Institute of Biodiversity and Environmental Conservation

Taxonomy and Modelling the Distribution and Ecology of the Genus *Glenea* (Subfamily Lamiinae, Coleoptera: Cerambycidae) in Sarawak

Ngumbang Anak Juat

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A thesis submitted

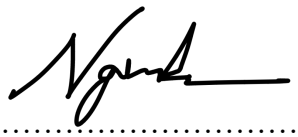
In fulfillment of the requirements for the degree of Doctor of Philosophy

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DECLARATION

I declare that the work in this thesis was carried out in accordance with the regulations of Universiti Malaysia Sarawak. Except where due acknowledgements have been made, the work is that of the author alone. The thesis has not been accepted for any degree and is not concurrently submitted in candidature of any other degree.



……

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ABSTRACT

The longhorn beetle is one of the most significant wood-boring insects from the family Cerambycidae. Yet, Sarawak has little enthusiasm for research into this family's biology, ecology, or taxonomy. As a result, little is known about this family. Aside from its broad contribution to scientific knowledge, understanding species taxonomy, composition, distribution, and abundance is essential for pest management, conservation, and species monitoring. The secondary and hill mixed dipterocarp forests of Sungai Sekabai, Sebauh, Bintulu; Ulu Sungai Mujuk, Julau; Loagan Bunut National Park, Lanjak Entimau Wildlife Sanctuary, Batang Ai National Park, and Ulu Baram were the survey locations of the Cerambycidae. Most of the Cerambycidae species in these woodlands were collected using the butterfly net, Malaise traps, and handpicking. Depending on the accessibility in these forests from 2004 to December 2006, a random survey was undertaken. A total of 406 individuals from 59 different species of *Glenea* were assessed from the museum collection. The specimens studied were from the Sarawak Forestry Corporation, Kuching, the Unimas Insect Reference Collection, Universiti Malaysia Sarawak, and the Sarawak Museum Collection, Kuching (S. M. Coll). (Forest Research Centre Coll.). Out of the 59 species that were reviewed, 18 new species nomen nudum have been described. The *Glenea* species of Sarawak are split into 6 major clades, with the smallest clade consisting of 3 species and the largest clade consisting of 23 species, based on dendogram reconstruction utilizing species morphological features distances analysis in R. The differentiation of the biological and sampling processes results in a more process-driven estimate of diversity, and hierarchical multispecies models that incorporate both the detection process and the occurrence state, such as the Multiple Species Occupancy Model (MSOM), offer a promising direction for the future. The local community (all species present at one site), the entire metacommunity, and

these potent community models can all represent patterns, such as covariate connections (regional pool of species in the wider area of study). As a result of its ability to make inferences at all levels of a meta-community (species, community, and metacommunity), as well as its explicit handling of measurement error, the Community N-Mixture Model, which is based on the abundance of a community of species, meets our main criteria for a flexible and reliable community modelling framework. This includes the estimation of species richness at various scales. This study is intended to be a foundational resource for references in the future, a comprehensive checklist, and a contribution to our knowledge of this genus.

Keywords: *Glenea*, dendogram, occupancy, abundance, hierarchical models

Pemodelan Analisis Data Ekologi (Genus Glenea) dari subfamily Lamiinae (Coleoptera: Cerambycidae) di Sarawak

ABSTRAK

Famili Cerambycidae dikenali juga sebagai kumbang sesungut panjang adalah salah satu serangga penebuk kayu yang paling penting dari segi ekonomi. Walau bagaimanapun, di Sarawak minat untuk mengkaji dan mempelajari biologi, ekologi, atau taksonomi famili ini adalah kurang. Oleh itu, maklumat mengenai famili ini adalah terhad. Memahami taksonomi, komposisi, taburan dan kelimpahan spesies adalah sangat penting untuk pengurusan serangga perosak, pemuliharaan, dan pemantauan spesies, selain dari sumbangan umum terhadap pengetahuan saintifik. Penyampelan Cerambycidae dijalankan di hutan sekunder dan hutan dipterokap campuran di Sungai Sekabai, Sebauh, Bintulu; Ulu Sungai Mujuk, Julau; Loagan Bunut National Park; Lanjak Entimau Wildlife Sanctuary, Batang Ai National Park dan Ulu Baram, Miri. Jaring serangga, perangkap Malaise dan kutipan dengan tangan merupakan teknik yang digunakan untuk pengumpulan kebanyakkan spesies Cerambycidae dalam hutan tersebut. Penyampelan dilakukan secara rawak bergantung dengan tahap kebolehmasukkan ke dalam hutan berkenaan pada tahun 2004 sehingga Disember 2006. Sejumlah 406 spesimen daripada 59 spesies dalam genus Glenea telah dikaji. Selain daripada spesimen yang dikumpul sendiri, spesimen yang digunakan untuk penyelidikan ini datang daripada pelbagai sumber; koleksi Muzium Sarawak, Kuching; koleksi rujukan serangga UNIMAS dan koleksi Pusat Penyelidikan Hutan, Sarawak Forestry Corporation, Kuching. Terdapat 18 spesies nomen nudum baru telah dihuraikan daripada 59 spesies yang ada untuk pengamatan. Berdasarkan pembinaan semula dendogram menggunakan analisis jarak ciri luaran spesies menggunakan R, didapati spesies Glenea di Sarawak terbahagi kepada 6 kumpulan utama mengandungi

pelbagai jumlah spesies, dengan kumpulan yang paling kecil terdiri daripada 3 spesies, dan kumpulan terbesar mengandungi 23 spesies. Model berperingkat pelbagai spesies seperti Multiple Species Occupancy Model (MSOM), yang mana menyatukan kedua proses pemerhatian dan keberadaan sebenar spesies menjanjikan halatuju yang lebih baik, kerana ia menjurus kepada penganggaran kepelbagaian biodiversiti yang melibatkan pelbagai proses melalui pembezaan proses biologi dan proses penyampelan. Model komuniti ini dapat menggambarkan corak, seperti hubungan kovariasi, pada tahap spesies individu, komuniti setempat (semua spesies yang terdapat di satu lokasi), dan keseluruhan metakomuniti (kumpulan spesies serantau di wilayah kajian yang lebih luas). Sementara itu, "Community N-Mixture Model" yang berdasarkan banyaknya spesies komuniti memenuhi syarat utama untuk rangka pemodelan komuniti yang fleksibel dan mantap kerana ia membolehkan kita membuat kesimpulan di semua peringkat metakomuniti (spesies, komuniti, metakomuniti), dan ia secara jelas menangani kesalahan pengukuran sehingga kesimpulan dapat dibuat melebihi sekadar sampel spesies yang diperhatikan, termasuk perkiraan kekayaan spesies pada beberapa skala. Adalah diharapkan kajian ini akan menjadi asas untuk rujukan di masa depan, di samping sebagai senarai rujukan yang lengkap dan menyumbang untuk pemahaman kita kepada genus ini.

Kata kunci: *Glenea, dendogram, keberadaan, kekayaan, model berperingkat*

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LIST OF ABBREVIATIONS

CSV	Comma Separated Value
CRS	Coordinate Reference System
DIC	Deviance Information Criterion
DEM	Digital Elevation Model
HMs	Hierarchical Models
JAGS	Just Another Gibbs Sampler
MCMC	Markov Chain Monte Carlo
MSOM	Multi Species Occupancy Modelling
OTU	Operational Taxonomic Unit
PPDs	Posterior Predictive Distributions
RN model	Royle-Nichols model
RSO	Rectified Skew Orthomorphic Projection
SDM	Species Distribution Modelling
S.M.Coll	Sarawak Museum Collection

CHAPTER 1

INTRODUCTION

Malaysia has a wealth of biodiversity and has been identified as one of the world's twelve-mega diversity areas. However, the highly dense and thick forests of Sarawak alone are relatively inaccessible, and partially, due to that, the flora and fauna diversity of this tropical forest has remained poorly known (Abang, 2003). One of insect family that is understudy is family Cerambycidae.

Since their wood-boring larvae harm plants and newly cut logs, the family Cerambycidae (Coleoptera) of beetles that attack dead trees or fallen logs is significant economically (Beeson, 1941).

As compared to the surrounding regions, taxonomic work on Cerambycidae of Sarawak is still lacking. The works by Fisher (1934, 1935), Gressitt & Rondon (1970), Hayashi (1969, 1975, 1976a, 1976b, 1977, 1978, 1979, 1982, 1985, 1986, 1987) and Hudepohl (1987, 1983, 1988, 1989a, 1989b, 1990a, 1990b, 1992a, 1992b) on the cerambycids from South-east Asian regions, are however not solely concentrated on Borneo or to be more precise, the state of Sarawak. Nevertheless, their findings gave us an insight as to how diversified and abundant the cerambycids are in this region. Together with the fact that many of the previously described species from Sarawak have never been found or reported again, there is a crucial need to carefully compile and catalogue the cerambycids fauna of Sarawak. Such study basically involves four principal aspects: taxonomy, phylogenetics, classification and taxagenetics (Savage, 1995). The application of taxanomic information will continuously be applied in many aspects of human life.

So, the primary goal of this study is to investigate the taxonomy and diversity of the longhorn beetles of the genus *Glenea* (subfamily Lamiinae) in Sarawak. The species distribution of this genus in the state is also covered in this study. The secondary goals are to present a phenetics theory for the taxa under consideration, based mostly on external morphological features, and to analyse the relationship between the distribution patterns of the genera.

There are four sections to this thesis. Based on specimens kept in the Sarawak Museum, Forestry Department, and University Malaysia Sarawak (Unimas) Insect Reference Collection, the first chapter deals with a systematic account of the genus *Glenea* in Sarawak. The second section focuses on reconstructing the phylogeny of the genus *Glenea* primarily using external morphological characteristics. The third discusses their distributions and the use of Multiple Species Occupancy Modelling (MSOM), which is based on information gathered from the state's current collections and literature citations. The last sections use Community N-Mixture Models on habitat and survey covariates to model the abundance of the species *Glenea*. This study is intended to be a foundational work for references in the future, a comprehensive checklist, and a contribution to our understanding of this genus.

The main objectives for data analysis are to evaluate newly-developed methods (Multi Species Occupancy Modelling and Community N-Mixture Model) for ecological data analysis, assess the scope for applying emerging methods of data analysis to field research, produce a guideline for optimal analysis execution, where it can provide information of direct use to wildlife managers and policymakers, and offer an alternative approach how quantitative ecology should be taught in the standard local university curricula.

CHAPTER 2

LITERATURE REVIEW

2.1 General introduction to the family of Cerambycidae (Coleoptera)

Cerambycids are commonly referred to as longhorned beetles, longicorns, capricorns, roundheaded borers, timber beetles, goat beetles, or sawyer beetles. Their body length alone ranges from less than 2.5 mm (*Cyrtinus* sp.) to just over 17 cm (*Titanus giganteus*), and they come in a wide range of shapes, colours, and ornamentation (Solomon, 1995). The term "longhorn" refers to the beetles' long antennae, which are notably lengthy in males. Long antennae and somewhat elongated bodies serve as common diagnostic features for identifying these beetles (Slipinski & Escalona, 2013). Although longhorn beetles exist in a wide variety of sizes, colours, and shapes, they sometimes mimic stinging insects like wasps or stinging ants, making it challenging to define the family (Slipinski & Escalona, 2013). In terms of taxonomy and ecology, longhorns are quite diverse and have a close relationship with the plants that serve as their hosts. As a result, they might offer crucial information and evolutionary "clues" for ecological and zoogeographic investigations (Maymoona, 2011).

2.1.1 Body Orientation and Relationship of Parts

Clear understanding depends on accurate descriptions of structures and their locations in relation to one another, which must be consistent in both keys and descriptions. Figures 2.1 and 2.2 illustrate and describe the terminology of relative locations utilised in this study.

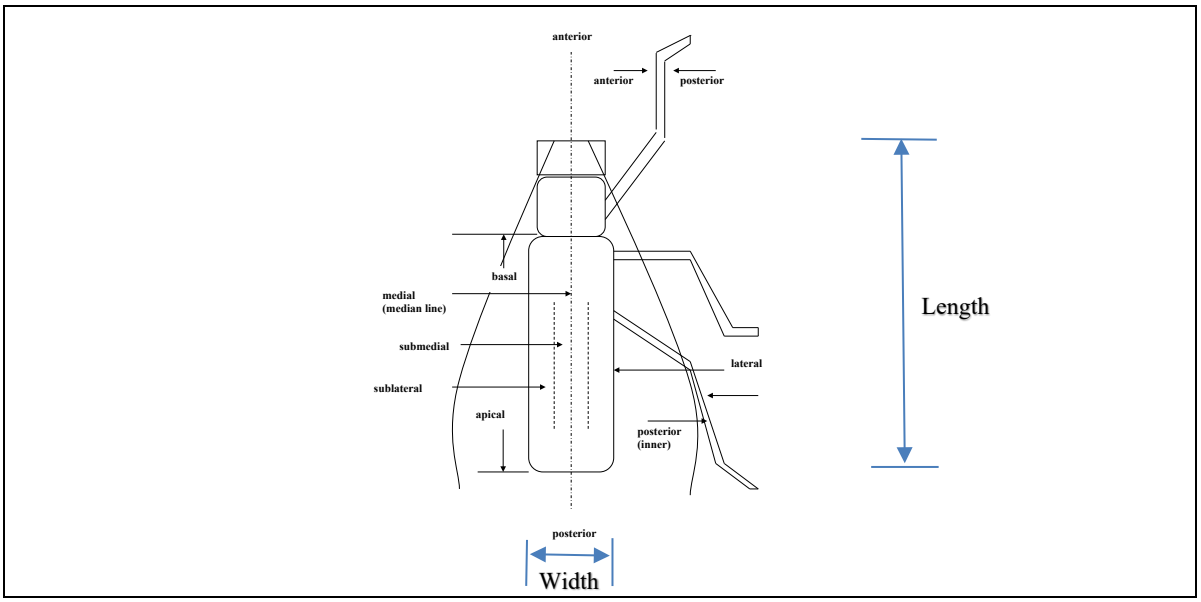


Figure 2.1: Term of relative position as used in the keys (Dorsal view).

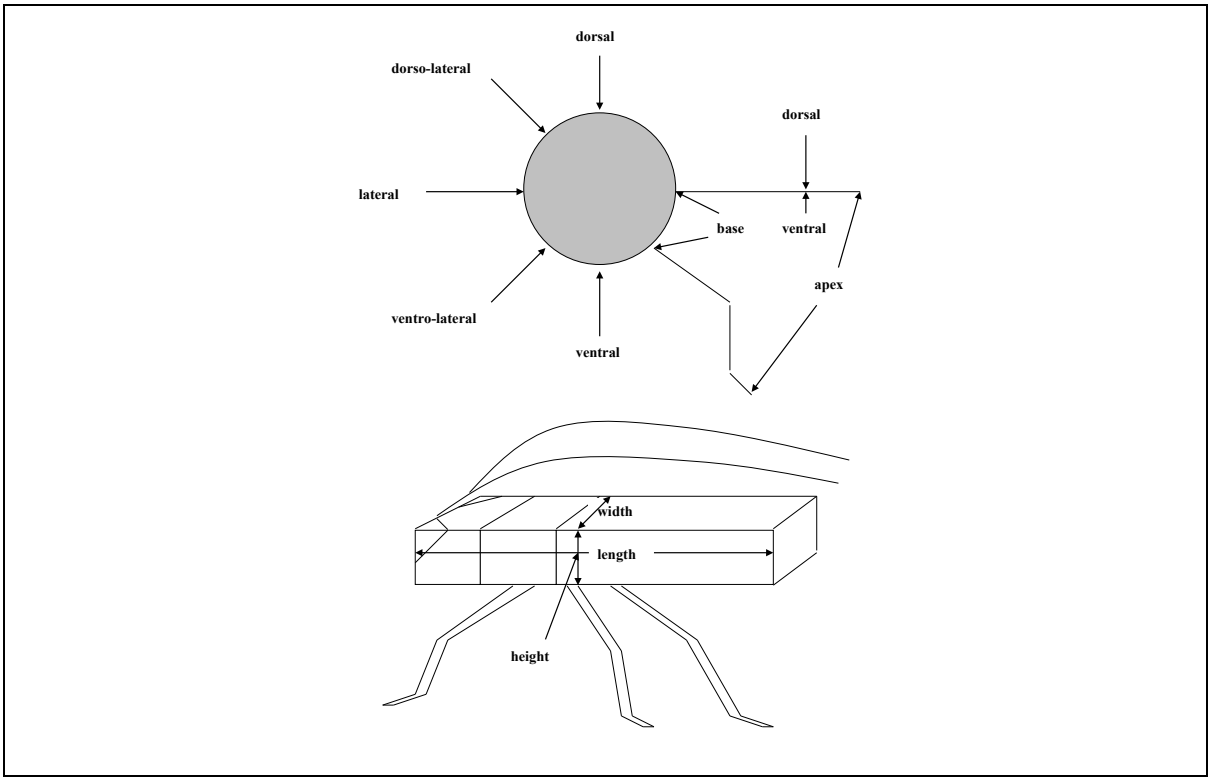


Figure 2.2: Term of relative position as used in the keys.

No matter the leg's natural orientation in the living insect or its location in a mounted specimen, it is convenient to describe the features of each part of any leg as though it were extended horizontally and at right angles to the long axis of the body. This is because leg positions vary depending on which leg is discussed and how it is bent.

There are only eight descriptors of position used in the keys, though these are combined in various ways, when necessary, e.g. anterodorsal, posterolateral.

Anterior - Toward or at the head end of the body or structure (front, frontal).

Posterior - Toward or at the hind end of the body or structure (rear, back).

Dorsal - Toward or at the top or upper surface of the body or structure (above).

Ventral - Toward or at the bottom or lower surface of the body or structure (below).

Medial/median - Toward or at the centre, or central area or line, of the body or structure (middle, mid).

Lateral - Toward or at the side of the body, or the margin or edge of a structure.

For the appendages (mouthparts, antennae, wings, legs, genitalia) additional descriptors are:

Apical - The end farthest away from the body (apex); at or toward the tip (distal).

Basal - The end closest to the body (base); at or toward the base (proximal).

The thorax-mesosoma junction has been referred to as basal and apical in the literature, with the thorax-abdomen (mesosoma—metasoma) junction serving as the primary reference point. However, these two terms are not used for the body; instead, anterior and

posterior are used to avoid misunderstanding and to do away with the necessity for a reference point. When describing an attribute that is close to the extremes, such as subapical or sublaterally, the prefix sub- may be appended.

When describing the dimensions or proportions of a construction, length, breadth, and height (but not depth) are employed, along with the adjectives long, wide, and high. Only when discussing the depth of a hole or specific sorts of sculpture is the word "depth" utilised. Further details on orientation are provided in Scholtz & Holm (1985) and Mackerras (1970).

2.2 General Characteristics of Cerambycidae

2.2.1 Head, Antennae and Mouthparts

The insect body's frontal portion is known as the head. It has a box-like structure with six sides and a longitudinal axis that is typically vertical. The mouthparts are directed ventrally (hypognathous). For a head orientated in this way, several parts are described in relation to their positions.

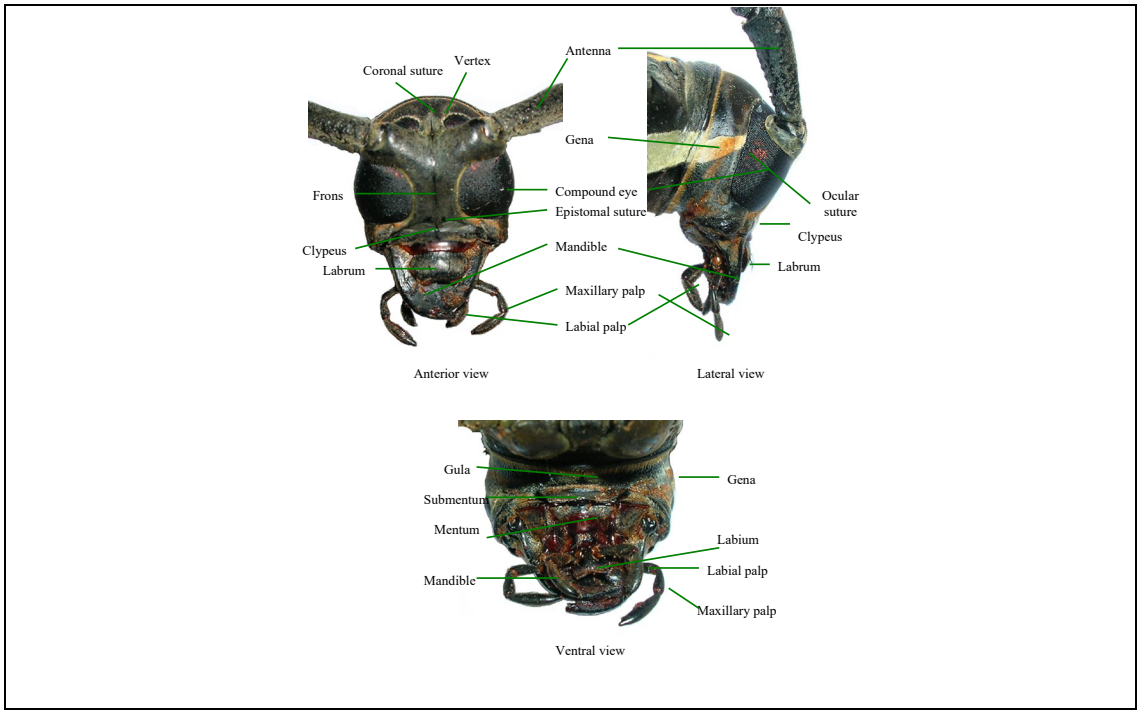


Figure 2.3: Generalized Cerambycidae head.

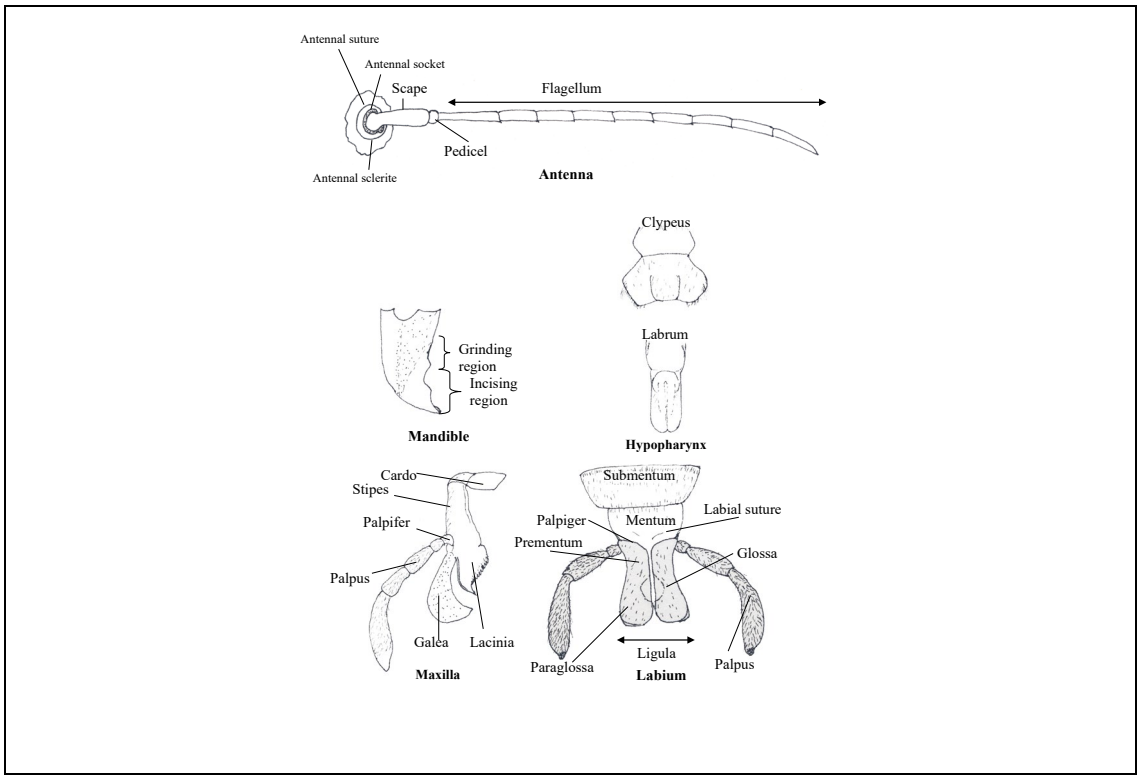


Figure 2.4: Generalized *Glenea elegans* antenna and mandibulate mouthparts as illustrated based on *Batocera thomsoni*.

