar, 1887 (described from Sumatra). The most reliable way of separating these species at the moment is their geographical distribution, at least until photographs of type specimens of *H. coactus* becomes available. Specimens with long pronotum look like *Euparatettix indicus* (Bolívar,

1887) (described from Southeast Asia—imprecise type locality), *Paratettix variabilis* (described from Philippines) and *Tetrix munda* (Walker, 1871) (described from India). All these species are similar, and comparison with type specimens is the only reliable option when trying to identify specimens with long pronotum.

History of identification. I am not sure what *H. coactus* looks like, and therefore find it to be a possible correct identification of my specimens since the description fits rather well. I find no strong morphological characters to not consider our specimens to be *H. gracilis*, and they even fit the already recorded variability of pronotum length in the species (Wagan & Kevan 1992). All the specimens we found in Peninsular Malaysia are of the same species, so for now I consider *H. gracilis* to be the only species of the genus in this region. The species is very problematic for identification because it looks like a lot of other species (listed above), and some of them will probably become synonyms in the future. I list Mahmood, Idris & Salmah (2007) here because the specimen from UKM collection that was labeled „*Paratettix singalensis*“ (with the minor misppelling) fits this species much better.

Type locality. Sulawesi.

Distribution. China, Pakistan, India, Nepal, Myanmar, Vietnam, Thailand, Taiwan, Sri Lanka, Peninsular Malaysia, Sumatra, Singapore, Java, Sulawesi (Gupta & Chandra 2017, Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. The species was very common in open meadows during night. We almost never encountered it during daytime, but at night it was found in large numbers, together with *Thoradonta*, *Euparatettix*, and *Lamellitettigodes*. This was one of the most common species we had encountered. It is likely that specimens with long pronotum inhabit most northern parts of Peninsular Malaysia (because the only such specimen we found is the one from Kedah) and southern states are inhabited by variety with shorter pronotum.

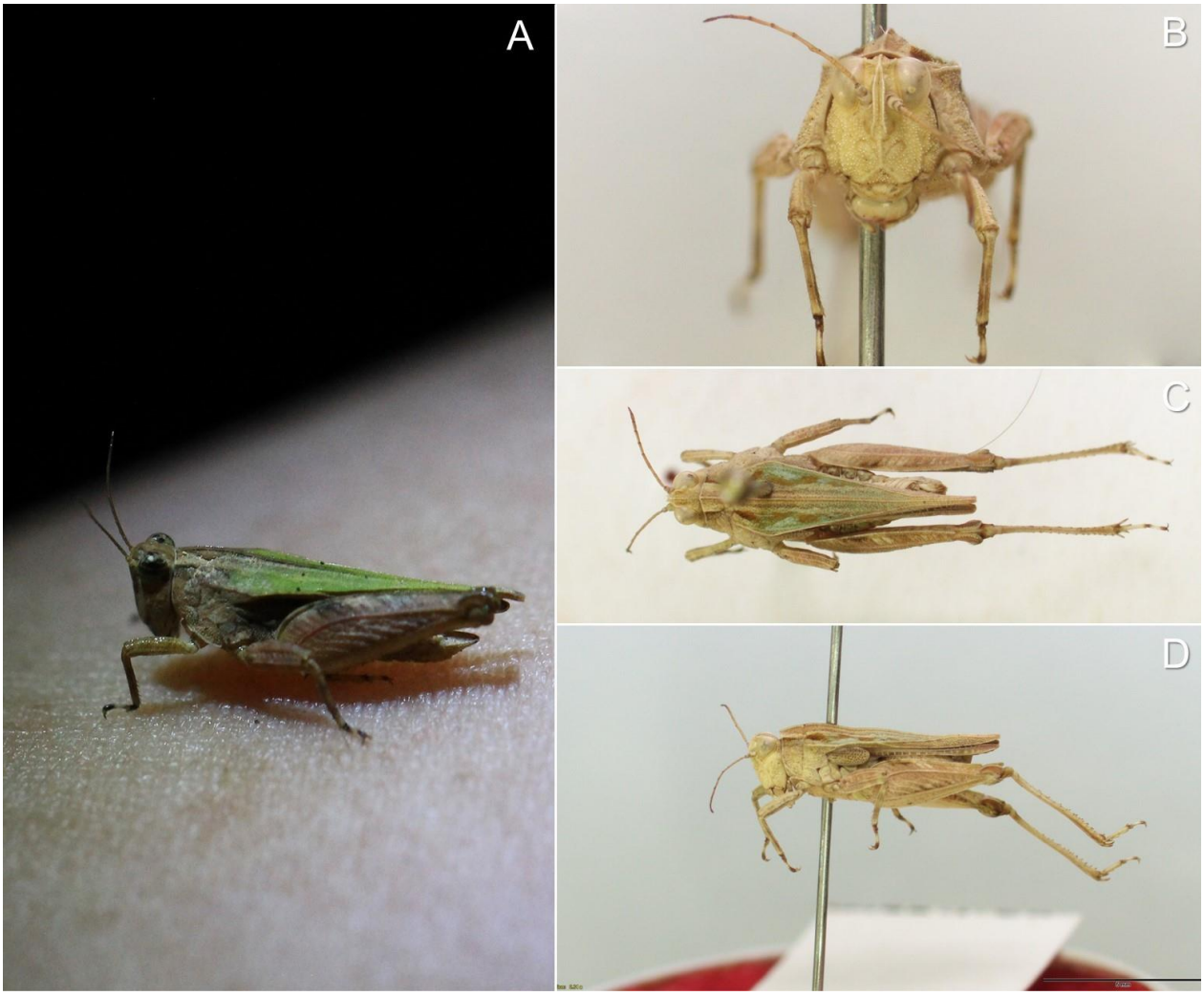

Figure 31. Morphology of *Hedotettix gracilis* (Haan, 1843) specimens with short pronotum from Peninsular Malaysia, both living (A) and pinned (B–D) (A: author's photography; B, C, D: photographs provided by Amira Aqilah Muhammad).

Figure 32. Pinned specimen of *Hedotettix gracilis* (Haan, 1843) with long pronotum from Kedah, Peninsular Malaysia, found at UKM collection (A–C) (author's photographs).

***Lamellitettigodes contractus* (Bolívar, 1887)**

Lamellitettigodes contractus (Günther 1939, Blackith 1992)

Examined material. UM: 2 ♀ from Pahang, Peninsular Malaysia.

Social media. iNaturalist: 1 ♂ from Pahang, Peninsular Malaysia (ID: 10112652).

Morphology. (Fig. 33) Coloration is very variable from one specimen to another, but often with two larger black spots on dorsal side of pronotum (posthumeral spots), that are sometimes merged in one dark line. Front and mid femora with well visible undulations of their carinae. When viewed from frontal view, fastigial horns can be seen, that either do not or just barely rise above the level of compound eyes. Pronotum long, relatively flat in lateral view (compare to *L. sagittatus*

below). In lateral view, tip of fastigium is projected in front of compound eyes, along with frontal costa (see Tumbrinck (2019) for detailed description).

Similar species. Living specimens are very similar to *Euparatettix personatus*, but can be easily recognised by the presence of fastigial horns and morphology of the tip of fastigium (which is not protruding and more rounded in *Euparatettix*). Very similar to *L. sagittatus*, but *L. contractus* has relatively flattened pronotum while it is elevated in *L. contractus* (see *L. sagittatus* section for further detail). Recently, the genus was revised, and detailed species description and species key for all *Lamellitettigodes* Günther, 1939 species was provided by Tumbrinck (2019).

History of identification. For identification of our specimens I used the key provided by Tumbrinck (2019), who was even kind enough to personally check and confirm species identification of a few specimens and provided some additional explanations. One specimen from UM collection was identified by D.K.McE. Kevan as being close to *Paratettix cingalensis* (Walker, 1871) („*Paratettix variegatus* group"), but its morphology completely agrees with this species.

Type locality. Borneo.

Distribution. Philippines, Borneo, Peninsular Malaysia, Sumatra, Singapore, Java, Sulawesi, and Solomon Isl (Tumbrinck 2019, Cigliano et al. 2021).

Ecology and behaviour notes. Relatively common species that we always encountered on or near dead trees, in the same place as *Thoradonta* specimens. These specimens almost always remained calm during daytime, making them very hard to spot thanks to their cryptic appearance. During night, we sometimes encountered the species in low grass habitats, together with *Hedotettix gracilis* for example.

Figure 33. Morphology of *Lamellitettigodes contractus* (Bolívar, 1887), both living (A) and pinned specimen (B), with a display of how specimens' morphology blends it in with dead tree bark (C) (each photograph represents different individual) (A, C: author's photographs; B: photograph provided by Amira Aqilah Muhammad).

***Lamellitettigodes sagittatus* (Bolívar, 1887)**

Euparatettix pulvillus (Hancock 1910)

Euparatettix sagittatus (Günther 1937a)

Euparatettix variabilis (Mahmood, Idris & Salmah 2007)

Lamellitettigodes sagittatus (Tumbrinck 2019)

Examined material. UM: 3 ♂ from Pahang, Peninsular Malaysia; 3 ♀ from Pahang, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia. UKM: 1 ♀ from Pahang, Peninsular Malaysia; 3 ♀ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 ♀ from Pulau Pinang, Peninsular Malaysia (ID: 62698926).

Morphology. (Fig. 34) As all other *Lamellitettigodes* species it has long pronotum, frontal costa and tip of fastigium projected in front of compound eyes in frontal view, undulated carinae of front and mid femora, and fastigial horns visible in frontal view. *L. sagittatus* has elevated median carina of pronotum, which is „*in lateral view, not continuously bent to tip of pronotum; in prozona (pronotum area anterior to shoulders) rising again*“ (Tumbrinck 2019).

Similar species. Very close to *L. contractus*, which lacks elevation of median carina of pronotum and the species can be separated based on that character. I consider no other species of pygmy grasshoppers to be similar to these two and I suggest Tumbrinck (2019) as further read and *Lamellitettigodes* species key.

History of identification. As can be noticed from the references listed above, this species has an interesting taxonomic past. However, taxonomic changes were mostly a result of synonymisaties and higher taxon changes (at the level of genus), rather than misidentifications of the specimens. Mahmood, Idris & Salmah (2007) identified their specimen as *Paratettix variabilis* Bolívar, 1887 (= *Euparatettix variabilis*). Their specimen completely agrees with *Lamellitettigodes sagittatus* by the characters listed above, most simple of which would be presence of fastigial horns and morphology of fastigium in lateral view. Same reasoning is applied to specimens identified by D.K.McE. Kevan as *Paratettix variegatus* in UM collection. For identification of our specimens I used the key provided by Tumbrinck (2019).

Type locality. Daraga, Philippines.

Distribution. Vietnam, Thailand, China (Hainan), Philippines, Borneo, Peninsular Malaysia, Sumatra, Java, Moluccas, New Guinea, and Timor (Tumbrinck 2019, Cigliano et al. 2021).

Ecology and behaviour notes. We encountered this species on dead trees in the jungle, often along *L. contractus* and *Thoradonta* specimens, but this species was much rarer than the mentioned species.

Figure 34. Living specimen of *Lamellitettigodes sagittatus* (Bolívar, 1887) standing on a rock in lateral view (A) and other angles represented by a pinned specimen (B, C) (A: author's photograph; B, C: photographs provided by Amira Aqilah Muhammad).

***Paratettix cingalensis* (Walker, 1871)**

Paratettix cingalensis (Shishodia 1987, Shishodia 1991b, Blackith 1992, Mahmood, Idris & Salmah 2007, Shishodia 2007, Shishodia, Chandra & Gupta 2010, Gupta & Chandra 2017)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

The species was reported for the region by the listed authors. I did find one specimen at Mahmood's collection at UKM museum, labeled as *C. cingalensis*, and that specimen turned out to be *Hedotettix gracilis* after examination. It is possible other specimens will be reidentified as that

species as well once they are examined in person. Therefore, to confirm species presence, new specimens need to be discovered or existing specimens need to be examined.

Type locality. Sri Lanka.

Distribution. India, Nepal, Taiwan, China (Hainan), Philippines, Sri Lanka, Borneo, Peninsular Malaysia, Sumatra, Java (Shishodia, Chandra & Gupta 2010, Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Paratettix histricus* (Stål, 1861)**

Pseudoparatettix histricus (Blackith 1992, Ingrisch 2006)

Euparatettix histricus (Shishodia, Chandra & Gupta 2010)

Paratettix histricus (Gupta & Chandra 2017)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

The species was mentioned for Peninsular Malaysia by numerous authors, and even specimens labeled as *P. histricus* (or being close to that species) were found at UM museum. These specimens turned out to be misidentifications of *C. rotundatus* (see that species' section for further explanation). Since I found no specimens I would place within this species, I think its presence should be confirmed.

Note. Species presence should be confirmed.

Type locality. Java.

Distribution. Widely distributed species (Cigliano et al. 2021).

***Paratettix obesus* Bolívar, 1887**

Euparatettix semihirsutus (Mahmood, Idris & Salmah 2007)

Examined material. UM: 1 ♂ from Perak, Peninsular Malaysia. UKM: 1 ♂ from Terengganu, Peninsular Malaysia.

Morphology. (Fig. 35) A rather robust species with two humps of median carina in shoulder area (roughly at the place of MM1 and MM2 projections). Wings significantly longer than pronotum, both longer than hind legs. When head is viewed from the front, small fastigial horns can be seen, and median carina visibly bifurcates just below the vertex. Hind femora very thick, and all legs are very hairy from the bottom side.

Similar species. I believe this species to be unique in its morphology in Peninsular Malaysia, though it is possible that living specimens might resemble some other species from the region.

History of identification. D.K.McE. Kevan identified the specimen from UM collection as „*Paratettix* sp. nr. *tumidus*“, a species described from New Guinea (Günther 1938). I think the specimen is closer to *P. obesus* in morphology, and type locality and known species distribution is just further proof. The specimen found at UKM was identified as *Euparatettix semihirsutus* (Brunner von Wattenwyl, 1893) (= *Euparatettix semihersutus* in paper), and I do not agree with this identification since I think the specimen does not resemble the mentioned species.

Type locality. Asia-Tropical (by the original description).

Distribution. China, India, Nepal, India, Myanmar, Thailand, Peninsular Malaysia, Sumatra, Indonesia, Zanzibar (Storozhenko & Dawwrueng 2015, Cigliano et al. 2021, *this thesis*).

Ecology and behaviour notes. We did not observe any living specimen of the species in natural habitat.

Figure 35. Morphology of *Paratettix obesus* Bolívar, 1887 specimen from Pahang, found at UM collection (A–C) (author's photographs).

***Paratettix shelfordi* Hancock, 1909**

Paratettix shelfordi (Hancock 1909, Blackith 1992)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Species was described from Peninsular Malaysia based on one (rather damaged) specimen (Hancock 1909). I am not sure if this is a valid species, and only Hancock (1909) and Blackith (1992) ever mention it, so both validity and presence of the species remain to be confirmed.

Type locality. Larut Hills, Perak, Peninsular Malaysia.

Distribution. Philippines, Peninsular Malaysia (Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Paratettix variabilis* Bolívar, 1887**

Paratettix variabilis (Storozhenko & Dawwrueng 2015, Storozhenko 2018)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

This is a widely distributed species which is likely indeed found in Peninsular Malaysia. Unfortunately, we did not find any specimens from the region, so species presence should be confirmed with specimens from Peninsular Malaysia in the future. Mahmood, Idris & Salmah (2007) report the species for the first time for Peninsular Malaysia as *Euparatettix variabilis*, but I disagree with their identification and place their specimens under *Lamellitettigodes sagittatus* (explained in that species' section).

Type locality. Philippines.

Distribution. China, Pakistan, India, Nepal, Myanmar, Bangladesh, Thailand, Philippines, Cambodia, Sri Lanka, Borneo, Peninsular Malaysia, Sumatra, Singapore, Java, Indonesia, New Guinea (Storozhenko 2018, Cigliano et al. 2021).

Note. Species presence should be confirmed.

4.1.7. Thoradontini Kevan, 1966

***Eucriotettix oculatus oculatus* (Bolívar, 1898)**

Eucriotettix oculatus oculatus (Günther 1955, Kim & Pham 2014)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

D.K.McE. Kevan recognized one pinned specimen in UM Museum as *Eucriotettix oculatus oculatus*, as proved by the label found on. I placed that specimen in *Criotettix bispinosus*, and I suppose that only one of those two species is present in Peninsular Malaysia. Until further research is done on type specimens of those two species, I list them both here but place all my specimens under *C. bispinosus* and add the note here that *E. oculatus oculatus* presence remains to be confirmed.