The face is the portion of the anterior surface of the head that extends between the compound eyes and between the mouth cavity and antennal socket (Figure 2.3). Oral cavity, clypeus, compound eyes, and frons are the typical divisions of the face. The ventral region, directly above the edge of the oral cavity, is known as the clypeus (not to be confused with the labrum). The dorsal and lateral edges of the clypeus are indicated by an epistomal suture, which runs from clearly apparent to barely perceptible below the frons. The medial region above the clypeus is known as the frons. At the level of the anterior margin of the antennal socket, an ocular suture between the compound eyes clearly distinguishes the lateral margin of the frons.

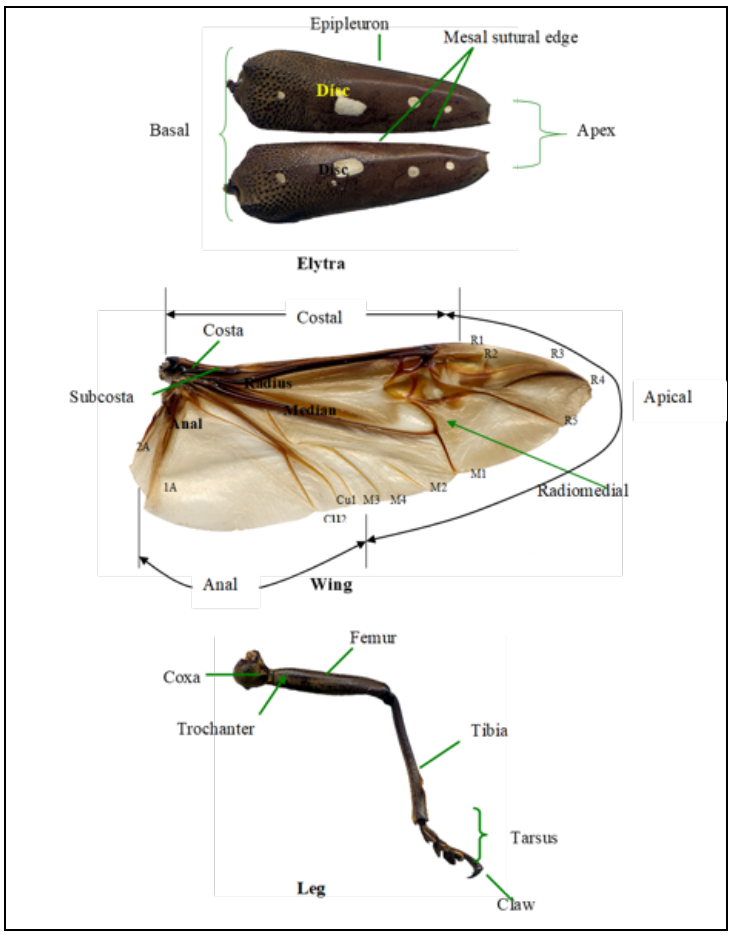
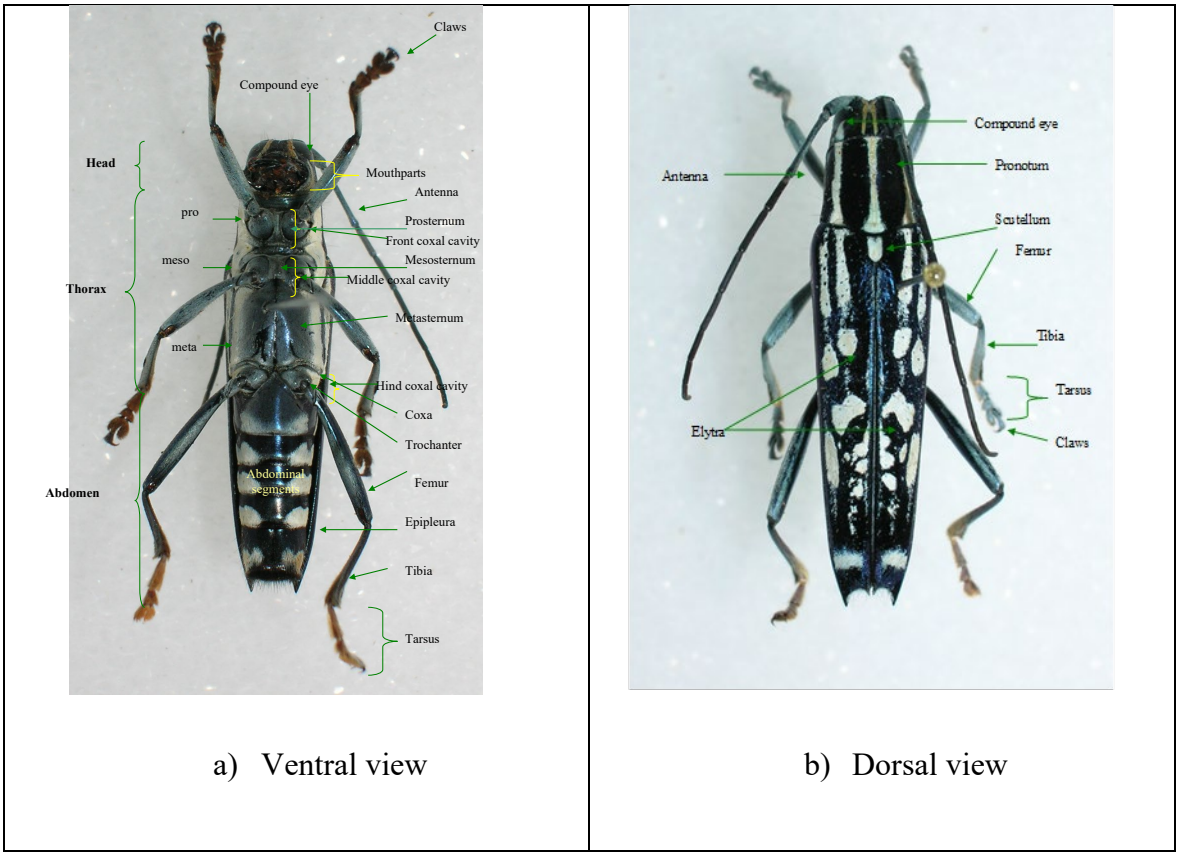


Figure 2.5: Dorsal view of elytra, wing, and midleg of Lamiinae.



a) Ventral view

b) Dorsal view

Figure 2.6: a) Ventral and b) dorsal view of *Glenea* sp. with the more important parts labelled.

The vertex is located on the dorsal surface of the head, between the dorsal edges of the compound eyes (Figure 2.3 and 2.6b). The frons' dorsal edge defines the vertex anteriorly, and the occipital carina, or groove, defines it posteriorly. If there isn't a ridge or groove, the vertex is defined posteriorly by either an imaginary line between the compound eyes or by the highest point of the head, which is behind the frons, at the level of the highest point of the head.

The occiput, postocciput, postgena, gena, and hypostoma are the five areas that make up the rear surface of the skull. Not all of these areas are present or clearly characterised in every species (Figure 2.3 and 2.6). The dorsal area between the postoccipital groove and, if present, the occipital groove or carina is known as the occiput. The postgena is located

ventrally between these two grooves. The gena is the ventral or lateral region that is in front of the occipital groove, below and behind the eye. An imaginary line connecting the ventral apex of the compound eye with the anterior articulation of the jaw serves as the anterior boundary of the gena. The hypostomal carina divides the hypostoma from the gena and postgena, which are both small sclerites that border the oral cavity posteriorly.

The antennae are a pair of structures that are divided into three parts at the base: the scape, pedicel, and flagellum (Figure 2.4). Typically, the flagellum is separated into two or more flagellomeres. A socket holds the scape to the top of the head (torulus). There is frequently a short, narrow radicle that can occasionally be easily distinguished from the scape between the socket and base of the scape. The radicle is not counted as a separate segment because it is a component of the scape.

The mouthparts that surround the oral cavity are made up of four externally visible parts (Figures 2.3, 2.4, and 2.6a). These parts are the labrum (often concealed behind the clypeus), paired mandibles, paired maxillae, and labium, in that order from anterior to posterior. There are four different types of maxillas: cardo, stipes, lacinia, and galea. The submentum, mentum, prementum, glossa, and paraglossa are divisions of the labium. The labium and maxillae both have segmented palpi.

2.2.2 Thorax, Legs and Wings

The centre section of an insect's body is known as the thorax. It can be visualised as a rectangular box with six sides and a long, horizontal axis. There are three parts to it: the prothorax, mesothorax, and metathorax. On the mesothorax are the first pair of fore wings and on the metathorax are the second pair of hind wings. The metathorax and the remainder of the abdomen are both extensively and immovably linked to the first segment of the

abdomen (Figure 2.6a). The mesosoma is made up of the real thorax plus this first abdominal section, which is called the propodeum (middle body).

There are dorsal (notum), lateral (pleuron), and ventral areas in each segment of the thorax (sternum). The sternum is undivided, reduced, and, on the mesothorax and metathorax, regarded to be invaginated internally and represented only by a median longitudinal line. The notum and pleuron are typically big and may be further subdivided. The scutum, scutellum, and postnotum are the three distinct areas that can make up the notum from anterior to posterior. Undivided pronotum is present. The elytra cover the mesonotum and metanotum (Figure 2.6b).

The lateroventral region behind the skull is home to the undivided paired propleuron (Figure 2.6). Normally, the pronotum and the rest of the thorax are loosely and flexibly joined to the propleuron. The posteroventral peak of the propleuron is joined to the foreleg. The largest pleura, the metapleuron, is typically separated into the anterior and posterior metepisternums (Figure 2.6a). The mesopleuron is a tiny structure that can be separated similarly to the mesopleuron.

Every given sclerite of the thorax or mesosoma may be divided into a number of specified sections by ridges or grooves, which are likewise given specific names but may differ according on the taxon. Hence, there are many and frequently unclear terms used to describe different sections of the thorax and mesosoma.

From the base to the tip of a leg, there are six main segments: the coxa, trochanter, femur, tibia, tarsus, and pretarsus (Figure 2.5). The trochantellus, a partial secondary division at the base of the femur, can occasionally give the impression that the trochanter is two-segmented. Protibiae of Lamiinae are typically internally obliquely grooved; mesotibiae are

typically grooved before the apex of the outer side, have a slightly concave profile, or have a surface that conceals small, stiff, upright hairs.

The plantar lobe, a ventral pad, may grow on each of the three to five tarsomeres that make up the tarsus' secondary division. The pretarsus is made up of two claws and related components (Figure 2.5).

The Comstock and Needham (1898–1899) system, which was revised by Comstock (1918), Ross (1936), and others, is the technique used here for naming wing veins and cells. Eight significant longitudinal veins are identified by the Comstock-Needham technique and are denoted by capital letters. They are as follows, starting with the front edge of the wing: costa (C). two anal veins (1A and 2A), the cubitus (Cu), the radius (R), the subcosta (Sc), and the median (M). The cubital vein has two branches (Cu1 and Cu2), the median vein has four branches (M1-M4), and the radius vein has five branches (R1-R4) (Figure 2.5).

The posterior portion of an insect's body is known as the abdomen. It looks like a horizontal cylinder. Although *Glenea*'s abdomen originally had 11 segments, only 5 of them are typically visible due to fusion and loss. As was previously mentioned, the first abdominal segment is joined to the thorax as the propodeum, and the succeeding segments (often four) are referred to as the metasoma collectively (Figure 2.6a). A dorsal plate, or tergum, and a ventral plate, or sternum, make up each segment. A spiracle opens at the side of one or more terga, which frequently extend ventrally to cover the lateral surfaces of the abdomen. There are no pleural sclerites. Tergites and sternites, respectively, are smaller sclerites that originate from the terga and sterna. Female *Glenea* have a hidden ovipositor, which is used to lay eggs. Male genitalia are not visible.

2.3 Life cycle and habitats of Cerambycidae

The eggs are laid on, or into, the tree bark, and the larvae bore into the wood. Some larvae prefer to tunnel in the bark, or just under the bark, whereas others prefer sapwood and some heartwood. When burrowing under the bark they sometimes ring the branch or small stem, causing rapid death. Larvae are white or yellowish, fleshy, soft-bodied, sometimes finely pubescent, and thoracic legs and abdominal pseudopods may be developed. In some species pseudopods are present, presumably to aid locomotion in the tunnel system. The head is small and invaginated into the prothorax. The body is generally cylindrical, and the tunnel bore is circular in cross-section, but some of the bark borers tend to be somewhat flattened, and the tunnel bore is oval. Larval development generally takes 1-3 years, according to the species and climate. *Batocera* larvae grow as large as 8-10 cm.

The larvae that feed on cambium material (such as *Glenea* on cocoa) have a more nutritious diet and developed more rapidly and there may be as many as 3-4 generations per year. The species that bore shrubs and herbaceous plants are generally smaller in size and develop quite rapidly. *Alcidon* in South America bores in the stem of eggplant and has 3-4 generations per year; and *Apomecyna* in cucurbit stems in Africa likewise develops rapidly and has 4-6 generations annually. A few species, tiny in size, have larvae that bore into ripe seeds of cotton and berries of coffee (*Sophronica* spp.).

Pupation takes place in a cell under the bark at the end of a tunnel; the chamber is close with the plug of frass or a wad of wood fibres. Sometimes a special operculum of calcium carbonate mixed with gummy exudates or silky material is constructed. The young adult may remain inside the pupal chamber for a while, then it bites its way to the exterior.

Newly emerged adults often to remain on the tree trunk after emergence where mating takes place. The adult emergence hole is neat and usually circular. Adult beetles often chew patches of tree bark, as well as leaves and shoots, and sometimes the surface of fruits. In several species, the adults are recorded girdling the stem on which they feed, and they may kill the plant. Adults live for 1-3 months. The smallest beetles are only 5-6 mm in body length but the largest have a body of 6-8 cm, and antennae 10-14 cm long, those of the males being longer than the females. Many beetles are brightly coloured, although a few are dull.

2.4 Important Roles of Cerambycidae

The family of Cerambycidae is worldwide, found wherever there are trees and shrubs, but is most abundant in the tropical rain forests. There are many species of importance, both agriculturally and as forestry pests; many shade trees and ornamentals are damaged. The host plants are typically trees, but sometimes woody shrubs, and a few herbaceous plants. The herbaceous plants are usually bored along the stem pith (cucurbits, etc.) or in the roots (carrot, etc.), these beetles are usually quite small. Some species prefer dead or dying trees, selecting either dry or moist wood, but others appear to prefer to attack healthy trees (Beeson, 1941).

Attacked mature trees usually show severe injury symptoms in a year or two, and larger trees can be seen to die after several years of heavy infestation by large species such as *Batocera*; branches can be killed rapidly but tree trunks take longer to be killed. Young trees and saplings can be killed in a matter of months. The work on timber borers has shown that trees can be vulnerable to beetle attack after only a moderate level of water stress; apart from the water stress the trees were healthy (Mercer, 1982).

The most common symptom of longhorn attack is a hole in the trunk or branch with frass extruded. Some species make frass hole as they tunnel so that frass is extruded at interval, but many do not make frass holes, the frass being contained under the bark and in crevices, the tunnel usually clear behind the larva.

2.5 General introduction and history of data analysis

According to research by Fidler et al. (2006), authors who publish in the two top journals in conservation biology, Ecology and Journal of Ecology, are changing the way they disclose statistical data. The Null Hypothesis Significance Testing (NHST) method continues to predominate, although the alterations are minor. Statistical hypothesis tests don't really contribute much to the value of study findings, despite their widespread use in academic journals like The Journal of Wildlife Management. In fact, they frequently muddle up the data interpretation (Johnson, 1999). Additionally, statistical power is infrequently added when NHST is utilised, and crucial extra details concerning impact size and variance are frequently omitted. It is obvious that additional work is required to enhance procedures (Fidler et al., 2006). Ecologists have primarily employed statistical techniques that emphasise formal hypothesis testing in their investigations to draw conclusions from the data (Hobbs & Hilborn 2006). A few initiatives have been made in ecology to enhance practise through editorial policy (Fidler et al., 2006). Statistical power and confidence intervals were promoted in the Journal of Wildlife Management (Otis et al., 1978).

Has the field of conservation biology in Malaysia been equally resistant to change, despite the many years of harsh criticisms of NHST in ecological science and the availability of alternatives (Cohen, 1994; Johnson, 1999; Ramsey & Schafer 2002; Fidler et al., 2006;

and Hobbs & Hilborn, 2006)? In Malaysia, the traditional method still predominates in the sciences, particularly in ecology and the management of natural resources.

History of data analysis:

Ronald Fisher developed the test of significance and published his first book, in 1925. He is an agricultural statistician at the Rothamsted Experimental Station in Harpenden, Hertfordshire, England, who stressed the importance of careful experimental design and techniques to derive a conclusion from a small amount of data under the assumption of Gaussian distributions. Ronald Fisher, Jerzy Neyman, Karl Pearson, and his son Egon Pearson were significantly responsible for the development of hypothesis testing. Neyman (who collaborated with the younger Pearson) emphasized mathematical rigor and techniques to draw more conclusions from many samples and a variety of distributions. The Fisher vs. Neyman/Pearson formulation, techniques, and terminology created in the early 20th century are the foundation of modern hypothesis testing.

In general statistics and statistical inference, statistical hypothesis testing is crucial. For instance, Lehmann (1992) notes in a review of Neyman & Pearson's fundamental paper that "the new paradigm formulated in the 1933 paper, and many developments carried out within its framework, continue to play a central role in both the theory and practise of statistics and can be expected to do so in the foreseeable future, despite their shortcomings".

Reverence Thomas Bayes, a nonconformist preacher in Kent, England (1702–1761), is credited with discovering the Bayesian technique. Thankfully, after his death in 1763, his friend Mr. Price published his paper. The "inverse probability" is dealt with by the Bayesian technique (Bayes, 1763).

Laplace rediscovered the same theory in 1781, and it was accepted and applied up to the 20th century. Then, Pearson and Fisher denounced the utilisation of earlier research as being unscientific, arguing that science should only be based on data. After Fisher's passing in 1962, the Bayes theorem was revived, initially for use in medical research, and is now widely acknowledged.

2.6 Recent methods and application – Alternatives to NHST

NHST is not completely unreliable or unusable, provided the meaning of the p value understood correctly, the term "significant" was used properly, null hypothesis was appropriate, and research question can be answered by "yes" or "no" (Cohen, 1994). Thus, interpreting the results of NHST needs to be a little more careful. Even if the statistical differences cannot be found, there may be some other things that could benefit or inspire others in the finding. Being statistically significant does not necessarily mean being important in a practical setting.

Another important improvement would be the ease of access for students and researchers in general to the current and comprehensive collection of research journals. Academic establishments and community libraries to have an updated collection of both physical research journals as well as access to online journals would be provide the accessibility for researchers and students to keep themselves updated to current issues and findings.

There has been a lot of emphasis and importance placed on the use of SPSS as a tool to analyze data and as a result, majority of Malaysian students come to understand that is the most widely recognized tool. Thus, to ensure acknowledgement of their research studies, it

would be “safer” to analyze and present their data using SPSS and NHST. In fact, there are already accessible programs and platforms such as R, JAGS, and others, which can be used to statistically analyze research data using possibly more suitable alternative methods to the customary NHST. If these alternative platforms can be introduced into academic curriculum and/or improved to be more user-friendly, it would improve the awareness of the alternative statistical methods of analysis.

What are the potential benefits of the alternative methods to NHST to Malaysian ecologists and Malaysia as a whole? We can push past the conservative mindset of “significant values” of research findings. This can help to give credit to study findings that were only found to be “non-significant” due to limitations like sample size, which may not necessarily equate to the conclusion of the data to be insignificant. So, the alternatives of NHST are better for decision making, where researchers know what to do before any decision is made.

What weaknesses and shortcomings if we continue to rely solely on NHST? Building a new dam, planning a new plot for a plantation, and any other important decisions made usually depend on research data. Ecological research data that were deemed statistically non-significant based on p-value may not necessarily mean the results bear no biological importance. For instance, the presence of wildlife in each forest area may be concluded to be statistically insignificant due to its small number, however it does not mean that one single sighting of a critically endangered tiger in that area is insignificant. Forecasting using decision theory and Bayesian approaches could provide a more accurate basis for making decisions that have substantial ecological impact.

2.7 Bayesian Methods

It is possible to think of the Bayesian approaches to probability as an extension of logic that permits reasoning with ambiguous claims. The Bayesian probabilist provides a prior probability to assess the likelihood of a hypothesis, which is then updated considering new pertinent data (Jaynes, 2003). According to the Bayesian (or subjectivist) interpretation, probability in this context refers to the "degree of belief" in a specific scenario or result. Now, in contrast to frequentist methods, we can discuss the likelihood that a hypothesis is correct. When it comes to testing hypotheses, estimate, and decision-making, Bayesian approaches have certain advantages over conventional (also known as frequentist) methods. This is because they evoke the idea of the long-term frequency of outcomes in hypothetical repeats of experiments or samples (Johnson, 1999).

The posterior probability is the likelihood that the hypothesis will hold once the experiment's results are known. Bayes' theorem states that the posterior probability is proportional to the likelihood of the observed data, multiplied by the prior probability (Bayes, 1763). Thus

$$\mathrm{P}(H|D) = \frac{\mathrm{P}(D|H)\,\mathrm{P}(H)}{\mathrm{P}(D)},$$

where

- P(H) is the prior probability of H: the probability that H is correct before the data D are seen.
- $\mathrm{P}(D|H)$ is the conditional probability of seeing the data D given that the hypothesis H is true. This conditional probability is called the likelihood.

- P(D) is the marginal probability of D.
- $\mathrm{P}(H|D)$ is the posterior probability: the probability that the hypothesis is true, given the data and the previous state of belief about the hypothesis.