Type locality. Sumatra.

Distribution. Japan, India, Tibet, China (south), Vietnam, Peninsular Malaysia, Sumatra, Java (Kim & Pham 2014, Shishodia, Chandra & Gupta 2010, Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Eucriotettix ridleyi* Günther, 1938**

? *Loxilobus* sp. (Tan & Kamaruddin 2016)

Examined material. UM: 3 ♂ from Pahang, Peninsular Malaysia; 3 ♀ from Pahang, Peninsular Malaysia. UKM: 1 ♂ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 ♀ from Pahang, Peninsular Malaysia (ID: 18838417). Facebook: 1 ♂ from Peninsular Malaysia (https://www.facebook.com/photo/?fbid=10153443476886429&set=pcb.935915553151299); 1 individual from Peninsular Malaysia (https://www.facebook.com/photo?fbid=10153443477041429&set=pcb.935915553151299).

Morphology. (Fig. 36) Long wings and pronotum. Vertex narrower than width of a compound eye, scutellum narrow, antennal grooves placed at the lower margin of compound eyes. Lateral lobes of pronotum curving away from the body, with indentation between the lobes, outer lobe not forming a spine. General body coloration in shades of brown, but living specimens (at least the ones we observed) have distinct white dots all over their body, which is either absent or much harder to see in pinned specimens, especially older ones.

Similar species. No other species has such dotted body coloration in Peninsular Malaysia, and that makes it a good character for recognzing the species. Also, morphology of lateral lobes is considered a good character for *Eucriotettix* Hebard, 1930 species recognition (for more information see Tan et al. 2017).

History of identification. I did not find any specimens at UM nor UKM museums that had identification labels and therefore there were no misidentifications of the species in the past, as far as I know. I identify examined specimens as this species because they agree with original description and holotype photographs available at OSF (Cigliano et al. 2021). Species was described from Singapore, with several consequent finds for the region (Güenther 1938, Blackith 1992, Tan et al. 2017). I think that specimen shown in the photo in Tan & Kamaruddin (2016), identified as *Loxilobus* sp. should belong to this species.

Type locality. Singapore.

Distribution. China, Peninsular Malaysia, Singapore, Sulawesi (Tan et al. 2017, *this thesis*).

Ecology and behaviour notes. We encountered this species in well-preserved forests in proximity to larger bodies of water (e.g. rivers), for example in Fraser's Hill. Specimens were observed on ground and rocks (even concrete) covered in moss.

Figure 36. Morphology of pinned specimen of *Eucriotettix ridleyi* Günther, 1938 from UM museum (A, C, D) and a living specimen in its natural habitat in Fraser's Hill (B). Notice white dots on living specimen, which are much harder to see in pinned one (A, C, D: photographs provided by Amira Aqilah Muhammad; B: author's photograph).

***Eucriotettix simulans* Tan & Storozhenko, 2017**

Loxilobus assamus (Mahmood, Idris & Salmah 2007)

Examined material. UM: 1 ♂ from Pahang, Peninsular Malaysia; 1 ♀ from Pahang, Peninsular Malaysia. UKM: 1 individual from Selangor, Peninsular Malaysia.

Morphology. (Fig. 37) Slender species with pronotum and wings extending beyond hind femora. Flat and pointed lateral lobes of pronotum (but do not form a spine). Pronotum is relatively flat and does not have any projections, but does have some minor rugose decorations. Hind femora are very slender. Eyes are large and prominent, but only partially protrude above the level of

pronotum. Vertex narrower than one compound eye. Antennal grooves placed at the lower margin of compound eyes.

Similar species. The species is similar to other *Eucriotettix* species found in the wider region, most closely resembling *E. neesoon* Tan & Storozhenko, 2018. When compared to that species, it has slightly lower positioned antennal grooves and more slender legs, but it also differs by ecology because it is associated with grass habitat, while *E. neesoon* is a forest species (as further read see Tan et al. 2017).

History of identification. The species was only recently described, and specimen Mahmood, Idris & Salmah (2007) identified as *Loxilobus assamus* agrees with description and key provided by Tan et al. (2017). However, I find this genus problematic for identification and believe that this genus and genus *Loxilobus* have a lot of misplaced and misidentified species, with many possible synonyms. Thus, it would be good to reidentify listed specimens once these two genera get revised.

Type locality. Nee Soon Swamp Forest, Singapore.

Distribution. Peninsular Malaysia, Singapore (Tan et al. 2017, *this thesis*).

Ecology and behaviour notes. We encountered many individuals in their natural habitat, always in tall grass and low plants communities, which agrees with information from the original description of the species (Tan et al. 2017).

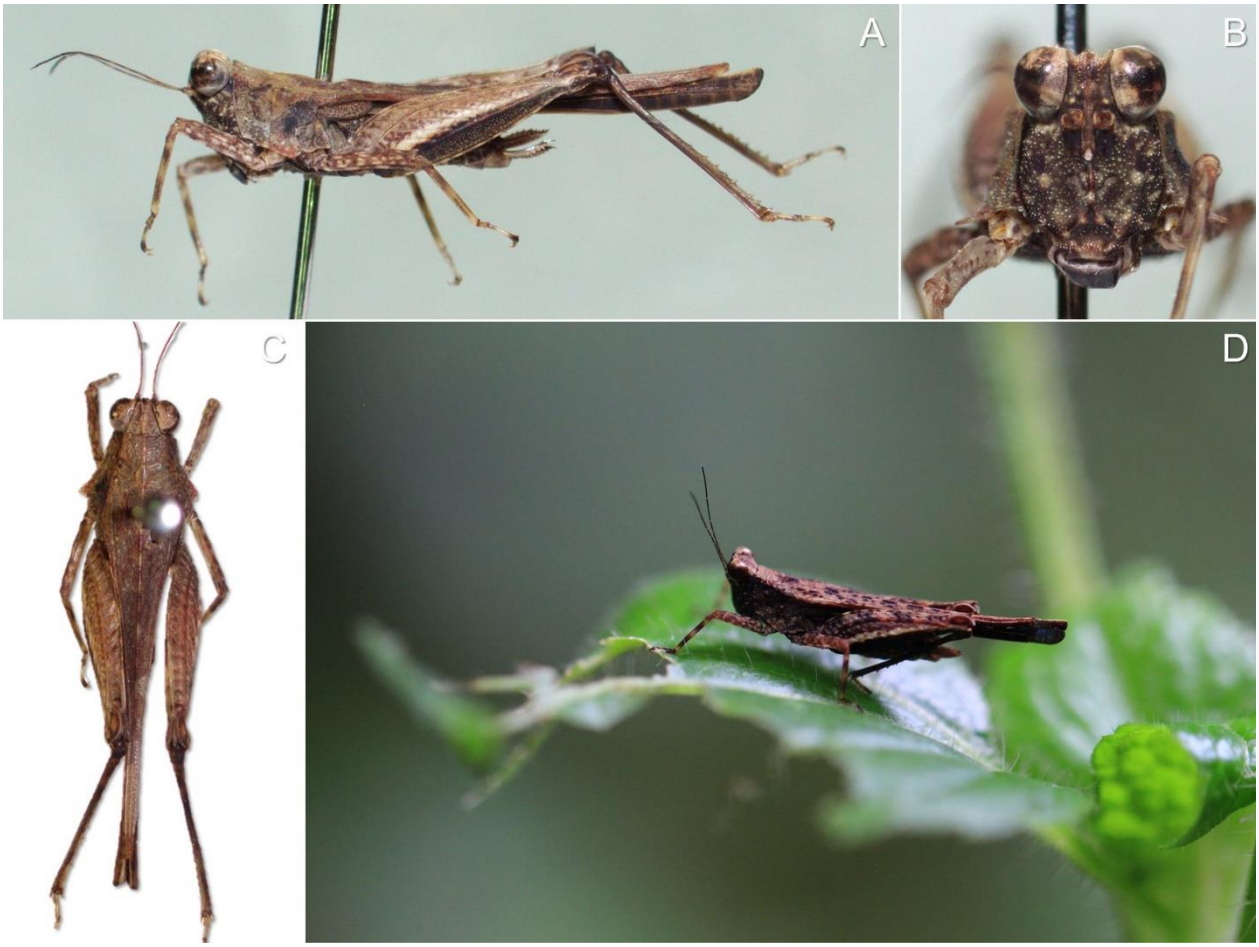

Figure 37. Morphology of *Eucriotettix simulans* Tan & Storozhenko, 2017 (A–C) and a photograph of living specimen in its natural habitat (D) (A, B, C: photographs provided by Amira Aqilah Muhammad; D: author's photography).