The quantity P(D)is the prior probability of witnessing the data D under all possible hypotheses, and it depends on the prior probabilities given to each of these other possible hypotheses. Given any exhaustive set of mutually exclusive hypotheses H_i,

$$\mathrm{P}(D) = \sum_i \mathrm{P}(D, H_i) = \sum_i \mathrm{P}(D|H_i)\mathrm{P}(H_i).$$

Here i can be considered to index alternative cases, of which exactly one is actually valid, and H_i is the hypothesis that case i is valid. Then, P(D,Hi) is the probability that both case i is valid and that the data from the experiment turn out to be what was observed. Since the set of alternative cases is assumed to be mutually exclusive and exhaustive, the above formula is a case of the law of total probability. In many, P(D), which is a normalizing constant, need not be evaluated. As a result, Bayes' formula is often simplified to:

$$\mathrm{P}(H|D) \propto \mathrm{P}(D|H)\ \mathrm{P}(H),$$

where $\propto$ denotes proportionality. The need for a sometimes-subjective prior probability is one criticism of Bayesian methods and is a major reason that Bayesian approaches fell out of favor. The other main reason is that Bayesian calculations tend to get heavy, but modern computer capabilities can largely overcome this obstacle (Johnson, 1999)

Johnson (1999) asserts that Bayesian confidence intervals are significantly more logical than their frequentist equivalents. If the study were to be repeated an infinite number

of times, 95% of the confidence intervals that emerged would contain the correct value of the parameter θ, as indicated by the frequentist 95% confidence interval for that parameter θ, denoted (θL, θU). Howson & Urbach (1991) noted that "statisticians repeatedly assert that one may be '95 per cent convinced' that the parameter resides in the confidence interval. Yet, it tells nothing about the specific study that was undertaken. Never do they explain why. A Bayesian confidence interval, also known as a credible interval, is interpreted to suggest that there is a 95% chance that the parameter's real value is contained within the interval. That definition is considerably more accurate, because it corresponds to what most people believe a confidence interval to be until statistics classes beat the idea into them. Bayes' theorem provides a logical approach to decision-making under uncertainty in the context of decision analysis. It enables the incorporation of ideas, facts, and the profits or losses anticipated from potential decisions' outcomes. One benefit of using Bayesian methods is the ability to incorporate prior knowledge into the study. As Bayesians do not rely on the notion of repeatedly running an experiment, they employ a subjective concept of probability (the "degree of belief"). So, Bayesian findings can be used to decision-making that is dependent on managers' perceptions of the circumstance.

2.8 Why Bayesian?

Bayesian approaches compute the probability of various values of a parameter given the data based on (Crome et al., 1996; Wade, 2000). Given that (1) Bayesian analyses are easy to understand and present and automatically include the estimate's uncertainty, (2) probability statements more accurately reflect the state of a population than p-values resulting from hypothesis tests, (3) Bayesian analyses directly relate to biological relevance in contrast to significance tests, in which biological importance typically plays no role; (4) Bayesian methods are therefore advantageous for conservation biologists; (5) uncertainty

from significant but unidentified parameters can be included; (6) model choice uncertainty can be formally incorporated into analysis results by combining the results from various plausible models via the Bayes factor; and (7) uncertainty can be reduced by incorporating additional information in a formal and transparent way, including combining different types of data, updating and analysis after collecting additional data, or subjectively using information from important but unidentified parameters.

2.9 What are the differences?

What are the differences compare to significance-based methods and why new approaches are needed for ecological data analysis? There are four main reasons for this; 1) wildlife data analysis should give managers and policy makers useful information; 2) to deal with complexity and uncertainty of ecological system; 3) the type of data that were collected and most of the time only small data set were obtained; and 4) the need to consider the probability of detection.

For managerial decision-making, the "p-values" produced by the conventional null hypothesis significance testing (NHST) procedures are ineffective or misleading (Wade, 2001; McGarvey, 2007). Although their use indicates appropriate scientific caution, it goes against the precautionary principle that environmental managers are required to follow. Contrarily, for formal decision-making procedures, Bayesian posterior probabilities can be simply included into the loss function (Berger 1985). Prior to the development of strong personal computers and clever algorithms, Bayesian approaches could only be used to very simple issues; nevertheless, they are now frequently utilised in the study of wildlife data (Royle & Dorazio, 2008; King et al., 2010).

Ecological systems are complicated, and the mechanisms at work are unknown. This complexity and ambiguity are ignored when judgements for individual impacts are restricted to "accept" or "reject." For wildlife science, a method that considers various models and the relative strength of each model's support from the data is preferred. Some specialised software programmes use information theory, which is based on Kullback-Leibler divergence, to give a foundation for comparing models (Burnham and Anderson, 2002). (eg. Presence, Distance, Mark).

The response variable, which is the variable of interest, is typically not continuous, and sampling errors are not normally distributed. The probability is typically based on binary outcomes (detected/not detected, survived/died, marked/unmarked, success/failure, etc.) or a positive integer based on counts (number of individual organisms, number of occupied places, number of species present, etc.) that are widely scattered. Although it is true that the binomial and poisson distributions both approach the normal distribution with large numbers, wildlife datasets are typically characterised by small numbers.

The data acquired are always impacted by the observing procedure. Since detection is rarely 100% accurate, some animals, species, or occupied sites may not be recorded. Expecting perfect detection results in false conclusions that are frequently highly misleading (MacKenzie et al., 2005). Studies must be planned in a way that allows for the joint estimation of the probability of detection and the parameter(s) of interest. Since there are no straightforward "plug-in" estimators, joint likelihoods must be explicitly calculated and maximised (Borchers & Efford, 2008). Fortunately, specialised software packages have been created for most of these scenarios.

Here are examples of a few currently available software or tools, which are free, useful, powerful, and considered user friendly:

An environment and language for statistical computing and graphics is called R. R offers a wide range of graphical and statistical tools, including time-series analysis, classification, clustering, and linear and nonlinear modelling. It is also very extendable. R is accessible as Free Software under the provisions of the GNU General Public License from the Free Software Foundation. It can be built and run on a variety of UNIX platforms and related systems, including Windows and Macintosh, FreeBSD, and Linux (R Development Core Team, 2020).

The BUGS (Bayesian inference Using Gibbs Sampling) project is interested in developing adaptable software for the Bayesian analysis of complicated statistical models using Markov chain Monte Carlo (MCMC) techniques. The research, which started in 1989 in the MRC Biostatistics Unit, eventually led to the WinBUGS software, which was created in collaboration with the Imperial College School of Medicine at St. Mary's, London (WinBUGS).

CHAPTER 3

MATERIALS AND METHODS

3.1 Study Area

Cerambycidae specimens were gathered from the secondary and hill mixed dipterocarp forests of Sungai Sekabai, Sebauh, Bintulu; Ulu Sungai Mujuk, Julau; Loagan Bunut National Park, Lanjak Entimau Wildlife Sanctuary, Batang Ai National Park, and Gunung Murud Kecil, Ulu Baram. These sites were chosen due to opportunities covered by other entomological research expedition grants. The specimens were collected by using a variety of techniques. The majority of the Cerambycidae species present in these woodlands were collected using the butterfly net, Malaise traps, and hand picking.

3.1.1 Sungai Sekabai, Sebauh, Bintulu

Sungai Sekabai is tributary at upper of Sungai Sebauh, under jurisdiction of Sebauh District Office, Bintulu Division. It is dominated by new and old secondary forest mostly consisted of *temuda*, logged over forest, and a portion of its hill mixed dipterocarp forest has been cleared for *Acacia* plantations and shifting cultivations. A few virgin forest patches of lowland and mixed dipterocarp forest designated for *Pulau Galau* or communal reserve, and some area is swamp forest. This area is *Pemakai Menua* or communal territory of one longhouse (Tr. Nor Nyawai) at the time of sampling, however it's surrounded with individual farmhouses and several small tributaries that weaves the landscape.

3.1.2 Ulu Sungai Mujuk, Julau, Sarikei

Ulu Sungai Mujuk is small tributary at upper river of Sungai Kanowit, located in Julau District, Sarikei Division. This study area is adjacent to Lanjak Entimau Wildlife

Sanctuary, therefore it dominated with mixed dipterocarp forest and old secondary forest. The habitat is very much pristine and intact with several small streams flowing from high elevation areas. There are a few Iban longhouses close to the mouth of Sungai Mujuk.

3.1.3 Loagan Bunut National Park, Miri

A national park called Loagan Bunut is situated in Sarawak's Miri Division. The largest natural lake in Sarawak, measuring 650 hectares and mostly covered in peat swamp, is known by its native Berawan inhabitants as Loagan Bunut. But, during the dry season, the lake vanishes. A portion of the park is covered in a mixture of dipterocarps.

3.1.4 Lanjak Entimau Wildlife Sanctuary, Sibu

The Lanjak Entimau Wildlife Sanctuary (LEWS) was established in February 1983 with the goal of safeguarding all wildlife, particularly the local hornbills and *mayas* (orang-utans). The LEWS is the largest fully protected area in Sarawak, covering 168,758 acres. The LEWS will eventually cover 191,568 ha when the anticipated enlargement of the neighbouring territories is considered. The Sanctuary is a main forest that has not been much altered, save for isolated areas of abandoned secondary forest. Iban longhouses serve as a buffer zone around almost every corner of this sanctuary, together with their ancient secondary forest.

3.1.5 Batang Ai Nationak Park, Sri Aman

In Malaysia's Sarawak state's Sri Aman Division is the Batang Ai National Park. It is located near Lubok Antu, around 250 km east of Kuching. The Batang Ai hydropower reservoir built an artificial lake that is 24 square kilometres in size that is surrounded by dense tropical rainforest covering 9.3 square miles of land in the park. Since it was established in 1991, both locals and visitors have grown to love this park. The orang-utans,

gibbons, and hornbills live in the luxuriant dipterocarp forests. The lake provides a peaceful, quiet atmosphere and a magnificent setting. Most of the locals are Iban.

3.1.6 Gunung Murud Kecil, Ulu Baram, Miri

The sandstone Gunung Murud Kecil is a famous geological structure that rises 1,615 metres above sea level. It is near to the border with Indonesia. Hill dipterocarp forest, upper dipterocarp forest, montane forest, and ericaceous forest were all present on Gunung Murud Kecil. For the Penan and Kelabit villagers that reside adjacent to Gunung Murud Kecil, the tropical rain forest that surrounds the mountain is still in pristine condition and has become the primary location for foraging and hunting activities.

3.2 Cerambycidae Survey and Field Data Collection

Depending on the accessibility in these forests from 2004 to December 2006, an opportunistic and convenience survey was undertaken. Malaise traps (Figure 3.1) were installed along airways in the forest or junctions at abandoned logging roads.



Figure 3.1: Malaise trap (Photo taken by: Ratnawati Hazali of UNIMAS Entomology Team)

Insects were collected every two days for 1 or 2 weeks. There were 2 years of data collection, on average 1 to 2 weeks of every month in these 6 study sites. Dead materials or living plants were inspected for Cerambycidae presence by open damaged woods, plant materials or abandon logs. Adult Cerambycidae were collected as many as possible by hand picking and butterfly net. Then these Cerambycidae were killed in killing jar. These Cerambycidae were pinned, set, and dried under the sun. Collecting was mainly done using the light sheet trap consisting of a piece of white cloth (1.5 m x 2 m) with a 160 W mercury vapour lamp powered by a 220 - 240 V portable generator. The trap was switched on from 1800 - 2400 hours. Specimens were picked off from the sheet using killing jar filled with ethyl acetate and were either pined in the field or kept inside the killing jars for transportation. In the laboratory, all fresh specimens were kept in oven at 37° C for 14 days before being transferred into standard insect drawers.

Aerial catching was done along jungle or forest trails, open clearing such as newly logged secondary forest, log ponds and logging camps. Specimens collected were treated in the same manner as above.

3.2.1 Data collection from preserved specimens

The specimens used in this study come from a variety of collection sources, including the Sarawak Museum Collection in Kuching, the Unimas Insect Reference Collection at Universiti Malaysia Sarawak, and the Sarawak Forestry Company in Kuching (Forest Research Centre Coll.).

The Sarawak Museum was founded in Kuching in 1886 and is the first museum in Borneo (Earl of Cranbrook & Leh, 1983). With a total holding of around 70,000 bug specimens, the museum has among other biological collections the oldest entomological

collections in Borneo. Hugh Low, Alfred Russell Wallace, G.E. Bryant, H.M. Pendlebury, E. Mjoeberg, and C. M. Enriquez were pioneers in the study of Bornean insects (Abang et al., 1996). Insectarium is where the Forest Department of Sarawak keeps all the dry and wet bug specimens since 1975. Under the direction of Professor Dr. Fatimah Abang, the Unimas Insect Reference Collection at Universiti Malaysia Sarawak (UNIMAS Coll.) was established in 1994.

All specimens were examined using a Jena Carl Zeiss stereomicroscope (0.8 X - 4.0 X) illuminated by a 6V halogen lamp with light-blue filter. Species identification was based on the Pascoe (1869); Gahan (1906a, 1906b); Aurivillius (1912); Gressitt & Rondon (1970); Gressitt (1951a, 1951b, 1951c) and Duffy (1968). Distribution mappings were done based on locality data labels of the voucher specimens studied and outline maps (base maps) were plotted using software R.

CHAPTER 4

SYSTEMATIC ACCOUNT OF THE GENUS *GLENEA* (FAMILY CERAMBYCIDAE) IN SARAWAK

4.1 Introduction

More than 10,000 species of invertebrates have been estimated to occur in Sarawak. Unfortunately, most of the insect fauna of Sarawak still await discovery. The taxonomy of most insect groups is still unknown. The paucity in knowledge of this dominant group is reflected in the discrepancies in the number of species known from this region (Abang et. al, 2003).

The cerambycids are known to target Leguminosae, Dipterocarpaceae, Thymelaeaceae, and Sapotaceae families of valuable wood in Sarawak. We therefore consider the cerambycids to be a pest to our wood-based sectors.

The family Cerambycidae in Sarawak is represented by 4 subfamilies, Lamiinae (68%), Cerambycinae (25%), Prioninae (6%), and Lepturinae (1%) (Abang et. al, 2003). Subfamily Lamiinae is the largest group in the family Cerambycidae, and many species are of considerable economic importance. Their larvae attack living trees sometimes and feed on evergreens, generally on recently felled logs.

Leconte, A. White, J. Thomson, T. Lacordaire, and F. P. Pascoe were among the scientists that first established the right classification of the Cerambycidae or Longicornia in the middle and late nineteenth century. The conceptual arrangement of longicorn beetles was first proposed by Leconte, but his expertise was limited to North American taxa (Pascoe, 1866; Fragoso, 1987). Thomson (1860) later treated all the longicorn genera of the then-

accepted families, namely Prionidae, Cerambycidae, and Lamiidae. Currently, these are recognised as belonging to the subfamilies Lamiinae, Cerambycinae, and Prioninae, respectively.

The Cerambycidae's most thorough and fundamental taxonomic study was first released by Lacordaire and Chapuis (1854) used the look of faceted eyes as the primary characteristic for handling this group, creating dichotomous keys that prioritise strongly or finely faceted eyes (Pascoe, 1869). The result was a basic division of the cerambycids that were active during the day or at night.

C. J. Gahan, C. Aurivillius, and W. S. Fisher conducted taxonomic research of the Cerambycidae in the Oriental regions at the beginning of this century. Gahan (1906a, 1906b) provided thorough coverage of most genera found in the Malaysian Subregion and the Indian Region. Aurivillius (1910, 1912) and Fisher (1934, 1935) paid more attention to the Cerambycidae from Java, Sarawak, and Sabah, respectively.

The late Judson Linsley Gressitt's contributions to the study of cerambycids in this area over the previous 50 years were very important. He extensively documented the diversity of Oriental and Australian (Papuan Subregion) cerambycids, many of which are directly relevant to this study, in his numerous papers (Gressitt, 1935a, 1935b, 1936, 1938, 1940, 1951a, 1951b; Gressitt, 1951c; Gressitt & Rondon, 1970), which mostly dealt with Prioninae and Cerambycinae.

Only two entomologists, Masao Hayashi and Karl-Ernst Hudepohl, are engaged in taxonomy research on cerambycids in Borneo or the surrounding areas. Most of the Hayashi's research was done in Peninsular Malaysia and Sabah, although he also described several new species from Sarawak in his publications from 1977 to 1987 (Hayashi, 1969,

1975, 1976a). Hudepohl simultaneously addressed the cerambycid fauna of the Philippines in general but also described a few species from Peninsular Malaysia and Sabah (Hudepohl, 1987, 1983, 1988, 1989a, 1989b, 1990b, l992b).

4.2 Materials and Methods

All the samples were examined using a Jena Carl Zeiss stereomicroscope (0.8 X - 4.0 X) lit by a 6V halogen lamp with a light-blue filter. In addition to the works by the authors mentioned above, the authors Pascoe (1869), Gahan (1906a, 1906b), Aurivillius (1912), Gressitt & Rondon (1970), Gressitt (1951a, 1951b, 1951c), and Duffy (1968) were used to identify and classify several species.

Coleoptera should be mounted in a uniform manner for study. Small specimens are mounted on triangular or rectangular cards, glued to the right side of the thorax so that the dorsal, ventral, and left sides of the body are clearly visible. Larger specimens are pinned through the elytra above mesonotum slightly to the right of the midline or are glued by the right side of the thorax to the side of a pin. Whether pointed or pinned, the head of the specimen should face to the left when it is examined in lateral view. When examined in dorsal view, positional terms used in the keys assume that the head of the specimen faces away from the observer (Gressitt & Rondon, 1970).

Based on Pascoe (1869), Gahan (1906a, 1906b), Aurivillius (1912), Gressitt & Rondon (1970), Gressitt (1951a, 1951b, 1951c), and Duffy, a systematic account and key of the family Cerambycidae up to tribe Gleneini were developed (1968). Yet, this study initiative led to the development of a dichotomous key to the species of the genus *Glenea* and a systematic explanation of the genus.

All appearances and morphological characteristics were listed down (Appendix 4.1) as a first step to create dichotomous key. The colouration of antennae, head, prothorax, scutellum, elytra, ventral view of mesothorax and metathorax, legs, and ventral view of abdomen were examined, described, and recorded in Operational Taxonomic Unit (OTU) table for dendograms analysis in the next chapter. The colouration and its code that were used is in Appendix 4.1. For general diagnostic characters, the marks, shapes and pattern of their colouration or appearances on their head, prothorax, scutellum, and elytra were examined, described, and recorded in OTU table. These characters were also coded as in Appendix 4.1. Based on coded morphological characteristics of genus *Glenea* in Appendix 4.1, details of external morphological characteristics of head, prothorax, scutellum, and elytra were examined, described, and recorded in OTU table.

All these appearances and morphological characteristics were organized orderly based on prominent features on elytra, thorax, head, and other parts. Then, specimens were divided based on these characteristics. These processes were repeated until all specimens sorted and belong to its characters in the right branches. During this sorting process, dichothomous key diagram was drawn to accommodate the process to make dichotomous key table as in results. The last step was another researcher testing it out.

All appearances and morphological characteristics that were listed down (Appendix 4.1) were also used in describing the species to develop a systematic account of genus *Glenea* in Sarawak. The describing process was start with general diagnosis of the species by describing the marks, shapes and pattern of their colouration or appearances on their head, prothorax, scutellum, and elytra. Then, details of external morphological characteristics of head, prothorax, scutellum, and elytra were described. Beneath of the body was also described. All specimens were examined at least two times. RS PRO 150mm Digital Caliper

was used to measure the length and width of the specimens. No parts were measured due to the fragility of the specimens.

4.3 Results

A total of 59 species of genus *Glenea* from 406 individuals was examined representing all from museum specimens and none from field collection. There was no species of genus *Glenea* found throughout the survey on 2004 to December 2006, only other species from the family Cerambycidae. There were 59 species available for evaluation, 41 species were redescribed, and 18 species were newly described.

4.3.1 Species distribution pattern in Sarawak

Based on the studied specimens, Glenea species distributed throughout Sarawak, and occupied difference level of elevation (Appendix 8.1 and Figure 4.1).

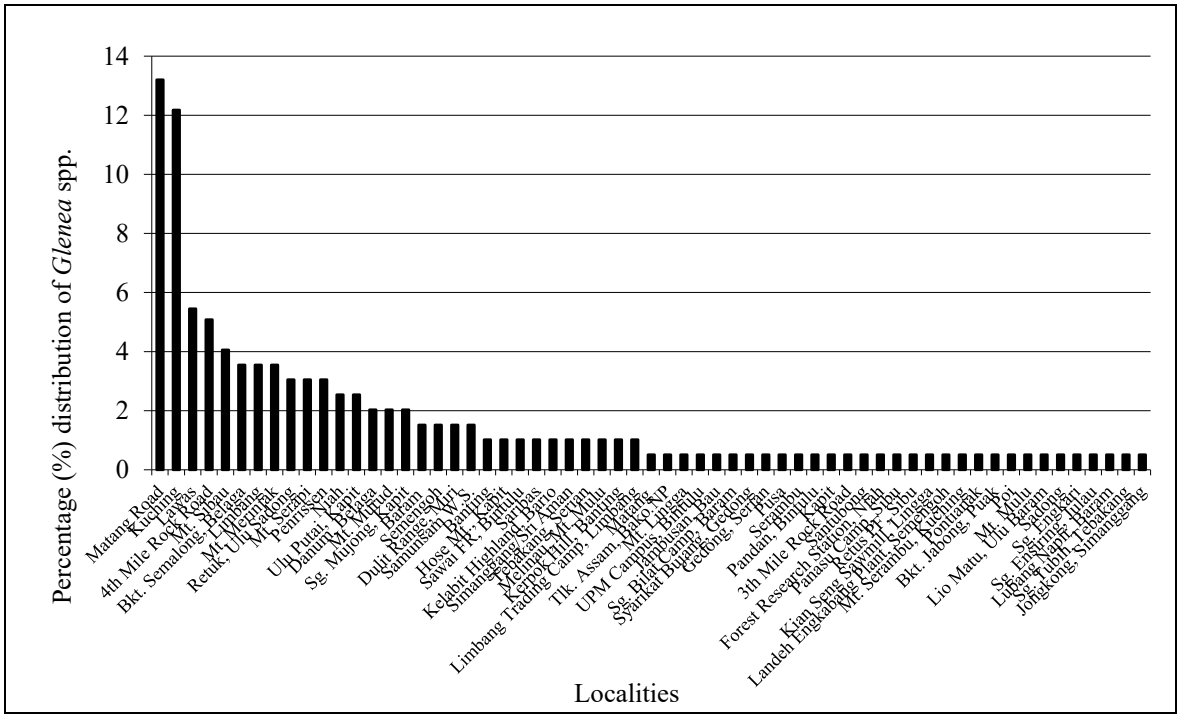


Figure 4.1: The percentage distribution of *Glenea* spp. in Sarawak

The lowest elevation is 4.28 meters above sea level at Sungai Bilat Camp, Baram, Sarawak, meanwhile, the highest elevation is 2197.30 meters above sea level at Mount

Murud, Sarawak. Matang Road and Kuching have the highest percentage of *Glenea* species distribution, 13.2% and 12.18% respectively out of 59 species; and then followed by Lawas (5.45%), 4th Mile Rock Road (5.08%), Mt. Sibau (4.06%), Bukit Semalong, Limbang, and Mount Merinjak (3.55%), while the rest are 2.54%, 2.05%, 1.52%, and 0.51% (Figure 4.1). The Appendix 6.8 and Figure 6.14 showed the details distribution of each studied specimens.