***Loxilobus brunneri* Günther, 1938**

Loxilobus brunneri (Tan & Kamaruddin 2016)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Species was reported for the region by Tan & Kamaruddin (2016). Based on living specimen photograph they provided, I think that specimen could in fact belong to the same species I report here report as *Coptotettix nigrifemurus*, but for this species I am not able to conclude based on a single photo and without specimen examination. Since I found no specimens that I would

place in this species, at this point I consider that species presence in Peninsular Malaysia should be additionally confirmed.

Type locality. Myanmar.

Distribution. Myanmar, China (Guangxi), Peninsular Malaysia (Cigliano et al. 2021).

Note. Species presence should be confirmed.

***Loxilobus insidiosus* (Bolívar, 1887)**

Criotettix insidiosus (Bolívar 1887)

Loxilobus insidiosus (Hancock 1907, Günther 1937a, Blackith & Blackith 1987, Blackith 1992)

Examined material. UM: 1 ♀ from Pahang, Peninsular Malaysia. UKM: 1 ♂ from Terengganu, Peninsular Malaysia.

Social media. Facebook: 1 individual from Peninsular Malaysia (https://www.facebook.com/photo/?fbid=10153443477226429&set=pcb.935915553151299).

Morphology. (Fig. 38) Small species, with cryptic appearance thanks to its brown coloration and rugose morphology of pronotum. Very noticeable character in living specimens is that they have bright yellow dot on tegmina which connects to a small yellow dot on pronotum just above tegmina. Hind femora very wide, with darker coloration on its ventral side. Wings are a bit longer than pronotum, and pronotum just barely exceeds hind femora in length. Area between the compound eyes of similar width as a compound eye in frontal view. Scutellum very narrow.

Similar species. First time I saw this species, it resembled *Thoradonta*, probably because of its small size and its somewhat gibbous appearance. Very close to *L. rugosus* in morphology, from which it differs by the fact that *L. insidiosus* has distal (= third) tarsal pulvillus as long as proximal two combined, while it is a bit shorter in *L. rugosus*; *L insidiosus* is much smaller, measuring around 8 mm in body length, while *L. rugosus* measures 11 mm (see Bolívar (1887) for detailed description of both species).

History of identification. This species is very close in morphology to *L. rugosus*. Bolívar described both of those species in the same paper (Bolívar 1887), but did not give a specific comparison commenting on how to tell those species apart. Based on original descriptions and type specimens photographs available on OSF (Cigliano et al. 2021) I assume these two species could be synonyms since I did not discover any strong morphological character that are separating them as distinct species. I identified our specimens as *L. insidiosus* because that species has a syntype from Peninsular Malaysia (Malacca), therefore making it more likely for our specimens to belong to that species. I consider that specimens Tan & Kamaruddin (2016) identified as *Loxilobus* nr. *rugosus* are in fact same species as specimens I list here under *L. insidiosus*, but further research is needed to clarify which is that species.

Type locality. Borneo and Malacca, Peninsular Malaysia (syntypes).

Distribution. Borneo, Peninsular Malaysia, Java (Cigliano et al. 2021).

Ecology and behaviour notes. We encountered this species deep in the jungle, where its morphology enabled it to blend in with the ground it was found on.

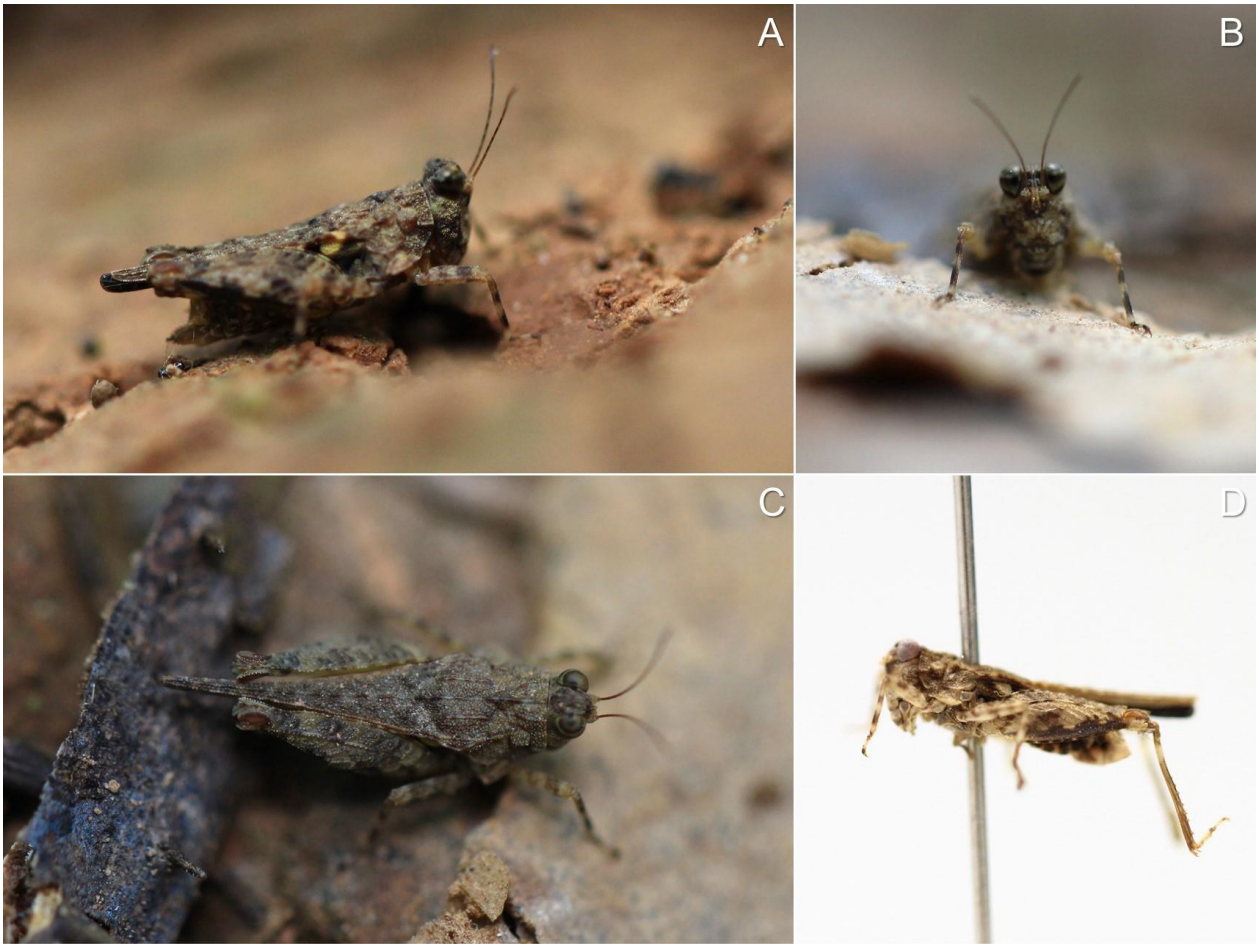

Figure 38. Morphology of living specimen of *Loxilobus insidiosus* (Bolívar, 1887) in its natural habitat (A–C) and a pinned specimen from UKM (D) (author's photographs).

***Loxilobus rugosus* (Bolívar, 1887)**

Loxilobus nr. *rugosus* (Tan & Kamaruddin 2016)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

Species was reported for the region by Tan & Kamaruddin (2016), though they identified their specimens as being close to *L. rugosus*, rather than being sure it belongs to that species. I think specimens should be compared to *L. insidiosus* as I consider it to be a preferred identification for the mentioned specimens, for the reasons listed above in that species' section.

Type locality. Borneo.

Distribution. Borneo, Peninsular Malaysia (Tan & Kamaruddin 2016, Cigliano et al. 2021, *this thesis*).