All five specimens of *Glenea camelina* were collected at four localities at southern part of Sarawak (Figure 6.14), and only two individuals collected at 4th Mile Rock Road. The *Glenea bellona albomaculata* are distributed at many parts of Sarawak from northern to southern part of Sarawak, but half of eleven individuals collected were at Matang and Bako (Figure 6.14). The Appendix 6.8 shown the distribution of *Glenea pustulata pustulata*; nine out of eighteen specimens were collected at Kuching, at seven localities are one each, and two specimens with no locality label. Thirteen specimens of *Glenea angerona angerona* were collected at Sarawak, six from Mount Sibau, three from Dulit Range, and another four localities with one each (Appendix 6.8). The eight specimens of *Glenea dimidiata dimidiata* was collected at Kuching, eight at Matang Road, four at 4th Mile Rock Road, three at Gedong, two at Baram, and only one specimen at other seven localities (Appendix 6.8). There were only two specimens of *Glenea fatalis* which were collected at Matang Road and Mount Serapi, Matang (Appendix 6.8). Out of six specimens of *Glenea regina* collected, there were three from Mount Merinjak, one from Kuching, one from Mount Serapi, and one from Sawai FR (Appendix 6.8). Two specimens of *Glenea celia* were collected at Serambu (Appendix 6.8). Appendix 6.8 shown that *Glenea juno* concentrated at southern part, and only two specimens were collected at centre part of Sarawak. The two specimens of *Glenea elegans* were come from Matang Road and Kelabit Highland, Bario (Appendix 6.8). The *Glenea extensa* one of the most abundance specimens in collection with 30 individuals, eleven from

Kuching, four from 4th Mile Rock Road, two from Simanggang, two from Retuk, one each from other nine localities, and one with no label (Appendix 6.8). All four specimens of *Glenea sejuncta* were collected from four localilties, Kuching, Ulu Putai, Semengoh, and Samunsam Wildlife Sanctuary (Appendix 6.8). *Glenea aspasia* can be found Mount Murud, Mount Merinjak, Mount Sibau, Penrissen (three specimens from here), Ulu Putai, and at Forest Researh Station, Niah (Appendix 6.8). Most of *Glenea interrupta* were collected around Kuching, with ten out of thirteen specimens, two collected from Sibu, and one from Lingga (Appendix 6.8). There are seven and four specimens of *Glenea despecta* were collected from Matang Road and Kuching, one from Mount Murud, one from Banting, and Semengoh (Appendix 6.8). The Appendix 6.8 shown that *Glenea latevittata* distributed at three localities, Kuching with five individuals, Matang Road with six individuals, and Mount Serapi only one individual. The *Glenea pulchella* is distributed at six localities (Appendix 6.8), three specimens at Mount Merinjak, four from Matang Road, six from Kuching, one from Ulu Sadong, and one at Baram. Sixteen specimens of *Glenea algebraica* collected from six localities, nine of them from Kuching, two from Matang, two from 4th Mile Rock Road, one from Retuk, one from Simanggang, and one from Landeh Engkabang Plantation, Semengoh (Figure 6.14). The eighteen individuals of *Glenea blandina* only collected from southern part of Sarawak, nine individuals from Matang Road, seven from Kuching, one from Mount Sibau, and one from Tebakang (Figure 6.14). All eight collected specimens of *Glenea funerula funerula* located at five localities, two specimens collected from Merinjak, two from Penrissen, two from Retuk, one each from Melinau and Bukit Semalong (Appendix 6.8). The two specimens of *Glenea numerifera* only collected from Niah (Appendix 6.8). Almost all of the nine *Glenea analytica* specimens collected from interior area of center part of Sarawak, only 1 collected at Banting (Figure 6.14). *Glenea rufifrons* only caught at

Kuching and 4th Mile Rock Road (Appendix 6.8). All of fifteen specimens of *Glenea myrsine* distributed at three localities, Kuching with six specimens, Matang Road with eight specimens, and only one at Mount Sibau (Appendix 6.8). *Glenea manto* distributed at four localities which are concentrated at southern part of Sarawak (Appendix 6.8). The only specimen of *Glenea subsimilis thetis* are collected from Limbang (Appendix 6.8), and almost all five specimens of *Glenea medea* collected at Kuching (Appendix 6.8). The *Glenea trivittata* only located at two place, Matang Road and Mount Serambu (Appendix 6.8). The *Glenea citrina* and *Glenea disa* were collected from Matang Road and Limbang respectively (Appendix 6.8), meanwhile nine specimens of *Glenea collaris* were distributed at five localities, Matang Road (four), Kuching, Penrissen (two), 4th Mile Rock Road, and Mount Sibau (Figure 6.14). The two individuals of *Glenea melia* were collected at Pontianak (Figure 48) in year 1899, when political border not an issue. The only specimen of *Glenea coris* is from Bukit Jabong, Puak, Simanggang (Appendix 6.8). Four specimens of *Glenea ochraceovittata ochraceovittata* were from Matang Road, and one each from Saribas, Mount Merinjak and Kuching (Appendix 6.8). Appendix 6.8shown that *Glenea calypso* occupied southern part of Kuching, and only one each at Poi, Limbang and Lawas. Five specimens of *Glenea iresine* were collected from Matang Road, two from Kuching and one from Retuk (Appendix 6.8). *Glenea saperdoides saperdoides* is distributed at four localities, three specimens collected from 4th Mile Rock Road, four specimens from Kuching, three from Mount Mulu, and one from Matang road (Appendix 6.8). The *Glenea matangensis* is also distributed at four localities, with six specimens collected from Matang Road, three from 4th Mile Rock Road, two from Lawas, and one from Kuching (Appendix 6.8Five specimens of *Glenea dimidiata* var. found at five difference localities, Matang Road, Mount Merinjak, Sabang, Lawas, and Mount Murud (Appendix 6.8), meanwhile the only specimen of *Glenea*

dimidiata semigresea was found at Melinau, Mount Mulu (Appendix 6.8). The Appendix 6.8 show the seven localities where all ten specimens of *Glenea laudata* distributed, four at Kuching, and one each at Lawas, Kerpok Hill, Lio Matu, Limbang, Sadong, and Matang Road. Appendix 6.8 showed the distribution of *Glenea* sp. 1 to *Glenea* sp. 18 respectively. Most of these species occupied only one locality based on studied specimens.

4.3.2 Account of Family Cerambycidae

CERAMBYCIDAE Leach, Zool. Misc. 3 (1815, 1817); Ganglbauer (Bestimm.-Tabell. Eur. Col. 7), Verh. zool-bot. Ges. Wien 31 (1881) 695: Aurivillius. Colt. Cat. 39 (1912), ibid. 73 (1922), ibid. 74 (1923); Craighead, Dept. Agric. Canada Tech. Bull. 27 (1923) 26; Comstock, Introd. Ent. rev. ed. (1924) 524; Matsushita, Journ. Fac. Agr. Hokkaido Imp. Univ. 34 (1933) 158.

CERAMBYCIDES Thomson, Classif. Ceramb. (1860) ix; Syst. Ceramb. (1864) 13.

LONGICORNIA Leconte, Proc. Acad. Sci. Philadelphia 14 (1862) 38; Pascoe, Trans. Ent. Soc. London (3) 3 (1865) 3; Gahan, Fauna Brit. India Col. 1 (1906) xi.

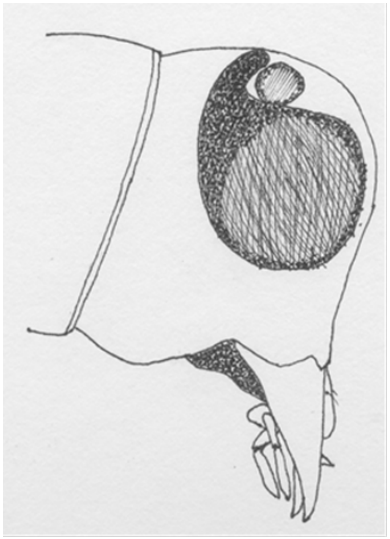
LONGICORNES Lacordaire, Gen. Col. 8 (1869) 5; Planet, Encyclop. Ent. 2 (1924) 9. Mentum transverse; maxillary palpi 4-segmented; labial palpi 3-segmented; antenna generally longer than body, normally 11-, rarely 12-segmented; prothorax more or less cylindrical; elytra entire or abbreviated, generally wider than prothorax; metepisternum more or less parallel; metepimeron generally hidden by elytra; legs long; tarsi with third segment more or less deeply bilobed, fourth segment very minute, fifth segment bearing a pair of divergent or divaricate claws.

4.3.3 Key to the subfamilies of Cerambycidae of Borneo

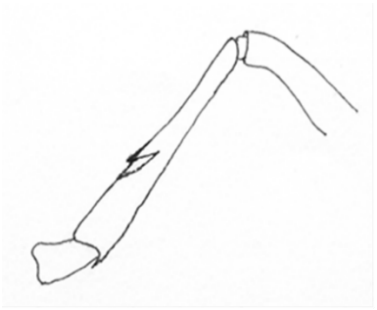
Key to the subfamilies of Cerambycidae of Borneo based on Gressitt & Rondon, 1970.

	Pro and mesotibiae simple, lacking oblique grooves or concave subapical portions bearing short, erect hairs……...2
	Protibiae generally obliquely grooved internally; mesotibiae usually grooved before apex of outer side or with a slightly concave profile or some short, stiff, erect hairs hiding surface; head more or less vertical in front or with mouth directed backward beneath; antennae inserted distantly from mandibles; frons generally robust; antennae lacking a fringe of very long, fine hairs for entire length, internally; genal margin always directed posteriorly; apical palpal segment acute (Figure 4.2a, 8b, 8c)…….……LAMIINAE
	Prothorax not margined laterally; procoxae strongly transverse; inner lobes of maxillae developed……...….…….3
	Prothorax with elevated lateral margin; procoxae strongly transverse; inner lobes of maxillae obsolete; antennae inserted closed to base of mandible; labrum fused to epistoma; apical palpal segment acute (Figure 4.2d, 9a)…….……..PRIONINAE
	Head elongate, strongly constricted behind eyes; clypeus very large; procoxae conical, angulate externally; second antennal segment not longer than broad, much less than one-half as long as third segment; submentum with intermaxillary process; mandible usually with molar tooth, densely

	fringed with pubescence on inner margin (Figure 4.3b)…….....LEPTURINAE
	Head not strongly constricted behind eyes; clypeus not particularly large; procoxae generally depressed, rarely strongly angulate externally; antennae not inserted close to base of mandible; apical palpal segment acute (Figure 4.3c, 9d)…….…….…….CERAMBYCINAE



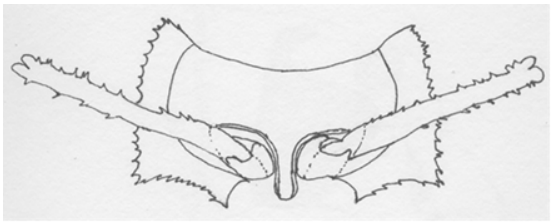
(a)



(b)



(c)

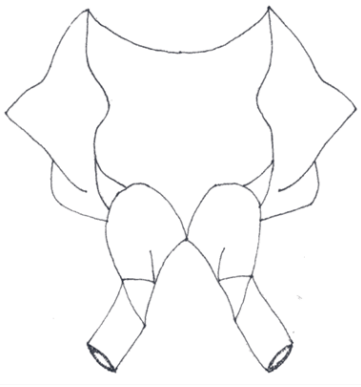


(d)

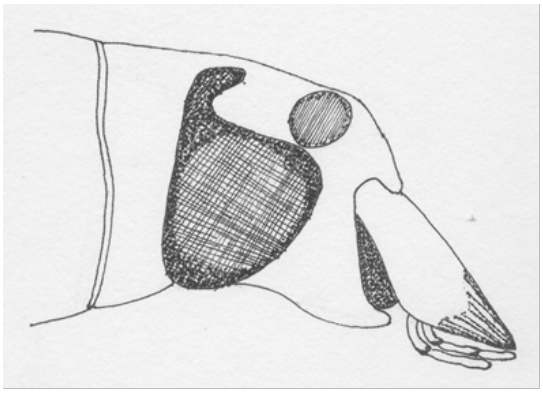
Figure 4.2: a) Lateral view head of Lamiinae, b) Anterior view mesotibia of Lamiinae, c) The Lamiinae, and d) Ventral view prosternum of Prioninae.



(a)



(b)



(c)



(d)

Figure 4.3: a) The Prioninae, b) Ventral view prosternum of Lepturinae, c) Lateral view head of Cerambycinae, and d) The Cerambycinae.

4.3.4 Account of subfamily Lamiinae

LAMIARAE Latreille, Hist. Nat. Crust. et Ins. 11 (1804) 282.

LAMIIDAE White, Cat. Col. Brit. Mus 8 (1855) 335.

LAMIITAE Thomson, Classif. Cer. (1860) 1.

LAMIIDES Lacordaire, Gen. Col. 9 (1869) 238.

LAMIINAE Leconte and Horn, Smiths. Misc. coil. (21) 507 (1883) 313; Aurivillius, Cot Cat. 73 (1922) 1.

Head vertical anteriorly; antennal insertions generally distant from mandibles and partly surrounded by eyes; apical palpal segments acute; neck generally broad; prothorax cylindrical and often tuberculate laterally; scutellum usually rounded behind; anterior coxae mere or less prominent, their acetabulae generally angulate externally; anterior tibiae obliquely grooved on inner surfaces.

4.3.5 Key to the tribes of Lamiinae of Borneo

Key to the subfamilies of Cerambycidae of Borneo based on Gressitt & Rondon, 1970.

1.	Tarsal claws simple, lacking teeth……..…...…….……2
	Tarsal claws toothed or appendiculate basally……..……...…...21
2.	Antennal scape with a cicatrix at apex……...…...…….3
	Antennal scape lacking a true cicatrix at apex……..……..……...7
3.	Cicatrix of scape generally completely closed, occasionally feebly margined-internally…….…….…….4
	Cicatrix of scape incomplete, open internally……..…...…...5
4.	Frons more or less rectangular……..……...……..…MONOCHAMINI
	Frons strongly narrowed above……...……..……...AGNIINI
5.	Head touching coxae in repose……..……...…….6
	Head not touching coxae in repose……..……BATOCERINI
6.	Middle tibia generally lacking a preapical groove…….MESOSINI
	Middle tibia generally possessing a preapical groove...…ANCYLONOTINI
7.	Middle coxal cavities open externally to epimera……..8
	Middle coxal cavities closed externally to epimera……...……...18
8.	Tarsal claws divergent, forming an angle of less than 90°……..……..……9
	Tarsal claws divaricate, forming an angle of about 180°……..……...13

9.	Middle tibiae with a preapical oblique groove externally……..…….....10
	Middle tibiae generally lacking a preapical oblique groove……NIPHONINI
10.	Front of head more or less rectangular……..……..…….11
	Front of head trapeziform, broader below than above; antenna with long hairs……...……...12
11.	Anterior coxae very prominent, produced posteriorly, conical or cylindrical ……..……...……...XYLORHIZINI
	Anterior coxae not very prominent, projecting but slightly above level of inter coxal process…….....……..APOMECYNINI
12.	Antennae very slender, much longer than body; head moderately angulate …….…….……..HIPPOPSINI
	Antennam hardly longer than body; head strongly produced at vertex, frons forming an acute angle with top of head……...…….…..…SPALACOPSINI
13.	Middle tibiae with a preapical oblique groove externally…….…..…14
	Middle tibiae lacking a preapical oblique groove……..……6
14.	Eyes emarginated……...……..……....15
	Eyes divided……..…..…….……...NYCTIMENINI
15.	Scape clubshaped, granulose; elytra never carinate……DORCASCHEMATI
	Scape slender, gradually thickened; elytra generally carinate laterally……..GLENEINI

16.	Antennal scape slender or subcylindrical; head not touching coxae in repose…….17
	Antennal scape club-shaped; head resting on coxae in repose……HECYRINI
17.	Metepisternum narrow, subparallel-sided…….……..……APODASYINI
	Metepisternum triangular, very broad anteriorly; elytra sometimes carinate laterally…… ……..….SAPERDINI
18.	Tarsal claws divaricate……..…… ……..……..19
	Tarsal claws divergent, forming angles of less than 90°….. PTERICOPTINI
19.	Antennal scape slender, subcylindrical, simple; antennal insertions widely separated……...…… …….20
	Antennal scape club-shaped, bearing a false granular cicatrix before apex; antennal insertions fairly close……...……XENOLEINI
20.	Anterior coxal cavities rounded……..……..…...ACANTHOCININI
	Anterior coxal cavities angulate externally……...…...…...……...ESTOLINI
21.	Eyes simply emarginate, not divided……..…….22
	Eyes completely divided…..……..……...…….…...TETRAOPINI
22.	Elytra generally carinate laterally; middle three abdominal segments shorter than first and last…….……..…..GLENEINI
	Elytra rarely carinate along edge of lateral declivity; first four abdominal segments subequal in length……...……...……..…...PHYTOECIINI

4.3.6 Account of tribe Gleneini

Tribe GLENEINI Aurivillius

GLENEITAE Thomson, Syst. Cer. (1864) 123, 401.

GLENEIDES Lacordaire, Gen. Col. 9 (1872) 841.

GLEINEINI Aurivillius, Col. Cat. 74 (1923) 494.

Antennal insertions distant, feebly raised; eyes finely facetted, emarginated; antennae but slightly longer than body; anterior coxal cavities angulate externally; middle coxae cavities open to epimera; middle tibiae obliquely grooved; tarsal claws divaricate, generally toothed beneath in male.

Genus *GLENEA* Newman

Glenea Newman, 1842d:301 (type species: *Sphenura novemguttata* Laporte) {key to subgenera: Rondon & Breuning, 1970:527} {Note 35}

Sphenura Laporte, 1840:489 (type species: *Sphenura novemguttata* Laporte) (pre-occupied by *Sphenura* Lichtenstein, 1823, Ayes)

Volumnia J. Thomson, 1860:58 (type species: *Saperda apicalis* Chevrolat)

Tanylecta Pascoe, 1866a:263 (type species: *Tanylecta lambii* Pascoe)

Cryllis Pascoe, 1867a:417 (type species: *Cryllis clytoides* Pascoe)

Moraegamus J. Thomson, 1868b:188 (type species: *Sphenura flavicapilla* Chevrolat)

Accola Jordan, 1894c:503 (type species: *Accola citrina* Jordan) (pie occupied by *Accola* Simon, 1889, Araneae)

Euglenea Heller, 1896:24 (type species: *Glenea sarasinorum* Heller)

Heteroglenea Gahan, 1897:490 (type species: *Glenea nigromaculata* J. Thomson)

Macroglenea Aurivillius, 1920:390 (type species: *Saperda elegans* Olivier)

Poeciloglenea Aurivillius, 1920:391 (type species: *Glenea celia* Pascoe)

Stiroglenea Aurivillius, 1920:391 (type species: *Lamia cantor* Fabricius)

Parazosne Aurivillius, 1926a:114 (type species: *Colobothea leucospilota* Westwood)

Accolona Strand, 1942:392 (replacement name for *Accola* Jordan, 1894) (type species: *Accola citrina* Jordan)

Lineatoglenea Breuning, 1950t:384 (type species: *Glenea Isneatopunctata* Breuning)

Luteoglenea Breuning, 1950t:385 (type species: *Glenea maculicollis* Breuning)

Sassaglenea Breuning, 1952b:317 (type species: *Glenea sassensis* Breuning)

Jordanoglenea Breuning, 1952b:317 (type species: *Gleneajordani* Lepesme & Breuning)

Bajoglenea Breuning, 1952b:318 (type species: *Glenea baja* Jordan)

Elongaloglenea Breuning, 1952b:320 (type species: *Glenea elongatipennis* Breuning)

Fasciculoglenea Breuning, 1952b:322 (type species: *Glenea fasciculosa* Breuning)

Rufoglenea Breuning, 1956f:93 (type species: *Glenea rufopunctata* Gahan)

Grossoglenea Breuning, 1956f:95 (type species: *Glenea grandis* Schwarzer)

Subgrossoglenea Breüning, 1956f:96 (type species: *Glenea subgrandis* Breuning)

Metaglenea Breuning, 1956f:97 (type species: *Glenea pseudograndis* Breuning)

Mesoglenea Breuning, 1956f:98 (type species: *Glenea invitticollis* Breuning)

Pseudotanylecta Breuning, 1956f:101 (type species: *Glenea keili* Ritsema)

Porphyrioglenea Breuning, 1956f:107 (type species: *Glenea porphyrio* Pascoe)

Punctoglenea Breuning, 1956f:108 (type species: *Glenea sexpunctata* Aurivillius)

Rubroglenea Breuning, 1956f:109 (type species: *Colobothea rubrico//is* Hope)

Vittiglenea Breuning, 1956f:120 (type species: *Glenea kraatzi* J. Thomson)

Vanikoroglenea Breuning, 1956f:124 (type species: *Glenea vanikorensis* Breuning)

ReginoGlenea Breuning, 1956f:125 (type species: *Glenea regina* J. Thomson)

Acutoglenea Breuning, 1958n:838 (type species: *Saperda acuta* Fabricius)

Spiniglenea Breuning, 1958n:850 (type species: *Glenea spinosipennis* Breuning)

Brunneoglenea Breuning, 1958n:852 (type species: *Daphisia brunnea* Aurivillius)

Cyhndroglenea Breuning, 1 958n:866 (type species: *Glenea cylindrica* Aurivillius)

Andoglenea Breuning, 1958n:869 (type species: *Glenea arida* J. Thomson)

Citrinoglenea Breuning, 1958n:885 (type species: *Glenea citrina* J. Thomson)

Annuliglenea Breuning, 1958n:892 (type species: *Paraglenea annuliventris* Pic)

Laoglenea Breuning, 1968h:36 (type species: *Gienea anterufipennis* Breuning)

Formosoglenea Breuning, 1 969b:36 (type species: *Glenea ochreomaculata* Breuning)

Menesioglenea Breuning, 1969h:191 (type species: *Glenea menesioides* Breuning)

Acronioglenea Breuning, 1974b:74 (type species: *Glenea besucheti* Breuning)

Frons higher than wide, emarginated laterally; vertex shallowly concave; antennae not much longer than body; prothorax subcylindrical; elytra broader than prothorax, gradually narrowed, carinate laterally, truncate apically, with external angles angulate or acuminate; first abdominal sternite much longer than second, third, or fourth.

Genotype. - *Glenea lepida* Newman.

Range. - Ethiopian and Oriental Regions; Manchurian and Indo-Australian Subregions.

4.3.7 Systematic Account of Genus *Glenea*

A total 59 species was examined, 41 species redescribed, and 18 new species was described. No name was assigned or named for these new species, just number in order (*Glenea* sp.1 to *Glenea* sp.18).

1. ***Glenea algebraica*** (J. Thomson, 1857d:144) [*Stibara*]

    analytica Pascoe, 1867a:399 [*Glenea*]

    griseosuturalis Pic, 1943c:8 [*Glenea*]

    mediovittata Pic, 1943d:12 [*Glenea*]

    tenuefasciata Breuning, 1956f:863 [*Glenea*] {Note 1}

    g*riseofrontalis* Breuning, 1956f:863 [*Glenea*] {Note 1}

Materials examined: 16 specimens (9 ♀, 7 ♂).

(FRC Coll.) – Sarawak, Semengoh, Landeh Engkabang Plantation, 8.XII.1981, Alexander and Haidir (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 14.V.1913 (♀); Sarawak, Kuching, 24.X.1899 (♀); Sarawak, Kuching, 5.I.1900 (♀); Sarawak, Kuching, 30.III.1900 (♀); Sarawak, Kuching, 10.III.1914 (♀); Sarawak, Kuching, Matang Road, 5.VII.1909 (♀); Sarawak, Retuk, Ulu Sadong, 15.V.1914 (♀); Sarawak, Kuching, 4th Mile Rock Road, 17.IV.1909 (♀); Sarawak, Simanggang, 27.V.1909 (♀); Sarawak, Kuching, 10.III.1900 (♂); Sarawak, Kuching, 23.X.1899 (♂); Sarawak, Kuching, 5.I.1900 (♂); Sarawak, Kuching,

13.II.1914 (♂); Sarawak, Kuching, Matang Road, 1.V.1914 (♂); Sarawak, Kuching, 4th Mile Rock Road, 5.V.1909 (♂).

Diagnosis: Body above uniformly dark brown, decorated with testaceous yellow, longitudinal pubescence vittae, spots, and bluish white, inconspicuous dots; body beneath rather sparsely clothed with recumbent, pale yellow hairs; leg uniformly reddish-brown; antennae entirely dark.

(♀) Length: 11 mm, width: 3 mm.

(♂) Length: 10 mm, width: 2.8 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad, feebly flattened, occiput weakly convex at the middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with inconspicuous, recumbent and erect, pale yellow hairs on gena and around eyes, sparsely clothed with short, inconspicuous, whitish blue hairs on median of frons, ornamented with testaceous yellow pubescence spot along median of occiput; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and weakly narrow from behind to middle, feebly constricted behind middle, side feebly, arcuately rounded anteriorly; surface finely, densely punctuated, feebly punctuated at sides, densely clothed with short, recumbent, dark brown hairs, and ornamented with broad, longitudinal, testaceous yellow pubescence vittae along median of pronotum, the punctures nearly

concealed by the pubescence. Scutellum transversely late obovatus, rounded at apex, broad, nearly flat, entirely clothed with testaceous pubescence, forming a spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short, recumbent and erect dark brown hairs, ornamented with a broad, longitudinal, testaceous yellow pubescence vitta along sutural margin extending from base to apex, and decorated with three, ill-defined, whitish blue, oblong pubescence dots, one on median of sublateral between basal fourth and third, one on median of sublateral at middle of disc, and one on median of sublateral between apical fourth and third, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown, rather densely clothed with short and recumbent, pale yellow hairs on pro metasternal episternum, basal sides of abdominal sternites, but sparsely on metasternum and centres of abdominal sternites; the external mucro at the apex of moderately length.

Distribution: Borneo, Sumatra, Java, W. Malaysia

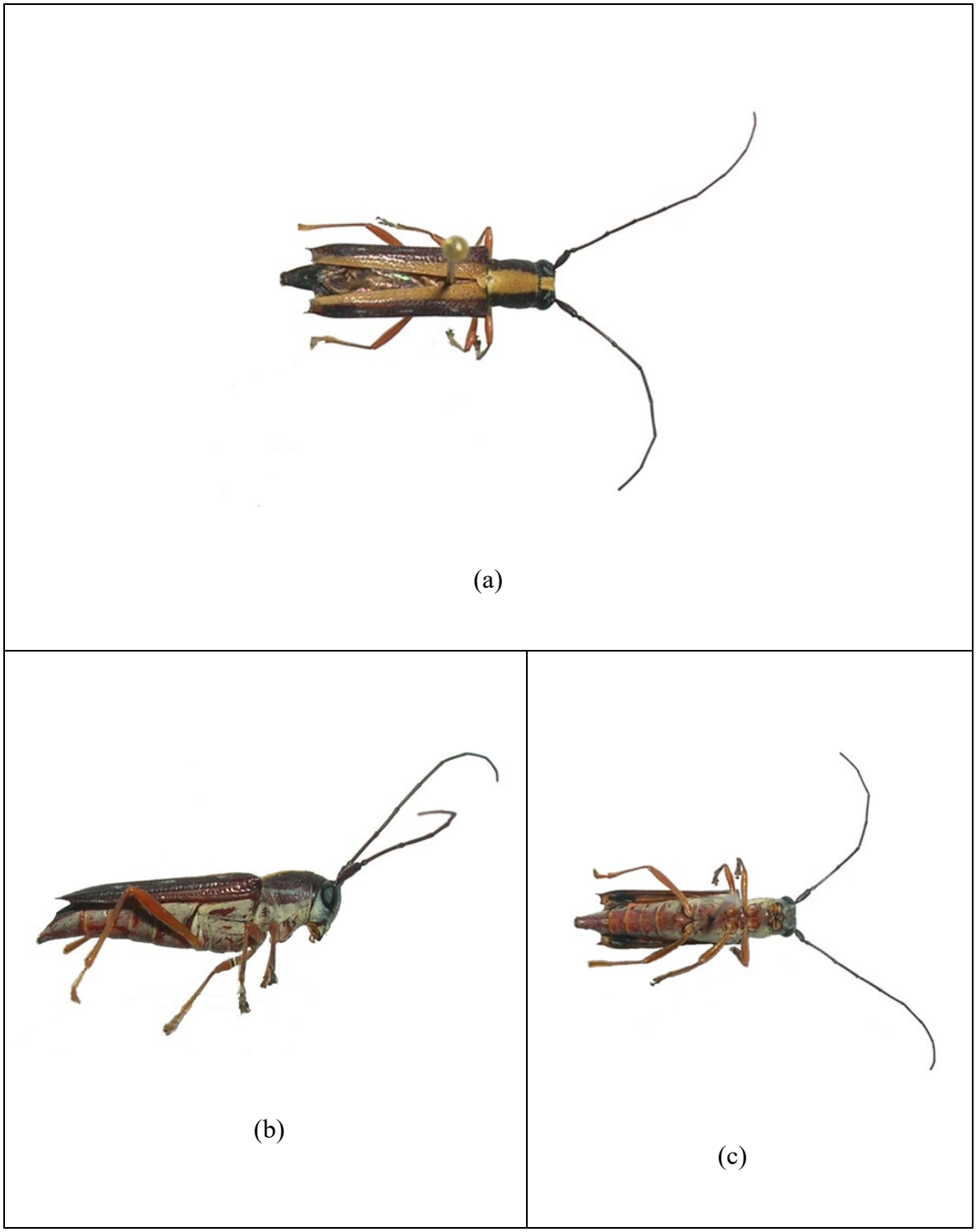


Figure 4.4: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea algebraica* J.Thomson, 1857.

2. ***Glenea analytica*** Pascoe, 1864

Materials examined: 9 specimens (6 ♀, 3 ♂).

(FRC Coll.) – Sarawak, Kapit, Ulu Putai, 12.V.2001, SFD Ento. Team (♂); Sarawak, Kapit, Sg. Mujong, 10.IV.1989, SFD Ento. Team (♂); Sarawak, Kapit, Sg. Mujong, 10.IV.1989, SFD Ento. Team (♂); Sarawak, Belaga, Danum, 19-21.VII.2001, SFD Ento. Team (♀); Sarawak, Belaga, Danum, 19-21.VII.2001, SFD Ento. Team (♀); Sarawak, Belaga, Danum, 17-19.VII.2001, SFD Ento. Team (♀); Sarawak, Kapit, Ulu Putai, 14.V.2001, SFD Ento. Team (♀); Sarawak, Kapit, Hose Mountain, 28.IX.1987, Abd. Rahman (♀).

(Sarawak Museum Coll.) – Sarawak, Banting, Kerpok Hill, 25.V.1909 (♀).

Diagnosis: Body above uniformly dark brown, browner in male, ornamented with broad and narrow testaceous pubescence; body beneath covered with testaceous pubescence in male, but pale greyish yellow on female; femora reddish-brown, tibiae and tarsal dark brown, sparsely clothed with moderately long, erect, pale yellow hairs; antennae uniformly dark brown.

(♀) Length: 11-12.5 mm, width: 3-3.7 mm.

(♂) Length: 9.7-10.5 mm, width: 2.5-3 mm.

Description: Head with the front as long as wide, slightly equal in width with prothorax, vertex broad, nearly flat between the antennal tubercles, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely covered with pale yellow, recumbent

hairs, and ornamented on occiput with a yellow pubescence spot, which extends along upper margin of eyes, and divided at middle by the longitudinal furrow, other part clothed with recumbent dark brown hairs; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than inferior eyelobe; antennae slender, slightly longer than body.

Prothorax longer than wide, almost parallel-sided at apical half and scarcely narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, vaguely constricted behind middle; surface finely, densely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, dark brown pronotum ornamented with longitudinal, testaceous pubescence vittae, one which broad along median, one which narrower along lateral of each side, also decorated with inconspicuous, elongated testaceous pubescence spot just behind middle of dorso-lateral on each side. Scutellum trapezoidal, nearly flat, densely covered with testaceous pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, and upper punctures rows sparsely clothed with narrow, longitudinal, pale yellow pubescence extending from base to apex, tapering posteriorly, apex of each elytron arcuately emaginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely punctuated basally, the punctures becoming finer and sparser apically, dark brown elytron ornamented with longitudinal, testaceous pubescence vittae, one which broad along sutural margin, and one which narrow along sublateral close to lateral carina, extending from base to apex, and connected at apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown in female and reddish-brown in male, densely clothed with testaceous pubescence on male and rather sparsely pale greyish yellow pubescence in female, leaving dark brown portions on metasternum, interior of metepisternal, and first to fourth abdominal sternites ventro-laterally, the external mucro at the apex of moderately length in male.

Distribution: Borneo, Sumatra, Java, W. Malaysia.

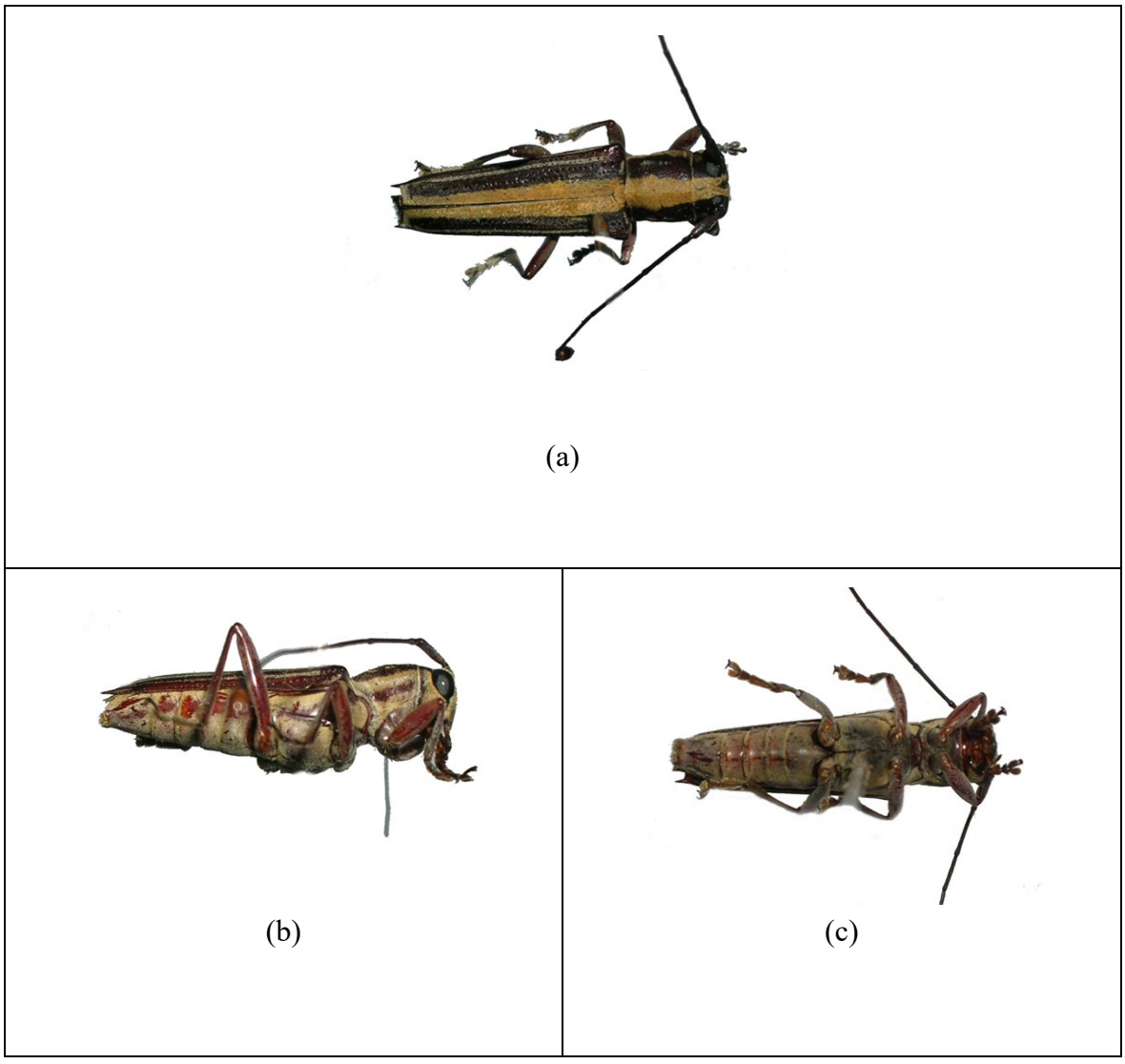


Figure 4.5: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea analytica Pascoe*, 1864.

3. ***Glenea aspasia*** Pascoe, 1867a:384 [*Glenea*]

Materials examined: 8 specimens (7 ♀, 1 ♂).

(FRC Coll.) – Sarawak, Kapit, Ulu Putai, 14.V.2001, SFD Ento. Team (♀); Sarawak, Niah, Forestry Research Station, 25.IX.1981, Lippa Akeng (♀).

(Sarawak Museum Coll.) – Sarawak, Mt. Murud, XII.1914 (♀); Sarawak, Mt. Merinjak, 29.V.1914 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Penrissen, V.1899 (♂).

Diagnosis: Body above uniformly dark brown, ornamented with fine, longitudinal orange-coloured pubescence vittae on head and prothorax, and orange-coloured dots and spots on elytra; body beneath densely and sparsely covered with white and yellow pubescence; legs uniformly dark reddish-brown, covered with sparsely, white recumbent hairs at femora and basal of tibiae; antennae uniformly dark brown.

(♀) Length: 15 mm, width: 5.2 mm.

(♂) Length: 14 mm, width: 5 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, vertex broad, feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, densely punctuated, sparsely clothed with inconspicuous, recumbent, and erect dark brown hairs, ornamented with orange-coloured recumbent hairs around eyes and margin of frons, and decorated with narrow , longitudinal, orange-coloured pubescence vittae on occiput, two along median, and two dorso-ventrally; eyes and mandible black, maxillary and labial palpal

reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, shorter than the body, just behind the middle of elytra.

Prothorax longer than wide, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely, densely, irregularly punctuated, scarcely, sparsely punctuate at sides, the punctures nearly concealed by the pubescence; densely clothed with short, erect dark brown hairs, ornamented with five narrow, longitudinal, orange-coloured pubescence vittae, one median, dorso-lateral pair, and lateral pair. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely covered with dark recumbent hairs and inconspicuous, fine, longitudinal, orange-coloured pubescence along median.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures and decorated with sparsely, orange-coloured elongated pubescence spot near apex; almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely, truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically, each elytron rather densely clothed with short, recumbent, dark brown hairs, ornamented with orange-coloured pubescence vitta, seven dots, and a spot as follows: a narrow, inconspicuous, longitudinal vitta along median of basal fourth extending from base to middle, a first dot at middle between basal fourth and third, a second dot at middle of disc, a third dot which smaller at sublateral just behind middle of disc, a fourth dot in front of middle of apical third, a fifth dot which smaller near lateral carina at middle of sublateral of apical third, a sixth dot which smaller behind middle of sublateral of apical third, a seventh dot which smaller at middle of

submedial between apical third and fourth, and a elongated spot which bend toward lateral margin, near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath largely dark reddish brown, densely clothed with white pubescence on metasterna episternum, and densely covered with yellowish pubescence on the sides of fourth abdominal segments, forming the spots.

Distribution: Borneo.

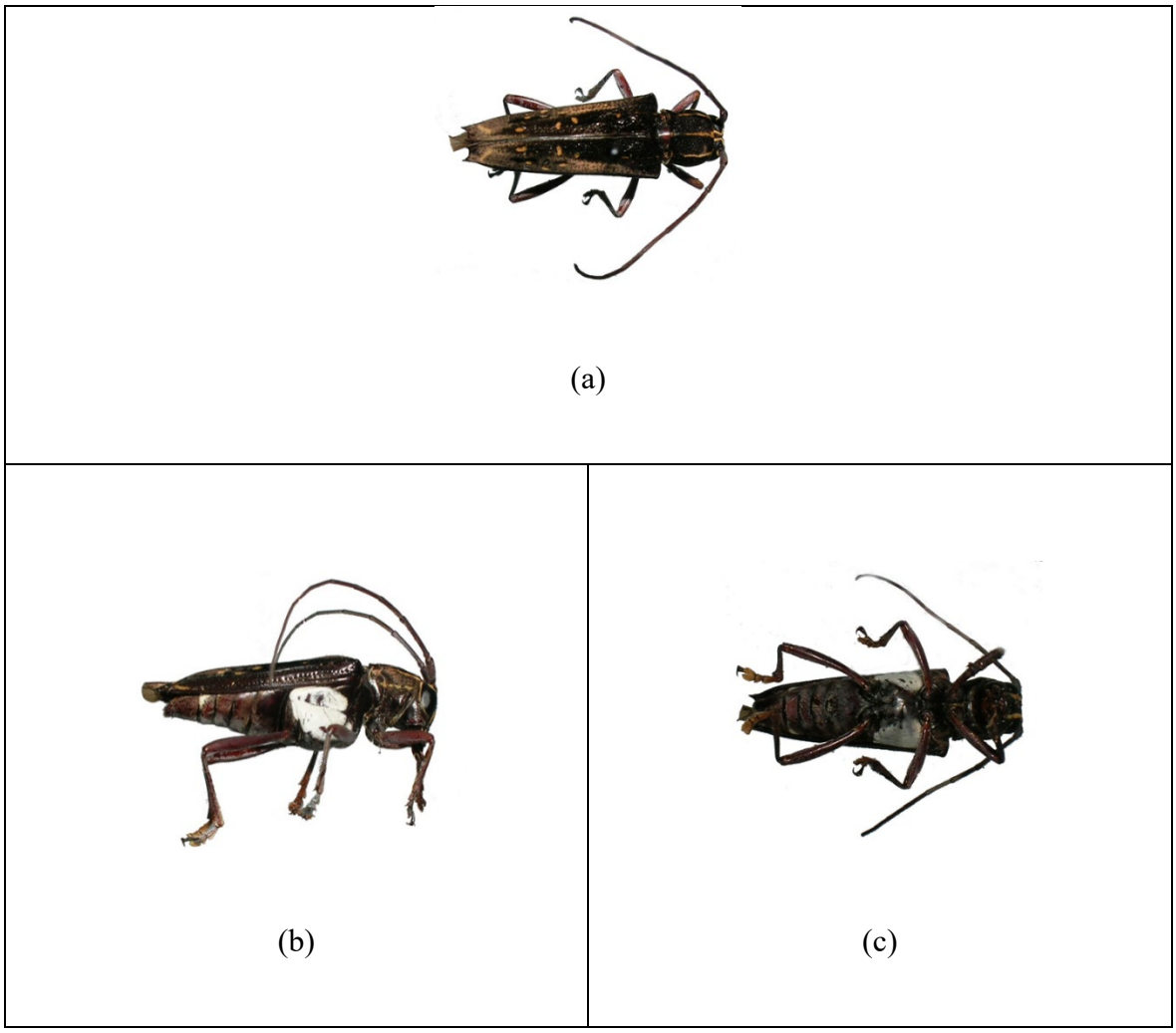


Figure 4.6: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea aspasia* Pascoe, 1867.

4. ***Glenea bellona albomaculata*** Gahan, 1889

Materials examined: 11 specimens (5 ♀, 6 ♂).

(FRC Coll.) – Sarawak, Kuching, Matang, 9.II.1985, Haidir Nusi (♀); Sarawak, Belaga, Danum, 19-21.VIII.2001, SFD Ento. Team (♂): Sarawak, Belaga, Bukit Semalong, 20.IV.1985, SFD Ento. Team (♂); Sarawak, Niah, 25.V.1981, Alexander and Yeo (♂); Sarawak, Bako N.P., Teluk Assam, 3.V.1979, Mercer and Yeo (♂).

(Sarawak Museum Coll.) – Sarawak, Banting, 14.V.1909 (♀); Sarawak, Kuching, Matang Road, 20.XI.1909 (♀); Sarawak, Kuching, Matang Road, 18.XII.1909 (♀); Sarawak, Kuching, Matang Road, 20.XII.1909 (♀); Sarawak, Baram, 14.X.1910 (♂); Sarawak, Kuching, Matang Road, 18.V.1910 (♂).

Diagnosis: Small and elongate, above uniformly dark reddish-brown and ornamented with yellowish pubescence; body beneath densely clothed with white pubescence; femora reddish brown, tibie dark brown, sparsely clothed with recumbent white hairs, mixed with moderately long and erect dark hairs, tarsal sparsely clothed with recumbent white hairs; scape, and first to seventh antennal segments dark brown, eighth and ninth white, the following segments dark.

(♀) Length: 10 mm, width: 3 mm.

(♂) Length: 8.2 mm, width: 2.2 mm.

Description: Head with the front as long as wide, slightly broader than prothorax, feebly, broadly depressed between the antennal tubercles, occiput convex at middle of base, frons with a fine longitudinal furrow extending from epistoma tro occiput; surface sparsely

clothed with inconspicuous, recumbent and erect blackish grey hairs, ornamented with two narrow, longitudinal vittae on the vertex and occiput, with moderately long, recumbent whitish yellow pubescence; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than body.