Note. Species presence should be confirmed.

***Thoradonta nodulosa* (Stål, 1861)**

Criotettix nodulosus (Stål 1861, Bolívar 1887, Hancock 1907)

Thoradonta nodulosa (Hancock 1915, Shishodia, Chandra & Gupta 2010, Zha et al. 2016b, Gupta & Chandra 2017)

Examined material. UM: 2 ♂ from Pahang, Peninsular Malaysia; 2 ♀ from Pahang, Peninsular Malaysia; 2 ♂ from Selangor, Peninsular Malaysia; 5 ♀ from Selangor, Peninsular Malaysia.

Social media. iNaturalist: 1 ♂ from Kedah, Peninsular Malaysia (ID 32256788); 1 ♀ from Perak, Peninsular Malaysia (ID: 68852838); 1 individual from Pahang, Peninsular Malaysia (ID: 19966597); 12 individuals from Selangor, Peninsular Malaysia (ID: 11635415, 24569774, 24349652, 24358521, 86595581, 82312480, 83610854, 82860700, 23810789, 20059811, 12072132, 81649418); 1 individual from Negeri Sembilan, Peninsular malaysia (ID: 66911533). Flickr: 1 individual from Selangor, Peninsular Malaysia (https://www.flickr.com/photos/some_soul/15947076360).

Morphology. (Fig. 39) Wide vertex and distance between compound eyes in frontal view (larger than width of one eye). Pronotum with large undulations along its carinae (both median and lateral). Legs also have undulations, giving the species overall rugose appearance. Lateral carina of pronotum curved inwards in the area above tegmina in dorsal view, not following the usually straight outline of pronotum. Length of pronotum and wings variable, length relation of mentioned body parts variable relative to hind femora as well.

Similar species. There are many similar species within the genera, but I consider this to be the only valid species of the genus known from Peninsular Malaysia. For specimen identification comparison with type specimens and original descriptions is needed.

History of identification. The most similar species is *T. dentata* Hancock, 1909, described from Pulo Penang (Peninsular Malaysia), but the species was already recognized as synonym by Josef Tumbrinck (2020, comment on OSF (Cigliano et al. 2021)) and I follow this hypothesis based on the observed variability of *T. nodulosa*. Since I did not examine the type material, species validity confirmation is a task for future research, additionally complicated by the fact that *T. dentata* is a type species of the genus. Other *Thoradonta* Hancock, 1909 species are also similar to *T. nodulosa*, and I expect a lot of them to be proven as synonyms once the genus gets revised.

Type locality. Java.

Distribution. Borneo, Peninsular Malaysia, Java (numerous other literature records, but there are likely misidentifications involved so in this paper I only consider confirmed specimen locations from Cigliano et al. (2021)).

Ecology and behaviour notes. Interesting observation we have come across about this species is that it showed different habitat preferences during day compared to evening. During daytime, specimens were observed mostly on dead trees, with few specimens found in bushes. During evening and night however, specimens were rather common in open field on grass, together with *Hedotettix* specimen.

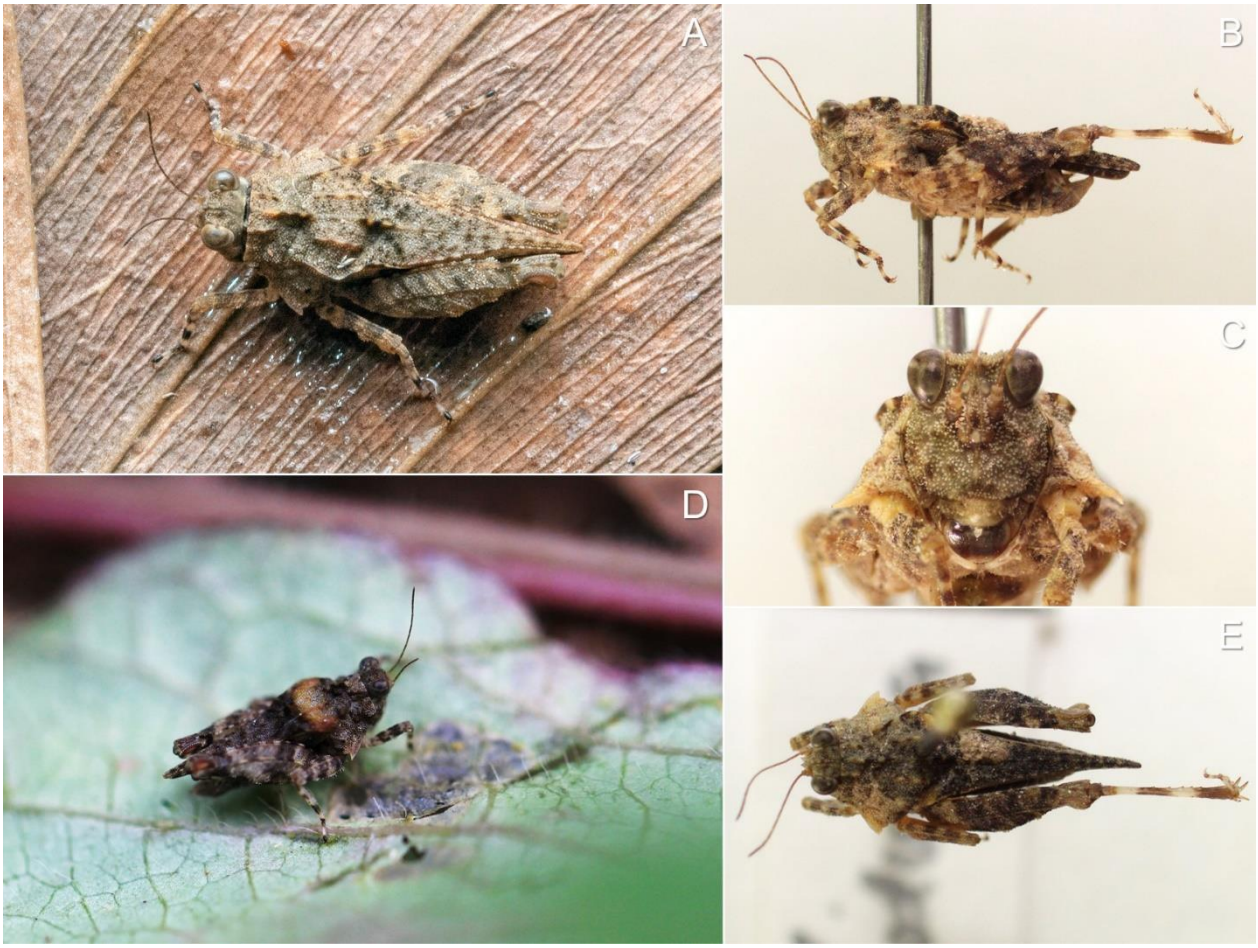

Figure 39. Living specimens of *Thoradonta nodulosa* (Stål, 1861) (A, D) in their natural habitat compared to pinned specimen deposited in UM collection (B, C, E) (A: provided by courtesy of Dr. Masatoshi Sone, Universiti Malaya, Kuala Lumpur; B, C, E: photographs provided by Amira Aqilah Muhammad; D: author's photography).

***Thoradonta dentata* Hancock, 1909**

Thoradonta dentata (Hancock 1909, Günther 1955, Blackith 1992, Zha et al. 2016a, b, Tumbrinck 2018)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

This species is described and known only from Peninsular Malaysia. It is considered to be synonymous with *T. nodulosa*, which was discussed in the section above, and I agree with that

hypothesis, especially after observing high variability of *Thoradonta* specimens from Peninsular Malaysia in person (see section 4.2). However, the species is currently valid so I give it a separate section and note that both its presence and validity remain to be confirmed for the region.

Type locality. Penang Island, Penang, Peninsular Malaysia.

Distribution. Peninsular Malaysia (Cigliano et al. 2021).

Note. Species presence should be confirmed.

4.1.8. Tripetalocerinae Bolívar, 1887

***Tripetalocera ferruginea* Westwood, 1834**

Tripetalocera ferruginea (Kirby 1914, Willemse 1930, Blackith 1992, Mahmood, Idris & Salmah 2007, Shishodia, Chandra & Gupta 2010, Storozhenko 2013)

Examined material. We did not find any specimen of this species from Peninsular Malaysia.

One specimen was collected from Pahang (Peninsular Malaysia) and reported for the region by Kirby (1914) and there is no other specimen of this species from this part of the country, as far as I know. It is very likely that there are multiple species within this genus that remain undescribed due to lack of research and available specimens, and until specimens from Peninsular Malaysia are discovered I cannot be sure which species is found in this part of the country.

Type locality. Travancor, Kerala, India.

Distribution. India, Myanmar, Borneo, Peninsular Malaysia, Sumatra (Shishodia, Chandra & Gupta 2010, Storozhenko 2013).

Note. Species presence should be confirmed.

4.1.9. *Unassigned genera*

***Phaesticus mellerborgi* (Stål, 1855)**

Phaestus insularis (Blackith 1992, Mahmood, Idris & Salmah 2007, Tan & Kamaruddin 2014, Storozhenko & Dawwrueng 2015 (authors comment that this is probably correct identification of *P. azemii* holotype from Peninsular Malaysia))

Phaesticus azemii (Mahmood, Idris & Salmah 2007)

Phaesticus mellerborgi (Zha et al. 2021)

Examined material. UM: 1 ♂ from Pahang, Peninsular Malaysia; 1 individual from Pahang, Peninsular Malaysia; 1 individual from Selangor, Peninsular Malaysia. UKM: 2 ♀ from Selangor, Peninsular Malaysia; 1 ♂ from Selangor, Peninsular Malaysia; 1 ♂ nymph from Selangor, Peninsular Malaysia (holotype of synonym *Phaesticus azemii*).

Social media. iNaturalist: 1 ♀ from Perak, Peninsular Malaysia (ID: 68712026); 2 nymphs from Pahang, Peninsular Malaysia (ID: 35706858, 18838261); 1 ♀ from Selangor, Peninsular Malaysia (ID: 10543992); 6 individuals from Selangor, Peninsular Malaysia (ID: 11872999, 53505556, 33309228, 67261276, 19776138, 19130921); 2 nymphs from Selangor, Peninsular Malaysia (ID: 33943958, 23321869).

Facebook: 1 nymph from Perak, Peninsular Malaysia (https://www.facebook.com/groups/TheEntomologyGroup/posts/10156137035088393/). Flickr: 2 nymphs from Terengganu, Peninsular Malaysia (https://www.flickr.com/photos/2121studio/3425886120, https://www.flickr.com/photos/2121studio/3425966828); 2 nymphs from Selangor, Peninsular Malaysia (https://www.flickr.com/photos/liewwk/2869410041, https://www.flickr.com/photos/some_soul/24160771851); 1 individual from Peninsular Malaysia (https://www.flickr.com/photos/orionmystery/4783067268).

Morphology. (Fig. 40) The species has smooth pronotum and flattened preapical antennal segments, with non-flattened apical antennal segments, standing out by their white coloration among other black coloured segments.

Similar species. There are no similar species in Peninsular Malaysia. The only otherwise similar species are *P. hainanensis* Liang, 1988 (from Hainan) and *P. montiliantennatus* (Günther, 1940) (from China and Thailand) which both have only moderately broadened antennal segments (opposed to strongly broadened segments seen in *P. mellerborgi*) (Zha et al. 2021).

History of identification. Until recently, *Phaesticus* and *Flatocerus* were separate genera, counting 17 species altogether. Numerous synonyms have been discovered and today only three species are considered valid, all within *Phaesticus* (Zha et al. 2021, Cigliano et al. 2021). Numerous specimens are listed as synonyms, but since the species were valid at the time I do not comment on those as misidentifications.

Type locality. Java.

Distribution. India (Assam), China (Yunnan), Thailand, Borneo, Peninsular Malaysia, Sumatra, Java (Zha et al. 2021).

Ecology and behaviour notes. We have encountered several specimens in natural habitat, all at forest edges, either on bushes or in grass.

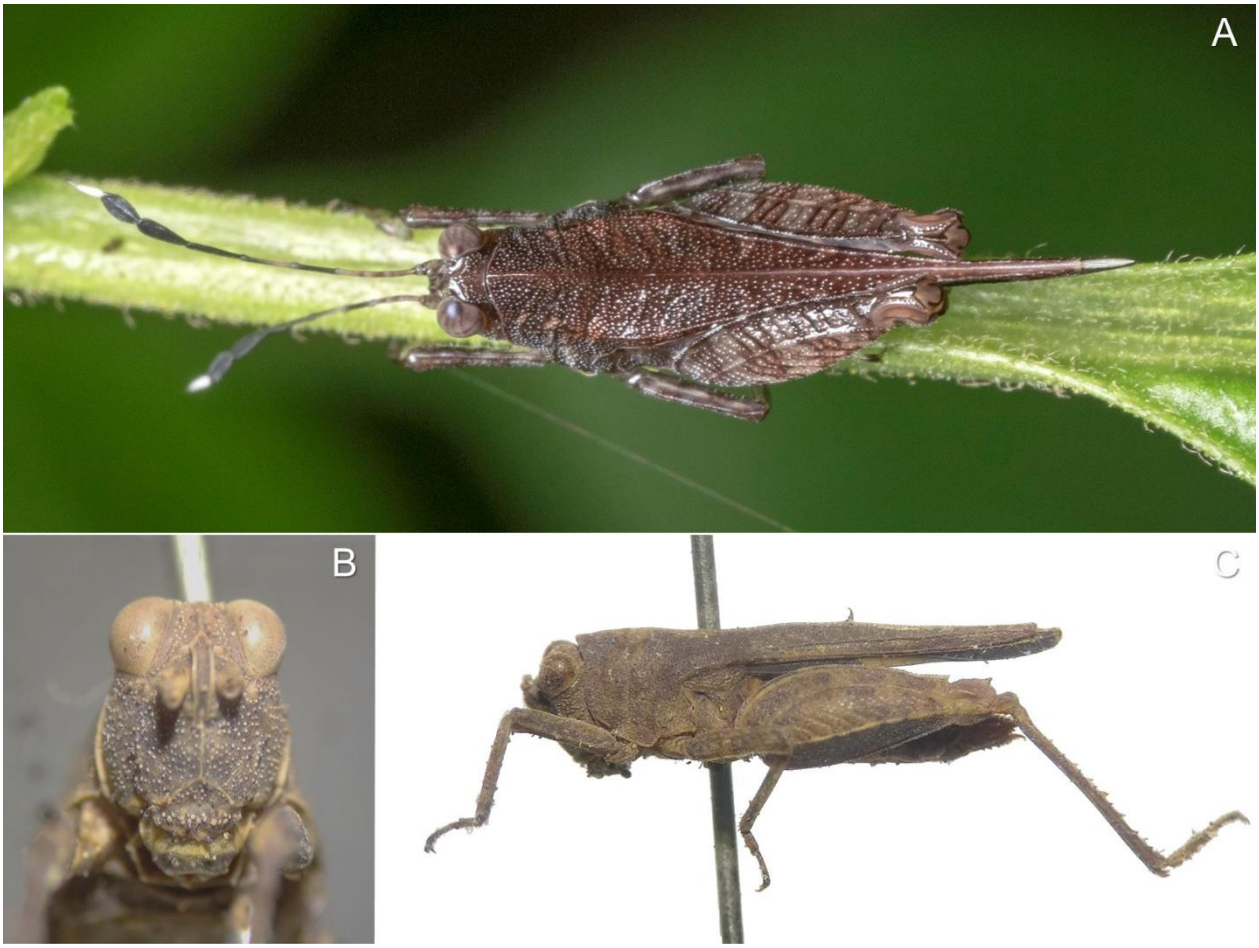

Figure 40. *Phaesticus mellerborgi* (Stål, 1855) living specimen (A) and morphology of pinned specimen from UKM collection (B, C) (A: provided by courtesy of Dr. Masatoshi Sone, Universiti Malaya, Kuala Lumpur; B, C: photographs provided by Maks Deranja).