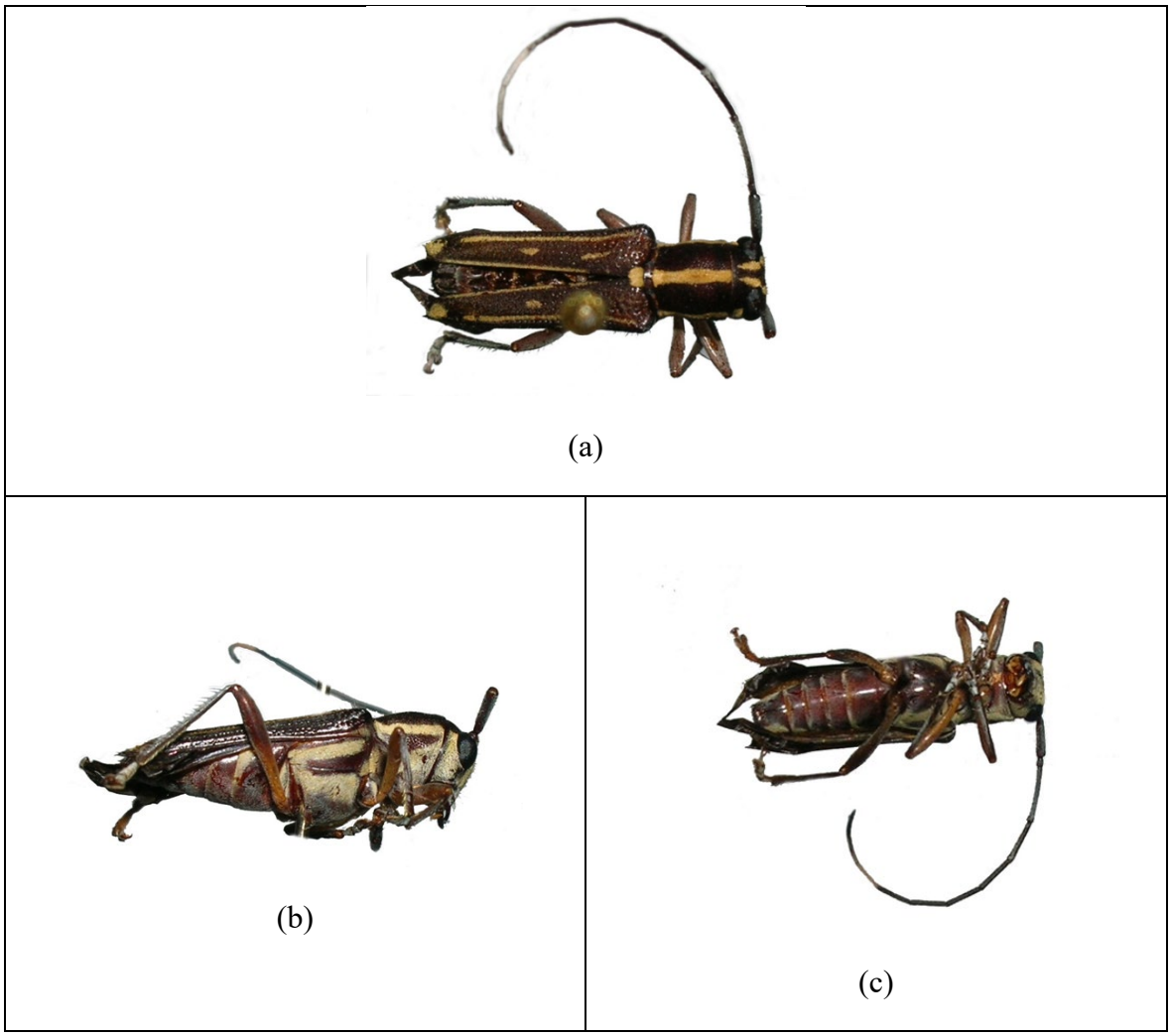
Prothorax dark brown, distinctly longer than wide, feebly constricted behind middle, parallel near base, side feebly, arcuately rounded anteriorly; surface densely coarsely irregularly punctuate, feebly punctuate at sides, punctures nearly concealed by the whitish yellow pubescence at sides and beneath; rather densely clothed with short, recumbent, conspicuous hairs, with a few long, erect hairs intermixed, and ornamented with a slightly broad, longitudinal yellow pubescence on median, and two broad longitudinal yellow pubescence on each side. Scutellum transverse late obovatus, rounded at apex, densely clothed with recumbent, tawny yellow hairs.

Elytra broader than prothorax at base, nearly two time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarsely punctures on basal two third, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuate basally, the punctures becoming finer, sparser and obsolete toward apices; dark brown elytra ornamented with a blotch densely covered with yellowish pubescence at the apex of each elytron, sublateral and sutural margin ornamented with yellowish longitudinal pubescence, and each disc decorated with two scarcely oblong spot, one on middle, the other on basal fourth, the pubescence nearly hiding the punctures in good specimens.

Body beneath reddish brown, densely clothed with whitish pubescence, predominating on sternum and side of abdomen; the external mucro at the apex of moderately length.

Distribution: Borneo.

Close to *G. despecta*.



(a)

(b)

(c)

Figure 4.7: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea bellona albomaculata* Gahan, 1889.

5. ***Glenea blandina*** Pascoe, 1858a:259 [*Glenea*]

pseudoblandina Breuning, 1950c:177 [*Glenea*]

subblandina Breuning, 1956l:809 [*Glenea*] {Note 1}

Materials examined: 17 specimens (13 ♀, 4 ♂).

(FRC Coll.) – Sarawak, Tebakang, 24.VI.1983, Lippa Akeng (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, 24.IV.1914 (♀); Sarawak, Kuching, Matang Road, 29.IV.1914 (♀); Sarawak, Kuching, Matang Road, 1.XI.1910 (♀); Sarawak, Kuching, Matang Road, 7.XII.1909 (♀); Sarawak, Kuching, Matang Road, 31.VII.1916 (♀); Sarawak, Kuching, Matang Road, 27.VII.1916 (♀); Sarawak, Kuching, 24.III.1900 (♀); Sarawak, Kuching, 26.III.1900 (♀); Sarawak, Kuching, 23.III.1903 (♀); Sarawak, Kuching, 24.I.1898 (♀); Sarawak, Kuching, 23.III.1914 (♀); Sarawak, Kuching, 10.VIII.1900 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Kuching, 21.VI.1909 (♂); Sarawak, Kuching, Matang Road, 5.V.1914 (♂); Sarawak, Kuching, Matang Road, 3.XII.1909 (♂).

Diagnosis: Body above uniformly dark brown, ornamented with bluish white pubescence vittae and spots; body beneath dark reddish-brown, densely and sparsely covered with recumbent white hairs; femora reddish-brown, tibiae and tarsal dark brown, sparsely clothed with recumbent, bluish white hairs, mixed with moderately long, erect, brown hairs; posterior of antennal scape, first, second, and base of third segment densely covered with bluish white pubescence, the other area and joints dark.

(♀) Length: 14 mm, width: 4.5 mm.

(♂) Length: 13 mm, width: 4 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad, feebly concave, occiput weakly convex at the middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with recumbent, bluish white hairs on posterior of gena and along margin of frons, and ornamented on occiput with two narrow, longitudinal, bluish white pubescence vittae which divided by longitudinal furrow on median, sparsely clothed with short, inconspicuous bluish white hairs on median part of frons, other parts sparsely clothed with short, recumbent dark brown hairs, sparsely mixed with long, erect, dark hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and weakly narrow from behind to middle, strongly constricted behind middle, side vaguely, arcuately rounded anteriorly; surface finely, densely punctuated, sides sparser, densely clothed with short, recumbent, dark brown hairs, mixed with long, erect dark hairs, and ornamented with a narrow, longitudinal, bluish white pubescence vitta along median of pronotum, and a broader, longitudinal, bluish white pubescence vitta laterally on each side, the punctures nearly concealed by the pubescence. Scutellum transversely late ovovatus, rounded at apex, broad, feebly concave, densely covered with bluish white pubescence, except of the sides and base, where the pubescence is dark.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures and decorated with a bluish white pubescence spot at base, and a narrow,

inconspicuous, longitudinal pubescence vitta along upper punctures row extending from middle of basal fourth to middle of deflexed sides; tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short, recumbent dark brown hairs, mixed with long, erect dark hairs, ornamented with five, bluish white pubescence spots as follows: one which smaller at sublateral of basal fourth, one at the middle of elytron just behind middle of basal fourth, one at sublateral before middle of elytron, one at sublateral between apical fourth and third, and one near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark reddish-brown, rather densely clothed with white pubescence on metasternal episternum and apical sides of first to fourth abdominal segments, sparsely on metasternum and centres of abdominal segments, but leaving black portions on interior half of metepisterna and basal sides of abdominal segments, apical of fifth segment covered with whitish blue pubescence; the external mucro at the apex of moderately length.

Distribution: Borneo.

Habitat: Caught on hilltop at logged over forest.

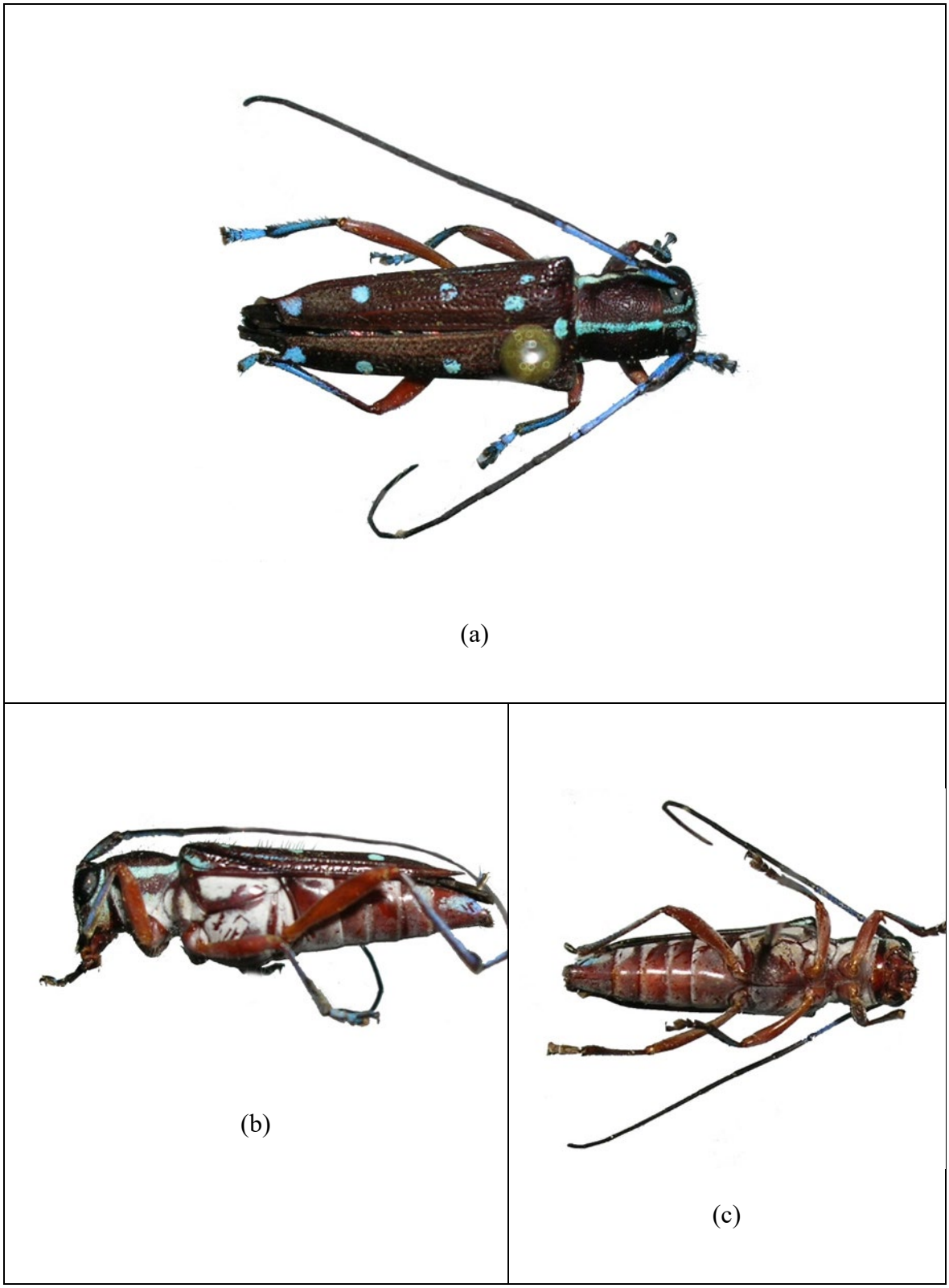


Figure 4.8: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea blandina* Pascoe, 1858.

6. *Glenea calypso* Pascoe, 1867a:382 [Glenea]

gloriosa Heller, 1916b:112 [*Glenea*]

Materials examined: 15 specimens (11 ♀, 4 ♂).

(Sarawak Museum Coll.) – Sarawak, Limbang, IV.1910 (♂); Sarawak, Kuching, VI.1899 (♂); Sarawak, Mt. Merinjak (alt. 2200 ft.), 25.V.1914 (♂); Sabah, Mt. Kinabalu (alt. 3100 ft.), 18.IX.1913 (♂); Sarawak, Penrissen, 17.V.1899 (♀); Sarawak, Penrissen, V.1899 (4♀); Sarawak, Mt. Sibau, V & VI.1902 (2♀); Sarawak, Lawas, 1.IX.1909 (♀); Sarawak, Poi, VII.1908 (♀); Sarawak, Kuching, Matang Road, 29.IV.1914 (♀); Sarawak, Kuching, 20.VI.1902 (♀).

Diagnosis: Body above uniformly dark brown, with slightly bluish metallic on head, pronotum and elytra, ornamented with pale yellow pubescence spots, six on pronotum and one on occiput, and decorated with four dots on each elytron; body beneath dark bluish, and densely covered with pale tallow pubescence; basal of femora third quarterly reddish-brown, apical of femora, tibiae and tarsal dark brown, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae uniformly dark brown.

(♀) Length: 14-19 mm, width: 4-5 mm.

(♂) Length: 12-16 mm, width: 3-4 mm.

Description: Head with the front slightly longer than wide, equal in width with prothorax, vertex broad and feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface

finely, sparsely punctuated, densely clothed with pale yellow or whitish pubescence on gena, around the eyes, along margin of frons and on occiput, forming a white spot on occiput, median part of frons sparsely clothed with short and inconspicuous dark hairs, nearly hairless; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, slightly constricted at apex, strongly constricted behind middle, sides feebly, arcuately rounded anteriorly; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short black pubescence, and ornamented with six pale yellow or whitish pubescence spots: two on median, one at base, and one which smaller at apex; two pair on lateral of each side, one at base, and one near apex. Scutellum transverse late obovatus, rounded at the apex, broad and feebly concave, densely clothed with pale yellow or whitish pubescence, except at the basal sides, where the pubescence is dark.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short dark brown pubescence, and ornamented with four inconspicuous white pubescence dots, one between basal fourth and third at median, one at sublateral of basal

third, one just behind middle of disc at median, and one at sublateral of apical fourth; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark bluish metallic, densely clothed with pale yellow or whitish pubescence, leaving black portions on metasternum, interior part of metepisternal, basal sides of first, second and fifth, and centres of abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo.

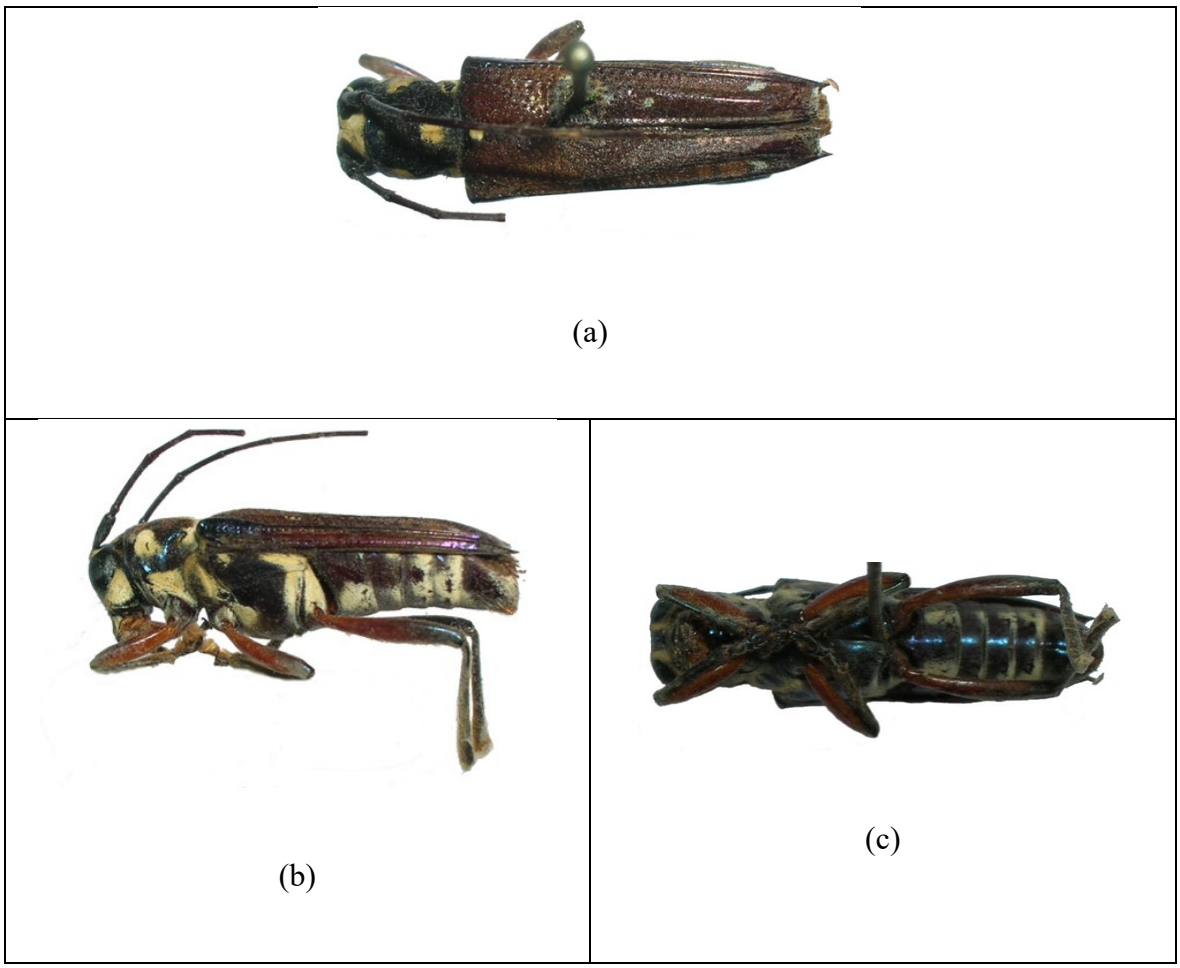


Figure 4.9: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea calypso* Pascoe, 1868.

7. *Glenea camelina* Pascoe, 1867a:392 [*Glenea*]

Materials examined: 5 specimens (4 ♀, 1 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 4th Mile Rock Road, 5.V.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 9.XI.1909 (♀); Sarawak, Kuching, 27.VI.1899 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Kuching, Matang Road, 10.XI.1909 (♂).

Diagnosis: Small and elongate; above uniformly dark brown; body beneath greyish black, with the legs yellowish testaceous; antennal scape dark brown, the following joint testaceous.

(♀) Length: 11 mm, width: 2.5 mm.

(♂) Length: 9 mm, width: 2 mm.

Description: Head with front as long as wide, slightly broader than prothorax, feebly flattened between the antennal tubercles, vertex very shallowly concave at middle, occiput convex at middle of base, without a distinct longitudinal, median carina, frons with a fine longitudinal furrow from apex to vertex; surface finely densely punctured, rather densely clothed with moderately long, recumbent dark brown pubescence, and ornamented with two narrow, longitudinal vittae on occiput, with moderately long, recumbent, yellow pubescence; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than body.

Prothorax distinctly longer than wide, slightly rounded at the sides; side feebly, arcuately rounded anteriorly, almost parallel-sided near base and weakly narrow at apex, feebly constricted behind middle; surface densely, coarsely, irregularly punctuate, feebly punctuate at sides, rather densely clothed with short erect hairs intermixed, and ornamented

with a narrow, longitudinal, yellow pubescent on median, prothorax dark brown. Scutellum transverse late ovovatus, rounded at apex; densely clothed with pale yellow pubescence.

Elytra dark brown, broader than prothorax at base, nearly two time as long as the basal width, strongly carinate and deflexed at the sides; apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuate basally, the punctures becoming finer, sparser and obsolete toward apices; tapering posteriorly, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with greyish dark pubescence predominating on sternum and side of abdomen, the external mucro at the apex of moderately length.

Distribution: Borneo.

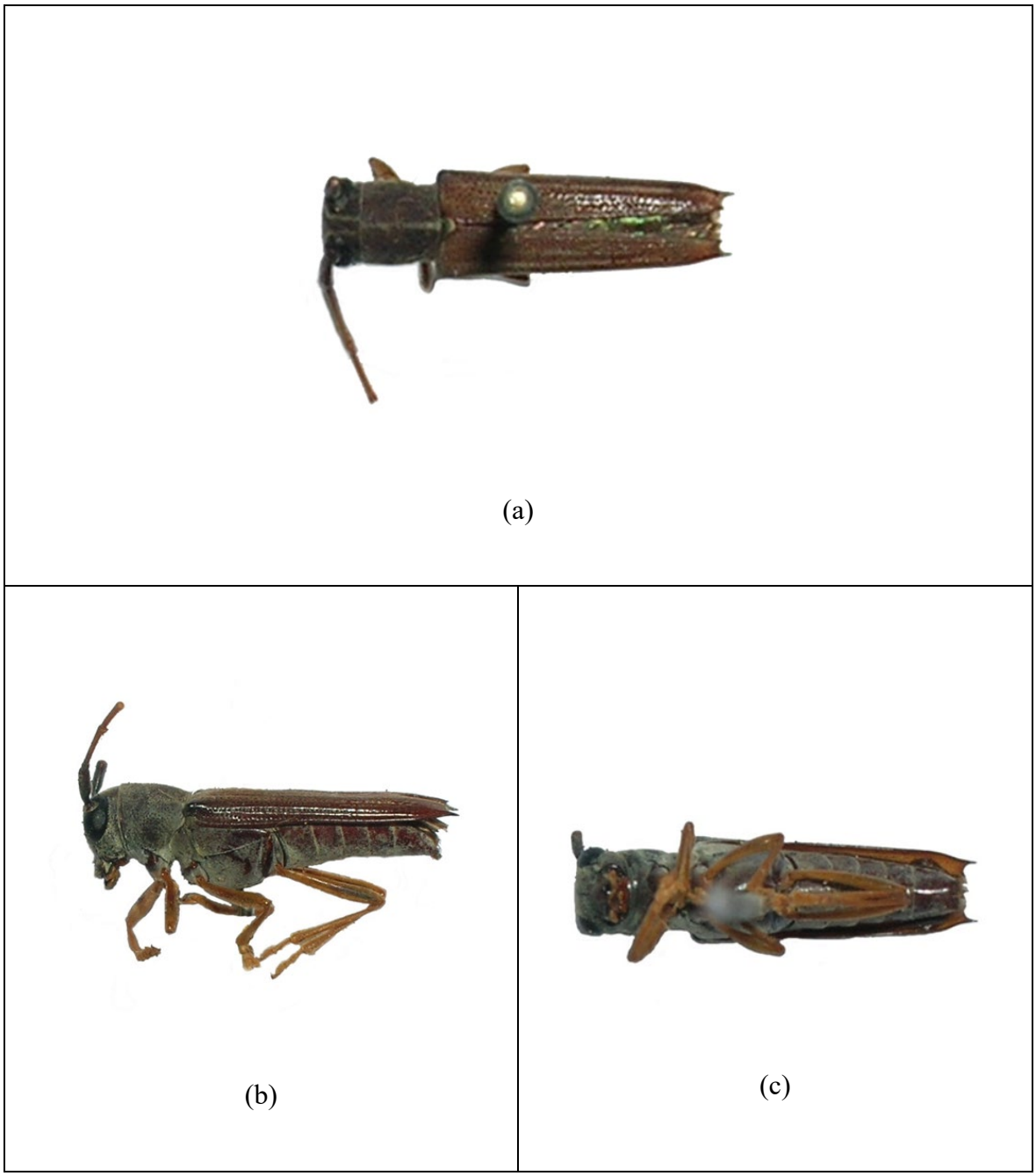


Figure 4.10: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea camelina* Pascoe, 1867.