4.2. VARIABILITY OF TETRIGIDAE SPECIES

High variability was observed in living specimens in Peninsular Malaysia, both in morphology of certain body characters and in coloration. Some aspects of species variability are described in species' paragraphs, but here it is discussed in more detail and represented by figures (Fig. 41, 42). One of the most interesting observations was variability of hind femur lengths compared to wing length and to pronotum length in *Thoradonta nodulosa* (Stål, 1861) specimens (Fig. 41). This variability could be observed in a single population on one meadow in Ulu Gombak, meaning that variability within this species is not something that was a result of population drift or a way to separate populations. This observation is interesting because some species were described using length of mentioned body parts as morphological differences among species, for example to tell *T. dentata* from *T. nodulosa* (Hancock 1909). This observation led me to the conclusion that these morphological characters do not bare any high value in differentiating among *Thoradonta* specimens, at least in Peninsular Malaysia, and this is the reason I only confirm *T. nodulosa* for the region (see *T. dentata* and *T. nodulosa* sections above). This could be true for other species from genus *Thoradonta*, but additional research backed with molecular analysis is needed to confirm this.

Additionally to variations in specimen body parts lengths, variability in coloration can also be observed, which is especially well visible in *Hedotettix gracilis* (Haan, 1843) specimens, as well as in *Systolederus cinereus* Brunner von Wattenwyl, 1893 specimens (Fig. 42). The reason I chose to show colour variability in *Systolederus cinereus* is again motivated by the fact that the species was described as being of light brown coloration. Though that coloration was most common in living specimens we observed, many other colours and patterns could be seen as well, ranging from dark grey (Fig. 42 E) to almost red (Fig. 42 C), and with different patterns from being uniformed in coloration (Fig. 42 D), over having small patterns (Fig. 42 A), to having larger patches of different colours (Fig. 42 F). Coloration variability was observed on all body parts of *S. cinsreus* specimens, including pronotum, head, and legs. Variabiliy in coloration of pygmy grasshoppers is not a completely new observation, since it has been known for a long time and was probably best represented in drawings provided by Naborus (1929), who even linked colouration to genetic

variability. However, this certainly remains an understudied topic in study of pygmy grasshoppers, making variability observations currently very valuable and important to note. It is unknown how much other species vary, especially because larger specimen collections or large number of observed living specimens is needed to discover this fact.

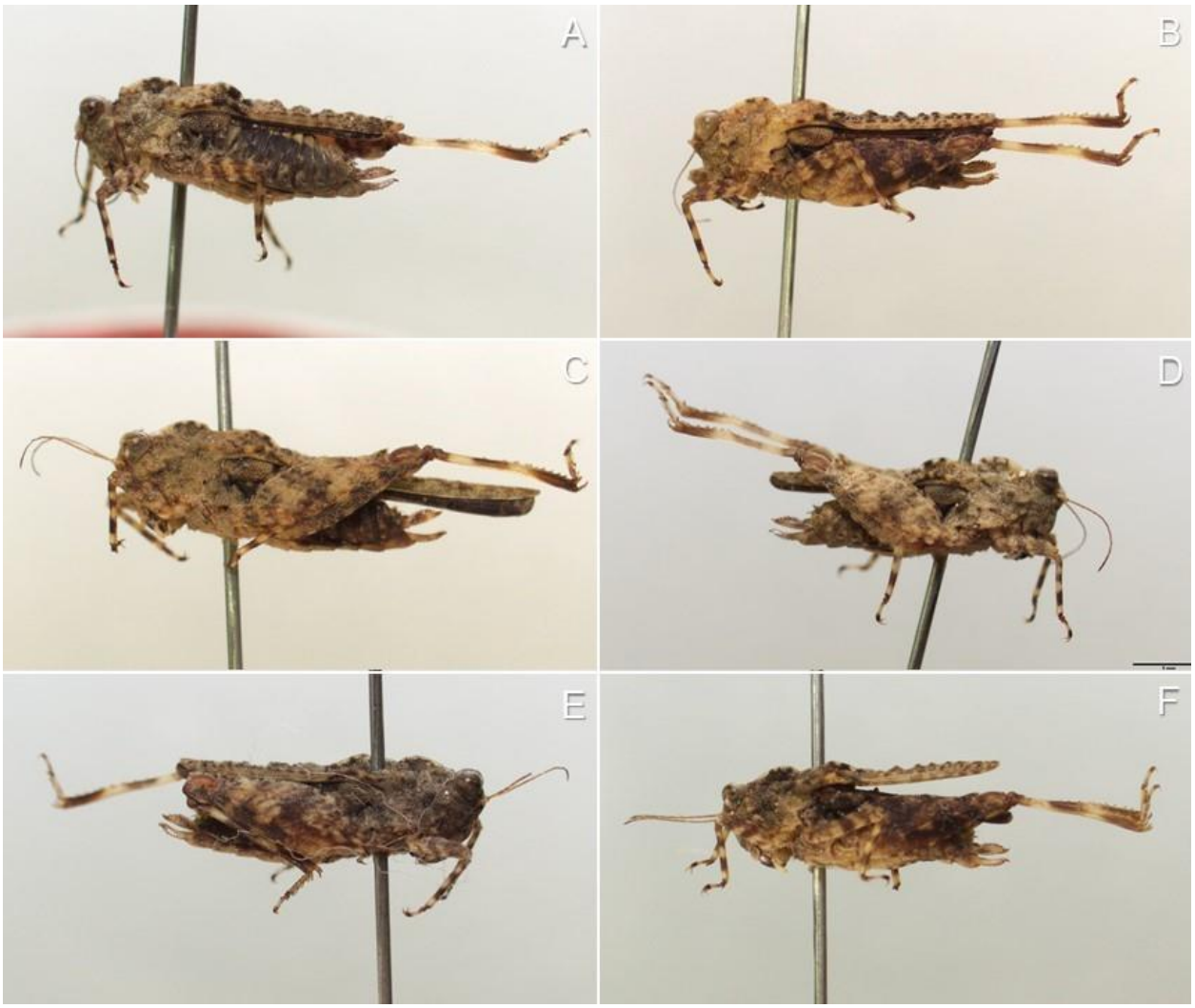

Figure 41. Variability of pronotum length relative to hind femora and wing length of *Thoradonta nodulosa* (Stål, 1861) specimens from Peninsular Malaysia. All specimens are females, for better comparison (A–F) (photographs provided by Amira Aqilah Muhammad).

Figure 42. Variability of *Systolederus cinereus* Brunner von Wattenwyl, 1893 living specimens coloration (A–I) (author's photographs).

5. DISCUSSION

Available literature was examined, and despite the large number of papers and books that were included only a few had any mention of Tetrigidae of Peninsular Malaysia in it. Most of the literature was of taxonomic nature, majority of it simply being species descriptions. Some of those species were described from Peninsular Malaysia (e.g. *Hyboella perakensis* Günther, 1939), some just confirmed to exist in the region by a single specimen (e.g. *Tripetalocera ferruginea* Westwood, 1834), and for a large number of pygmy grasshoppers species that was pretty much all that was previously published for the region. For this reason it was very hard to find all literature mentions of Peninsular Malaysia, and some data probably still exists in literature that was not available to me at this moment.

Peninsular Malaysia is a region for which systematic research focused on Tetrigidae was never done in the past, with paper by Mahmood, Idris & Salmah (2007) being the most comprehensive work so far. Unfortunately that paper, like many others listed in this thesis, had a large number of misidentified species. For a region that currently officially counts just 15 species and 1 subspecies of pygmy grasshoppers (Cigliano et al. 2021), Tetrigidae of Peninsular Malaysia have proven to be a very complicated topic. Lack of research and literature makes it hard to track specimens which were used by previous authors, and lack of available material (such as photographs or detailed drawings) makes it hard to confirm previous identifications.

Even though I expected some species will be new for the region, the final result was not something I expected. High number of species discovered in literature which were not shown on OSF (Cigliano et al. 2021) points to overall lack of research and literature examination for the region in the past. This is a large problem, and was likely the cause of numerous misidentifications. The number of species did turn out to be larger than the one represented on OSF, as I expected, but number of species which were actually backed by existing specimens found in museum collections and during fieldwork was significantly smaller than species found in literature. Additionally, species we discovered and species reported in literature were not overlapping in significant amount, which leads me to the conclusion that many of the non-overlapping species I report and the ones

found in literature in fact belong to the same species, meaning that there are still a lot of misidentifications left to be resolved in the future.

This thesis shows that local specimen collections are of crucial value for faunistic research for given area. Most of the specimens in UM collection were unidentified, which is unfortunate because some are more than 50 years old and are in danger of being destroyed due to old age, mold, or pests that can eat specimens. Thanks to collections of specimens from UM and UKM museums, 33 species of pygmy grasshoppers were confirmed by examined and documented specimens in this thesis. Most of the specimens in mentioned specimen collections were collected by students and people that were not Tetrigidae experts, showing how much such consistent collection of specimens done by locals can contribute to the knowledge of fauna for one region.

In order to encourage the very needed future research of pygmy grasshoppers in the region, I present ecological notes in this thesis and try to give simple explanations about morphology and recognition of each species, supplemented by specimen photographs. Altogether 54 species were discussed in this thesis, but 21 species still lack specimens and need to be confirmed for the region, both to prove their validity and to prove that they are in fact found in Peninsular Malaysia. After that, knowledge of pygmy grasshoppers can be connected to biogeography of the region, which is until now discussed only in the work done by Günther (1955).

During our own fieldwork in Peninsular Malaysia, we were able to spend a lot of time in field, gathering information about the ecology of living specimens and collecting living specimen photographs. Thanks to this, we have gathered notes on ecology and behaviour of pygmy grasshoppers, as well as on species variability—this shows how important comprehensive research of larger number of specimens is, especially if they can be observed in their natural habitat as well. It is very likely that further research will link species to their habitat more precisely, and some species will likely turn out to be more sensitive to habitat changes than the others, making them great habitat quality indicators, as Orthoptera are known to be (Hochkirch et al. 2016). For example, high variability in coloration of *Systolederus cinereus* (Fig. 42), perhaps the most

common species we encountered in habitats close to water, likely comes from the fact that the species has large populations and thus probably high genetic variability, a subject that was previously studied to a certain extent in some other pygmy grasshoppers species (e.g. Naborus 1929, Tinnert et al. 2016). Observations like these help in forming future research and show which aspects of these animals need to be investigated.

To demonstrate how knowledge in this thesis can be applied, I have included specimens from social media. Applying this approach, I have identified specimens and listed them under species they belong to, or species they are most similar to. Along with showing how this thesis can be applied, this also shows how living specimens look and where they can be found. This nicely demonstrates how social media can provide valuable information about morphology, ecology, and distribution of living specimens, which is especially important in understudied species that have insufficient amount of collected specimens (example of such discoveries are Skejo 2017, Skejo & Bertner 2017, Mathieu et al. 2021).

Social media are a valuable alternative when organized fieldwork is lacking, as they can provide valuable data about species distribution, show us how living specimens look in species that were only documented by pinned specimens, and show us how species microhabitat looks. Though observers on certain platforms can be biased, mostly photographing and posting visually appealing species, the data is still very valuable, especially in the tropics where it can be very hard to organize and conduct fieldwork due to habitat complexity and inaccessibility. Including observations from social media will probably encourage more people to get involved, and to post even more observations, resulting in a better and more complete source of information for scientists.

In future, examination of remaining specimens at local museums are needed. Additionally, new specimens should be collected, especially for species that only have one specimen and whose status in the region is unknown, namely *Tripetalocera ferruginea* Westwood, 1834, *Bermania daniili* Storozhenko, 2012, and *Amphibotettix hafizhaii* (Mahmood, Idris & Salmah, 2007). Collected specimens should be identified carefully in the future, with critical approach to all potential species

that could be their correct identification. All the species listed in comments on history of identification and listed as similar species in this thesis should be considered, possibly in addition to some other morphologically similar species.

Because most of the species discussed in this thesis belong to complicated genera, likely having a lot of synonyms, being synonyms themselves, or being wrongly identified, it is very likely that Tetrigidae species list of Peninsular Malaysia will change to a significant extent in the future. I gave my comments on each examined species and to list all alternative identifications for specimens in hopes that it will encourage other researchers to contribute to the knowledge of fauna of Peninsular Malaysia as well.

This can only be resolved with future research, as additional specimen examination is needed to see if literature species I was not able to confirm in this thesis can actually be found in the region. In most cases the question is even more complicated, because a lot of species and genera are in need of taxonomic revision, and only after all that work is done can we discover the true identity of pygmy grasshoppers species which inhabit Peninsular Malaysia.

Everything considered, this thesis probably does not show complete list of pygmy grasshoppers species from Peninsular Malaysia, and I expect the list to both change and expand, but it is the best I could do with available information and the basis I had. Even though it is not the final list, it is applicable and practical because it makes identification of pygmy grasshoppers in Malaysia relatively simple, meaning scientists can now at least know which species they are referring to in the region, even if it is still not linked to its correct name.

6. CONCLUSIONS

As was hypothesised at the beginning of this thesis, Peninsular Malaysia counts more than the 15 species and 1 subspecies of pygmy grasshoppers listed on OSF (Cigliano et al. 2021). Over 50 species were found in existing literature, pointing to the problem of lack of comprehensive research of this subject. With addition of examined specimen collections, 33 species were confirmed for the region, and a total of 54 species was discussed, meaning that the true number of pygmy grasshoppers species in the region is still uncertain.

Other hypothesis was confirmed as well, because numerous species have been misidentified, some for a number of other species, which is all listed and discussed in detail in this thesis as well. A lot of research needs to be done in the future in order for our knowledge of these animals in this region to be complete and hopefully this thesis can help with that.

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CURRICULUM VITAE

EDUCATION

Primary school Osnovna škola Bakar, Bakar
2003–2011

Highschool Prva Sušačka Hrvatska gimnazija u Rijeci, Rijeka
2011–2015

Bachelor's degree, University of Zagreb, Faculty of Science, Department of Biology, Biology, Zagreb
2015–2018

Master's degree, University of Zagreb, Faculty of Science, Department of Biology, Experimental Biology, module Zoology
2018–2021

VARIOUS EXTRACURRICULAR ACTIVITIES

Assistant to teaching assistant
2018–2019
Assisted in a total of 90 hours in hours in a practical course of Biological Evolution; under mentorship of mag. biol. exp. Josip Skejo and Assoc. Prof. dr. sc. Damjan Franjević

Assistant to teaching assistant
2019
Assisted in a total of 90 hours in hours in a practical course of Evolutionary Biology; under mentorship of mag. biol. exp. Josip Skejo and Assoc. Prof. dr. sc. Damjan Franjević

RESEARCH OF PYGMY GRASSHOPPERS (ORTHOPTERA: TETRIGIDAE) OF PENINSULAR MALAYSIA
Scientific expedition
2019
20 days of exploring Malaysian jungles and rainforest to study a family of Tetrigidae and 5 days of work on Malaysian entomological collections

(collections visited: Khalid Mahmood's collection at Universiti Kebangsaan Malaysia, Kuala Lumpur, and collection of University of Malaya, Kuala Lumpur)

CRICKETS AND GRASSHOPPERS OF THE ADRIATIC ISLANDS
hr. Istraživanje skakavaca i zrikavaca jadranskih otoka
Scientific expedition
2020–2021
97 days of fieldwork with student colleagues that aims to contribute to the knowledge of Croatian Orthoptera fauna of 17 Adriatic islands under the mentorship of Fran Rebrina, mag. biol. exp.

LECTURES AND POPULARIZATION OF SCIENCE

SAPROXILIC BEETLES AS INDICATORS OF FOREST PRESERVATION
Public lecture
2019
for middle school and highschool students under the mentorship of Ass. prof. Andreja Brigić as a part of college course „Biodiversity of Croatian Fauna“

EVOLUTION, PHYLOGENY, & TETRIGIDAE IDENTIFICATION
Workshop
2019
held a total of 15 hours in workshops for students of Institute of Biological Sciences, Faculty of Science, University of Malaya, Kuala Lumpur, conducted in English

PENINSULAR MALAYSIA—FORGOTTEN BIODIVERSITY HOT-SPOT
Popular lecture
2020
as a part of BIOMs' popular-science lectures at Faculty of Science, Department of Biology, Zagreb (available on Youtube)

CRICKETS AND GRASSHOPPERS OF THE ADRIATIC ISLANDS
hr. Istraživanje skakavaca i zrikavaca jadranskih otoka
Popular lecture
2021
for colleagues at biology student's symposium (SISB)

PUBLICATIONS

Adžić, K., Deranja, M., Franjević, D., & Skejo, J. (2020). Are Scelimeninae (Orthoptera: Tetrigidae) Monophyletic and Why it Remains a Question?. *Entomological News*, 129: 128–146.
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