8. ***Glenea collaris*** Pascoe, 1858a:258 [*Glenea*]

biparticollis Pic, 1943d:11 [*Glenea*]

discolineatipennis Breuning, 1858c:327 [*Glenea*] {Note 1}

Materials examined: 9 specimens (7 ♀, 2 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching. Matang Road, 14.III.1911 (♀); Sarawak, Kuching, Matang Road, 31.VII.1909 (♂); Sarawak, Penrissen, V.1899 (♂); Sarawak, Kuching, Matang Road, 2.II.1910 (♀); Sarawak, Kuching, Matang Road, 7.II.1910 (♀); Sarawak, Kuching, 24.V.1903 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Kuching, 4th Mile Rock Road, 23.IV.1909 (♀); Sarawak, Mt. Sibau, VI.1902 (♀).

Diagnosis: Body above uniformly dark in female, and slightly dark brown in male, ornamented with whitish pubescence blotch at the posterior half or rather more of the prothorax, forming a collar on prothorax, and the narrow longitudinal pale yellow pubescence vittae on elytra; body beneath densely covered with white pubescence; legs uniformly reddish-brown; antenna entirely dark.

(♀) Length: 11-13 mm, width: 3.5-4 mm.

(♂) Length: 12-13 mm, width: 3.5-4 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, vertex broad and feebly flattened, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with whitish pubescence on gena, around the eyes, and along margin of frons, pubescence sparser in female, median part of frons sparsely clothed with

short and inconspicuous white and dark hairs, occiput densely clothed with short black pubescence in female, but dark brown in male; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at middle and weakly narrowed at apex and strongly constricted behind middle, sides feebly, arcuately rounded anteriorly; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short black pubescence anteriorly, but ornamented with a whitish pubescence blotch at the posterior half or rather more. Scutellum transverse late ovovatus, rounded at the apex, broad and nearly flat, densely covered with short black pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence in female and rather dark brown in male, and ornamented with three narrow pale yellow pubescence vittae, one along sutural margin extending from base toward apices, one along sublateral extending from near base to near apex, and one shorter and inconspicuous along median of disc extending from middle of basal fourth to middle of elytron; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown, densely clothed with short white pubescence, leaving dark brown portions on metasternum, interior part of metapisternal, basal dorso-ventrally, and centres of abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo, W. Malaysia.

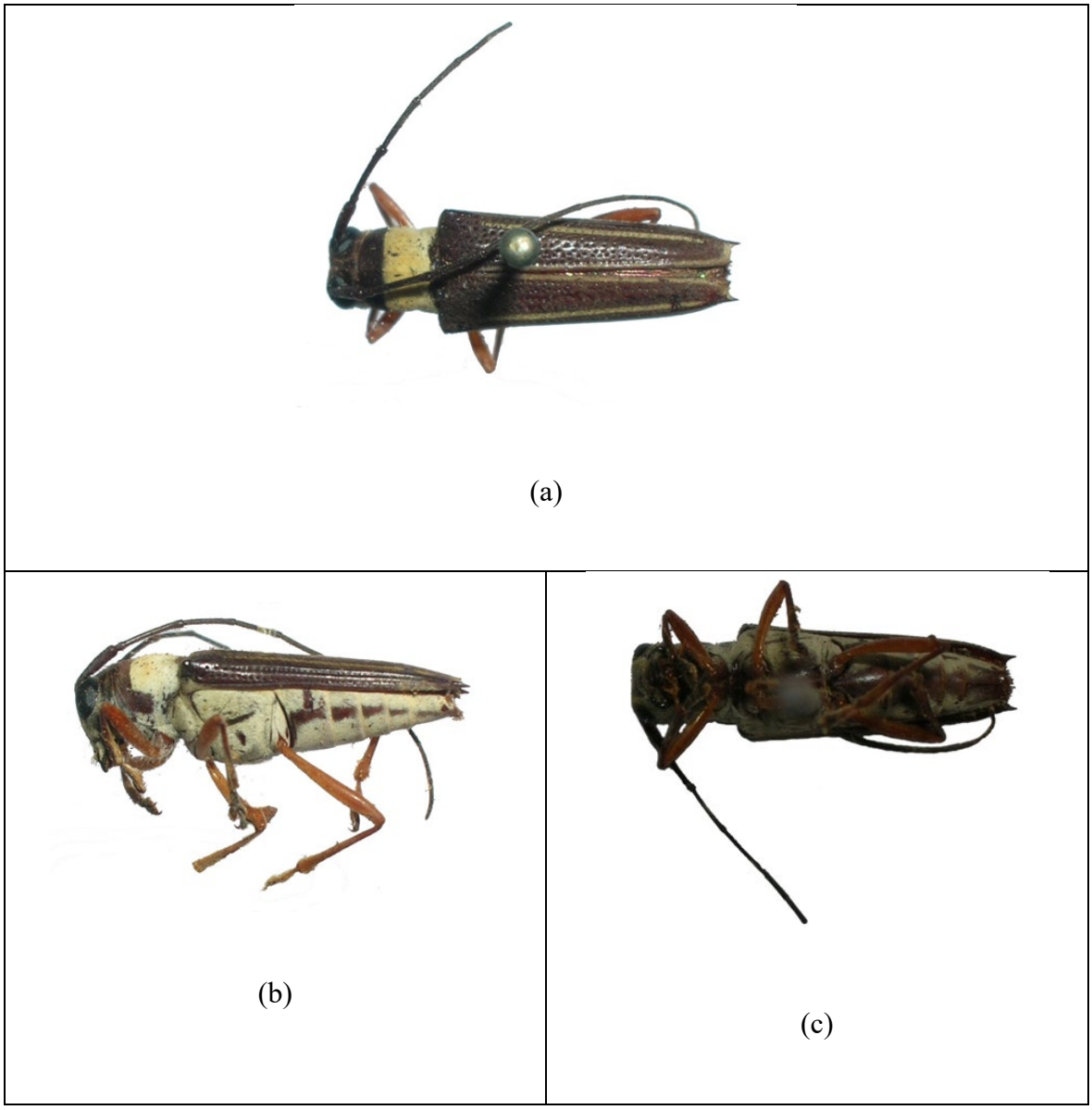


Figure 4.11: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea collaris* Pascoe, 1867.

9. *Glenea coris* Pascoe, 1867

Materials examined: 1 specimen (♀).

(Sarawak Museum Coll.) – Sarawak, Simanggang, Puak, Bukit Jabong, 22.IV.1911 (♀).

Diagnosis: Body above uniformly dark brown, ornamented with whitish blue pubescence spots and dots on elytra, and longitudinal white pubescence vittae on pronotum and elytra; body beneath uniformly dark, sparsely clothed with white pubescence; femora, tibiae and tarsal of hind legs reddish-brown, tibiae and tarsal of front and middle legs dark brown, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae uniformly dark.

(♀) Length: 11.2 mm, width: 3 mm.

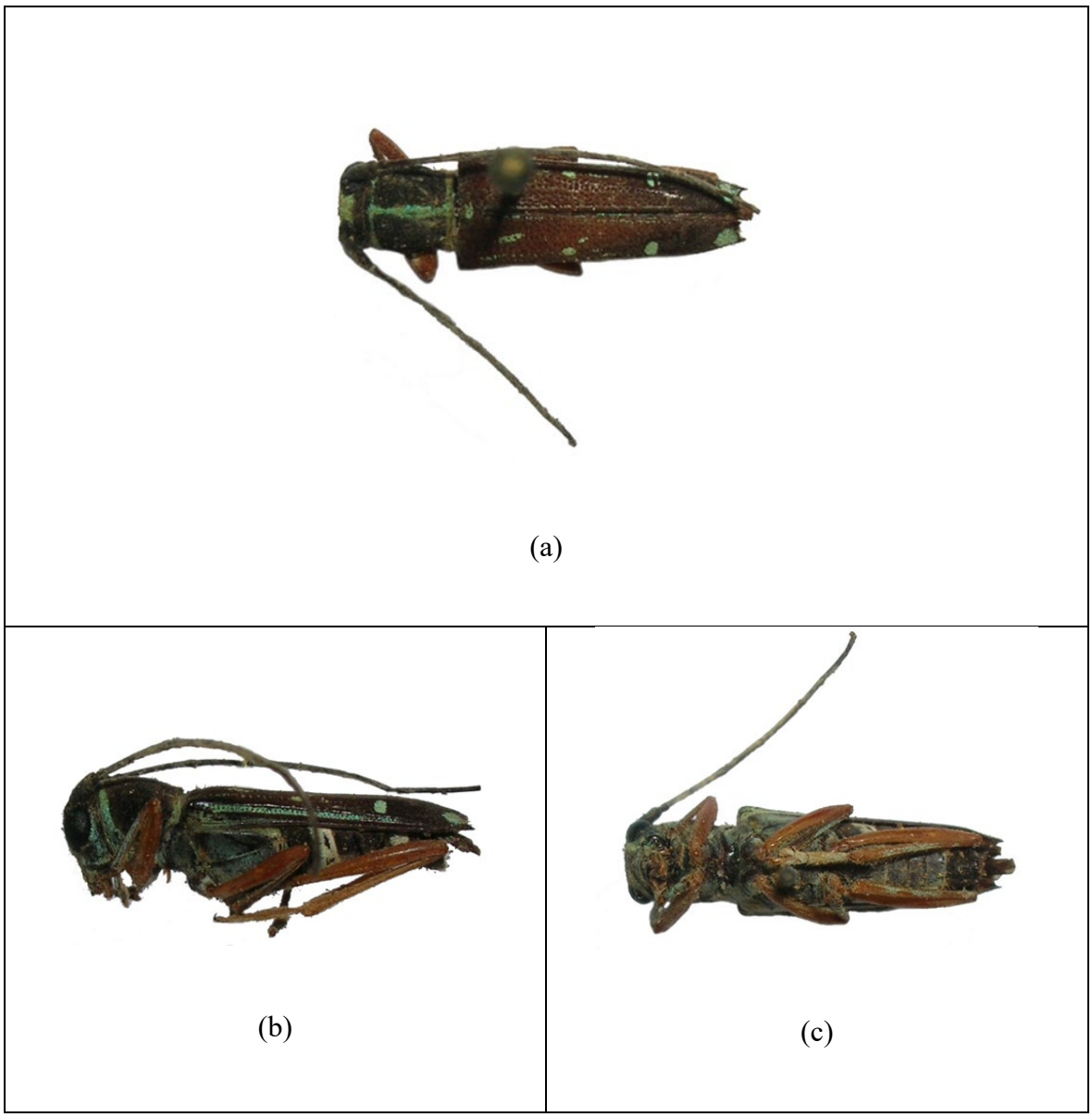
Description: Head with the front as long as wide, equal in width with prothorax, vertex broad and feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with whitish blue pubescence on gena, along margin of frons, around the eyes, and on vertex, forming a pubescence spot, median part of frons sparsely clothed with inconspicuous, short and recumbent dark hairs, occiput densely clothed with short dark brown pubescence; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided and narrowed from at base and apex, sides feebly, arcuately rounded anteriorly, strongly constricted at base; surface

finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with dark brown pubescence, and ornamented with a narrow longitudinal whitish blue pubescence vitta along median, and two narrow whitish blue pubescence collars at base and apex connected by the longitudinal median vitta. Scutellum transverse late obovatus, rounded at the apex, broad and feebly flattened, densely covered with whitish blue pubescence, except at the sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with dark brown pubescence, and ornamented with whitish blue pubescence as follows: three narrow longitudinal vittae, one along sutural margin extending from base to middle of apical fourth, one along sublateral extending from middle of basal fourth to middle of elytron, and one along upper punctures row of deflexed sides extending from base to middle of apical fourth; two spots, one between apical fourth and third at sublateral, and one at apex sublaterally; three dots, one which oblong at middle of basal fourth, one before middle of disc at sublateral, and which smallest at middle of disc; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, densely clothed with white pubescence on apical sides of first and fourth abdominal sternites, sparsely on metasternum and metapisternal, leaving black portions on others area.



(a)

(b)

(c)

Figure 4.12: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea coris* Pascoe, 1867.

10. *Glenea despecta* Pascoe, 1858a:259 [*Glenea*]

guttigera J. Thomson, 1865b:563 [*Glenea*]

sophia J. Thomson, 1879:15 [*Glenea*]

lumulumensis Fisher, 1935:623 [*Glenea*]

albitarsis Pic, 1943d:11 [*Glenea*]

Materials examined: 14 specimens (7 ♀, 7 ♂).

(FRC Coll.) – Sarawak, Semengoh Engkabang Plantation, 4.III.1982, Abdul Rahman (♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, VI.1905 (♀); Sarawak, Kuching, Matang Road, 24.IV.1914 (♀); Sarawak, Kuching, Matang Road, 27.IV.1914 (♀); Sarawak, Kuching, 26.IX.1899 (♀); Sarawak, Mt. Murud, XII.1914 (♀); Sarawak, Banting, 16.V.1909 (♀); Sarawak, Kuching, Matang Road, 23.IV.1914 (♂); Sarawak, Kuching, Matang Road, 21.XII.1909 (♂); Sarawak, Kuching, Matang Road, 5.V.1914 (♂); Sarawak, Kuching, Matang Road, 3.II.1911 (♂); Sarawak, Kuching, 25.II.1900 (♂); Sarawak, Kuching, 14.III.1903 (♂); Sarawak, Kuching, 17.XII.1899 (♂).

Diagnosis: Body above uniformly dark reddish-brown, ornamented with, longitudinal, yellow pubescence vittae and dots; body beneath reddish-brown, sparsely covered with yellow pubescence; legs uniformly ochraceus; antennae scape and first to sixth segment dark brown, the following dull yellow.

(♀) Length: 11.5 mm, width: 3.7 mm.

(♂) Length: 10 mm, width: 3.5 mm.

Description: Head with the front as long as wide, slightly than prothorax, feebly flattened between the antennal tubercles, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with yellow recumbent hairs on gena and around eyes, sparsely at median of frons; occiput densely clothed recumbent, dark brown hairs, and ornamented with two, longitudinal, yellow pubescence vittae on median, which divided at middle by a longitudinal furrow; eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from middle to bese, sides vaguely, arcuately rounded anteriorly, feebly constricted behind middle; surface and sides finely, densely, irregularly punctuated, scarcely, the punctures nearly concealed by the pubescence; densely covered with short, recumbent, erect, with a few long dark brown hairs intermixed, and ornamented with three, rather broad, longitudinal, white pubescence vittae, one along median, and two along dorso-lateral. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely clothed with recumbent, yellow hairs, forming a small yellow spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser

apically; each elytron rather densely clothed with short, erect and recumbent, dark brown hairs, ornamented with two narrow, longitudinal, yellow pubescence vittae, one along sutural, and one which broader along sublateral next to lateral carina extending from base to a more or less distinct apical spot; also decorated with two yellow dots, one which inconspicuous, elongated at median of basal fourth,one which rather ill-defined at middle of disc, and a yellow pubescence spot at apex, the pubescence nearly hiding the punctures in good specimens

Body beneath rather sparsely clothed with pale yellow pubescence, but densely clothed at the sides of metasternal episternum and the sides of abdominal segments, leaving dark reddish-brown portions on inner part of metasternal episternum, and inner part of the sides of abdominal segments.

Distribution: Borneo, Sumatra, Vietnam.

Behavior: Caught in flight.

Close species: *G. bellona albomaculata*

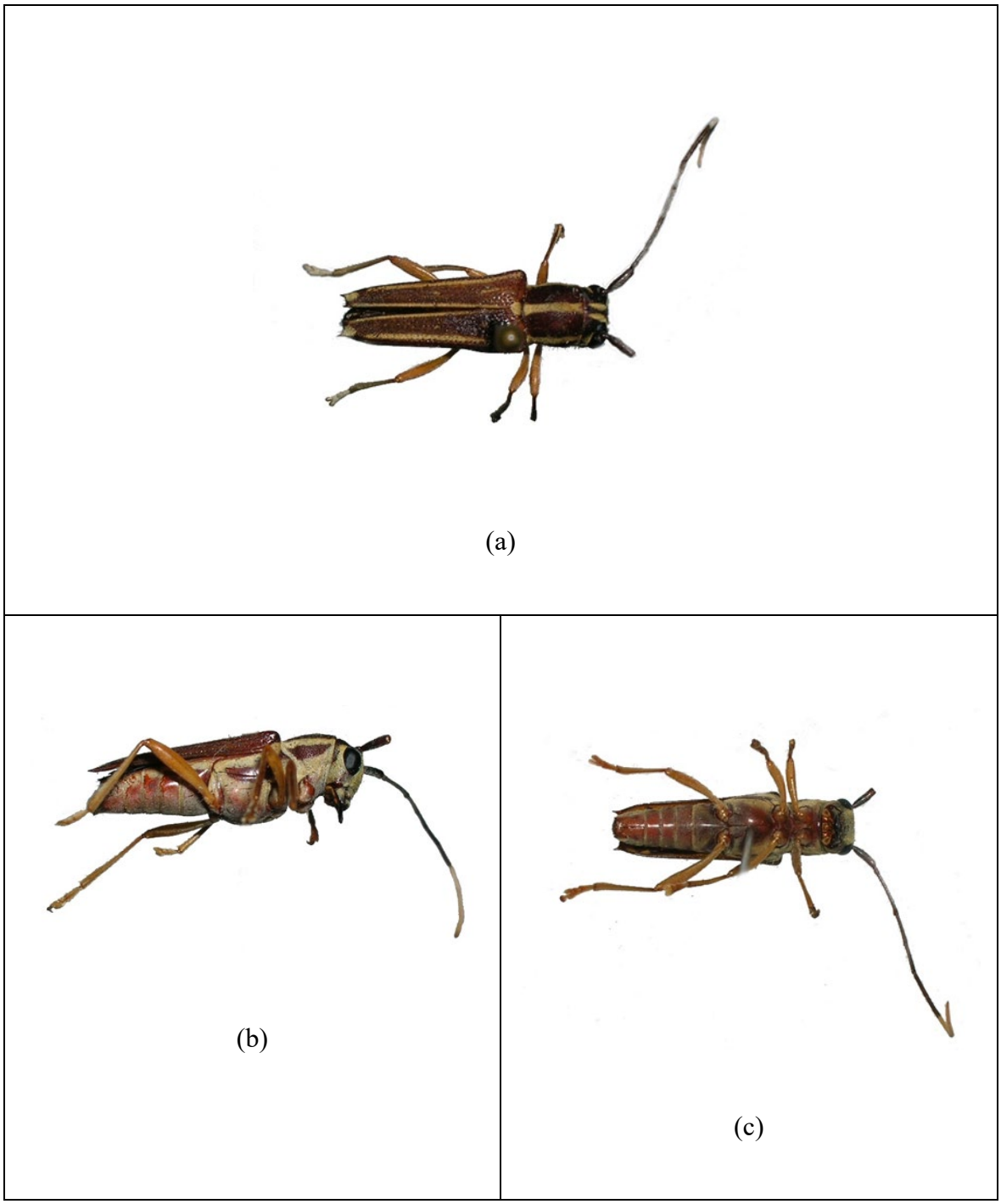


Figure 4.13: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea despecta* Pascoe, 1858.

11. *Glenea dimidiata dimidiata* (Fabricius, 1801:327)[*Saperda*]

oudetera (J. Thomson, 1857d:143) [*Stibara*]

semipartita Pic, 1943d:12 [*Glenea*]

niasica Breuning, 1950c:180 [*Glenea*] {Note 1}

Materials examined: 32 specimens (18 ♀, 14 ♂).

(FRC Coll.) – Sarawak, Baram, Sg. Bilat Camp, 28.III.1980, Mercer and Suhaili (♀); Sarawak, Gedong, Syarikat Bujang, 11.III.1983, Hamid and Lippa (♀); Sarawak, Bintulu, Sawai Permanent Forest, 9.X.1978, Hamid and Yeo (♀); Sarawak, Gedong, 2.III.1980, A.A. Hamid and Lippa (♀); Sarawak, Gedong, 2.III.1980, A.A. Hamid and Lippa (♂); Sarawak, Gedong, 2.III.1980, A.A. Hamid and Lippa (♂); Sarawak, Kapit, Ulu Putai, 12.V.2001, SFD Ento. Team (♂); Sarawak, Miri, Dulit Range, 20.V.1990, SFD Ento. Team (♂); Sarawak, Pusa, 26.VI.1978, A.A. Hamid (♂); Sarawak, Samunsam Wildlife Sanctuary, 28.X.1979, Mercer and Suhaili (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, V.1900 (♀); Sarawak, Kuching, 18.II.1914 (♀); Sarawak, Kuching, 11.IV.1900 (♀); Sarawak, Kuching, 20.III.1899 (♀); Sarawak, Kuching, 11.II.1914 (♀); Sarawak, Kuching, 4.IV.1914 (♀); Sarawak, Kuching, Matang Road, 2.II.1910 (♀); Sarawak, Kuching, Matang Road, II.1911 (♀); Sarawak, Kuching, Matang Road, 29.IV.1914 (♀); Sarawak, Kuching, 4th Mile Rock Road, 31.III.1900 (♀); Sarawak, Kuching, 4th Mile Rock Road, 8.VII.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 28.IV.1909 (♀); Sarawak, Baram, 15.X.1910 (♀); Sarawak, Baram, 14.X.1910 (♀); Sarawak, Kuching, 24.I.1900 (♂); Sarawak, Kuching, 14.III.1899 (♂); Sarawak, Kuching, Matang Road, 19.II.1911 (♂); Sarawak, Kuching, Matang Road,

7.I.1910 (♂); Sarawak, Kuching, Matang Road, 15.XI.1909 (♂); Sarawak, Kuching, Matang Road, 3.II.1911 (♂); Sarawak, Kuching, Matang Road, 2.XII.1909 (♂); Sarawak, Kuching, 4th Mile Rock Road, 12.IV.1909 (♂).

Diagnosis: Above uniformly dark reddish-brown, ornamented with yellow and white pubescence; body beneath dark reddish-brown, decorated with yellow and white pubescence; legs testaceous; antennae uniformly reddish-brown, slightly darker toward basal and apices.

(♀) Length : 13 - 14 mm, width: 4.0 mm.

(♂) Length : 12 - 13 mm, width: 4.0 mm.

Description: Head with the front longer than wide, equal in width with prothorax; vertex broadly, feebly concave, occiput convex at middle of base, frons with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with white pubescence along margin of frons, sparsely clothed with short white hairs on median part, gena sparsely clothed with short, recumbent white hairs and long erect white hairs intermixed, ornamented with a yellow pubescence spot at apex and occiput medially; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface densely, coarsely, irregularly punctuated, dorsal densely clothed with short erect brown hairs, meanwhile ventral, dorso-lateral basally and base of pronotum densely clothed with white pubescence. Scutellum transverse late

obovatus, rounded at apex, concave anteriorly, brown, sparsely clothed with short, recumbent white hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, dark reddish-brown elytron ornamented with transverse white pubescence on middle of disc, basal half sparsely clothed with short, recumbent white hair, and apical half densely clothed with short, erect dark brown hairs, which decorated with yellow pubescent spot near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath rather densely covered with whitish and pale yellow pubescence, leaving dark brown portions on interior half of metepisternal, ochraceus yellow on centre of first to fourth abdominal segments, and brown on fifth segment.

Distribution: Borneo, Sumatra, W. Malaysia.

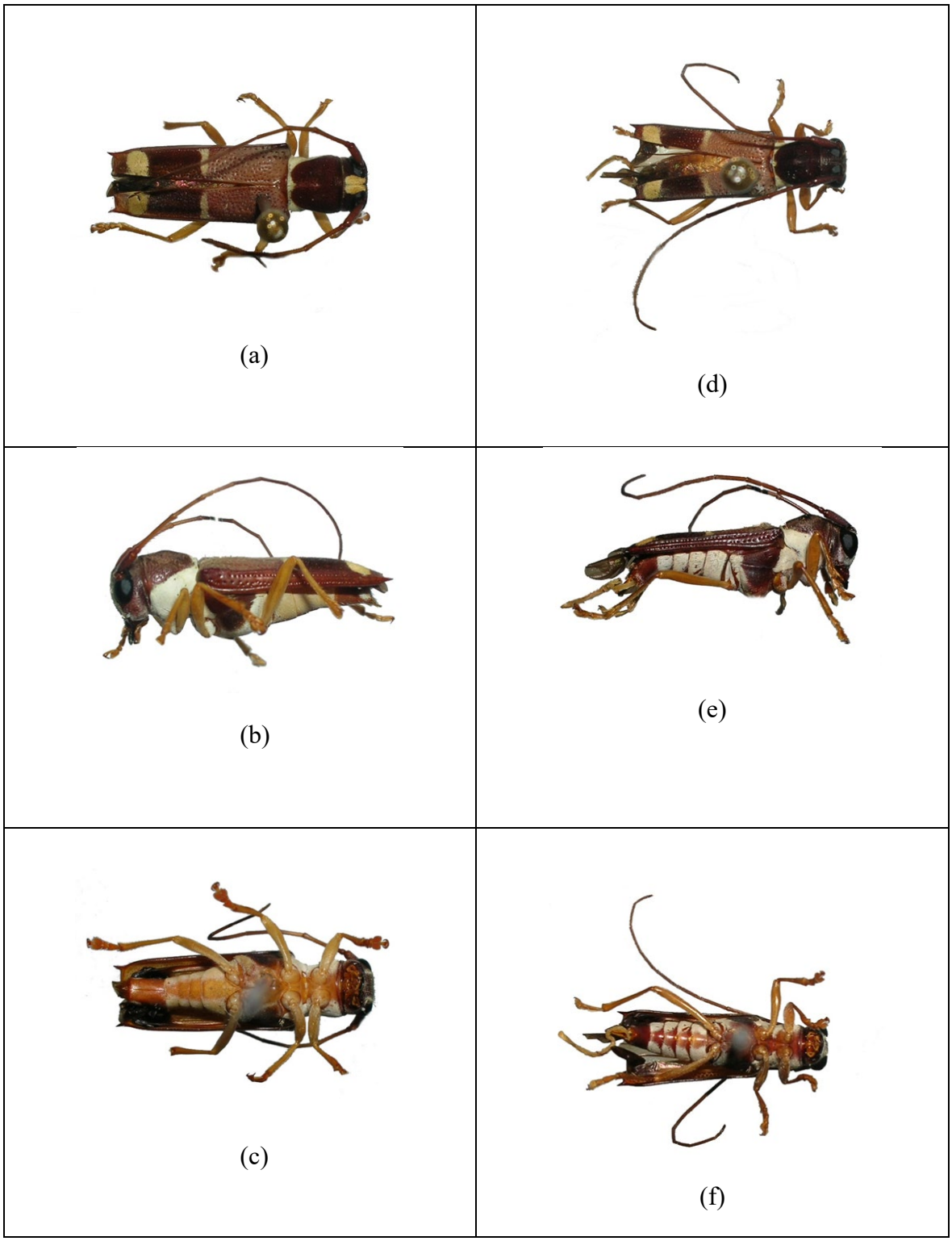


Figure 4.14: a) Dorsal view (female), b) Lateral view (female), c) Ventral view (female), d) Dorsal view (male), e) Lateral view (male), and f) Ventral view (male) of species *Glenea dimidiata dimidiata* Fabricius, 1801

12. *Glenea dimidiata semigrisea* Aurivillius, 1913a:258 [*Glenea*]

Materials examined: 1 specimen (♀).

(Sarawak Museum Coll.) – Sarawak, Melinau, Mt. Mulu, 4.XII.1910 (♀).

Diagnosis: Head, pronotum, and posterior half of elytra uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a longitudinal vitta on head and pronotum, and yellow pubescence transverse bands and spots on elytra; body beneath uniformly dark, sparsely clothed with white or yellow pubescence; legs uniformly reddish-brown; antennae uniformly reddish-brown, slightly darker toward basal and apices.

(♀) Length: 12 mm, width: 3.5 mm.

Description: Head with the front slightly longer than wide, equal in width with prothorax; vertex broad and nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with white pubescences on gena, around the eyes and margin of frons, median of frons sparsely clothed with inconspicuous white hairs, occiput densely clothed with short black pubescence, and ornamented with a narrow longitudinal yellow pubescence vitta along median; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, sparsely, irregularly punctuated, the punctures nearly concealed by the pubescence, pronotum densely clothed with short dark pubescence, and ornamented with a narrow yellow pubescence vitta along median. Scutellum transverse late obovatus, rounded at apex, densely clothed with dark brown pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, posterior half of elytra densely clothed with short black pubescence, and anterior half densely clothed with short brown hairs, each elytron ornamented with transversely yellow pubescence at middle of disc, and a yellow pubescent spot near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, sparsely clothed with white and pale yellow pubescence, sparser on metasternum and centres of first to fourth, and apical sides of fifth abdominal segments, leaving dark portions on metepisternal, centres and basal sides of fifth abdominal segments.

Distribution: Borneo.

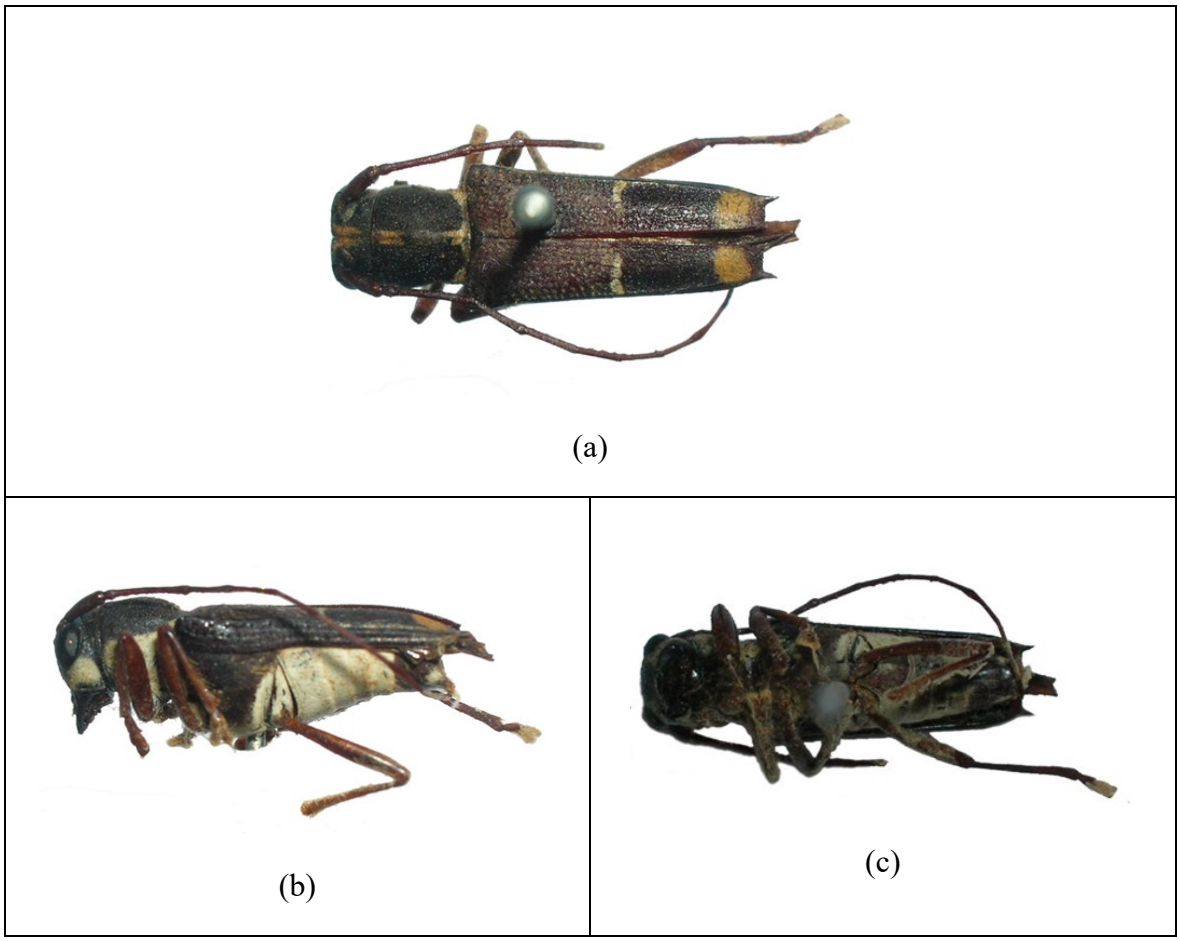


Figure 4.15: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea dimidiata semigrisea* Aurivillius, 1913.

13. *Glenea dimidiata* var.

Materials examined: 5 specimens (5 ♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, VI.1905 (♀); Sarawak, Mt. Merinjak, 26.V.1914 (♀); Sarawak, Sadong, VIII.1905 (♀); Sarawak, Lawas, 27.VIII.1909 (♀); Sarawak, Mt. Murud, XII.1914 (♀).

Diagnosis: Head, pronotum, and posterior half of elytra uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a longitudinal vitta on head and pronotum, and yellow pubescence transverse bands and spots on elytra; body beneath uniformly dark, sparsely clothed with short greyish pubescence; legs uniformly reddish-brown; antennae uniformly reddish-brown, slightly darker toward basal and apices.

(♀) Length: 13-14 mm, width: 3.5-4.5 mm.

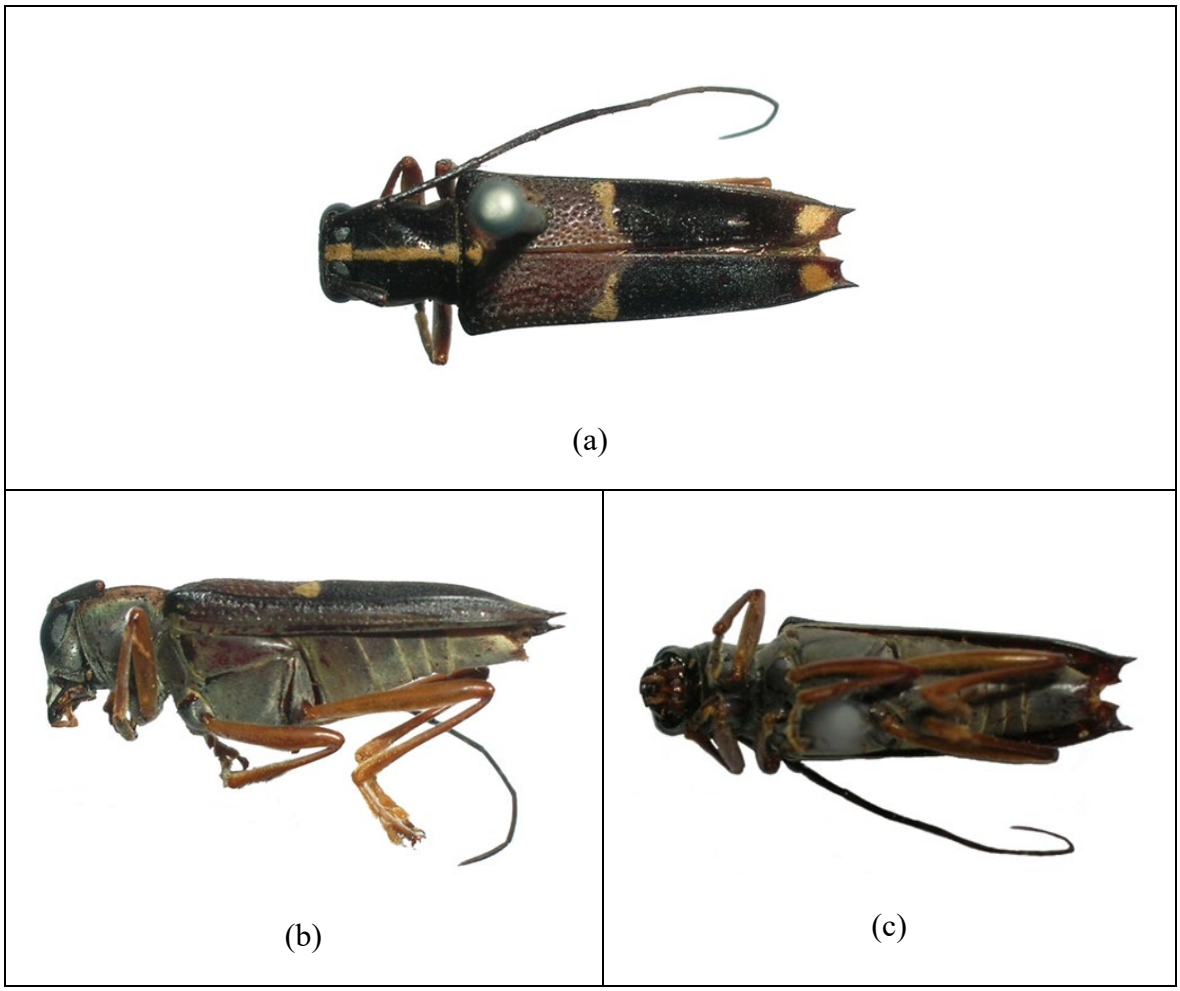
Description:

Head with the front slightly longer than wide, equal in width with prothorax; vertex broad and nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with inconspicuous whitish grey recumbent hairs on gena, around the eyes and margin of frons, occiput densely clothed with short black hairs ornamented with a narrow longitudinal yellow pubescence vitta along median; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, sparsely, irregularly punctuated, the punctures nearly concealed by the pubescence, pronotum densely clothed with short dark pubescence, and ornamented with a narrow yellow pubescence vitta along median. Scutellum transverse late obovatus, rounded at apex, densely clothed with yellow pubescence, except at the sides, where the pubescence is black.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, posterior half of elytra densely clothed with short black pubescence, and anterior half densely clothed with short brown hairs, each elytron ornamented with transversely yellow pubescence at middle of disc, and a yellow pubescent spot near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, sparsely clothed with shorth greyish pubescence, sides of fifth abdominal segments rather densely covered with pale yellow pubescence.



(a)

(b)

(c)

Figure 4.16: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea dimidiata* var.

14. *Glenea disa* Aurivillius, 1911:222 [*Glenea*]

Materials examined: 1 specimen (♂).

(Sarawak Museum Coll.) - Sarawak, Limbang, IV.1910 (♂).

Diagnosis: Body above uniformly dark, ornamented with testaceous yellow pubescence blotches and spots on elytra; body beneath dark, densely clothed with short and pale yellow pubescence; legs uniformly reddish-brown, except the dark front and middle tasrsal, sparsely clothed with short and recumbent, and long and erect testaceous yellow hairs intermixed, denser toward apices; antennae uniformly dark.

(♂) Length: 15 mm, width: 4.5 mm.

Description: Head with the front as long as wide, slightly smaller than the prothorax, vertex broad, nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with pale yellow pubescence on gena, around the eyes and margin of frons, sparsely clothed with short, inconspicuous dark and pale yellow hairs on median of frons, occiput densely clothed with short dark pubescence; the eyes and mandible black, maxillary and labial palpal dark reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides feebly, arcuately rounded anteriorly, feebly constricted behind middle; surface finely, densely punctuated, scarcely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short black pubescence with a testaceous yellow pubescence dot at median of base. Scutellum transverse late

obovatus, rounded at apex, broad and nearly flat, densely covered with testaceous yellow pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence, and ornamented with testaceous yellow pubescence blotch at basal fourth entirely, common to both elytra, and a testaceous yellow pubescence spots at apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark, and entirely clothed with short pale yellow pubescence, sparser on metasternum and centres of fifth abdominal sternites; the external mucro at the apex of moderately length in male.

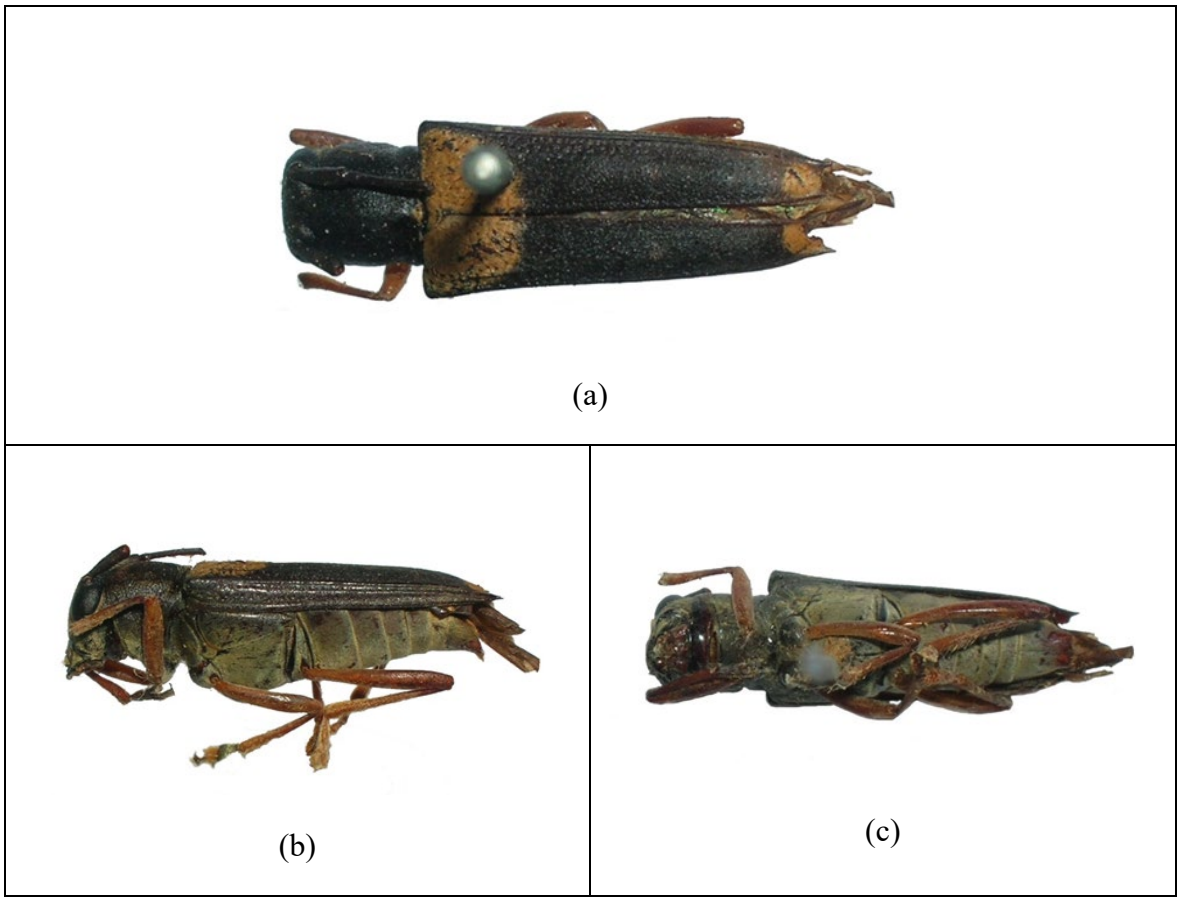


Figure 4.17: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea disa* Aurivillius, 1911.

15. *Glenea extensa* Pascoe, 1858a:258 [*Glenea*]

mima J. Thomson, 1879:11 [*Glenea*]

jubaea Pascoe, 1866a:260 [*Glenea*]

bipunctulipennis Breuning, 1958n:844 [*Glenea*]

Materials examined: 29 specimens (22 ♀, 7 ♂).

(FRC Coll.) – Sarawak, Tebakang, 24.VI.1983, Lippa Akeng (♀); Sarawak, Niah, 24.II.1979, A.A. Hamid (♀); Sarawak, Baram, Sg. Bilat, 28.III.1980, Mercer and Suhaili (♀); Sarawak, Belaga, Bukit Semalong, 16.IV.1980, Bunsu Buang (♀); Sarawak, Matang, Mt. Serapi (alt. 3000 ft.), 20.V.1982, SFD Ento. Team (♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, 15.II.1899 (♀); Sarawak, Kuching, 7.VI.1899 (♀); Sarawak, Kuching, 18.II.1898 (♀); Sarawak, Kuching, 17.XII.1898 (♀); Sarawak, Kuching, 29.X.1899 (♀); Sarawak, Kuching, IV.1896 (♀); Sarawak, Kuching, 14.III.1899 (♀); Sarawak, Kuching, no date (♀); Sarawak, Kuching, 4th Mile Rock Road, 19.VII.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 4.V.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 29.IV.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 6.VII.1909 (♀); Sarawak, Kuching, 3rd Mile Rock Road, 10.V.1909 (♀); Sarawak, Simanggang, 29.V.1909 (♀); Sarawak, Retuk, Ulu Sadong, 16.V.1914 (♀); Sarawak, Santubong, V.1899 (♀); No label (♀); Sarawak, Kuching, 11. I.1900 (♂); Sarawak, Kuching, XII.1902 (♂); Sarawak, Kuching, 17. XII.1899 (♂); Sarawak, Mt. Sibau, VI.1902 (♂); Sarawak, Simanggang, 27.V.1909 (♂); Sarawak, Lawas, 27.VIII.1909 (♂); Sarawak, Retuk, Ulu Sadong, 15.V.1914 (♂).

Diagnosis: Above uniformly dark reddish-brown, decorated with longitudinal yellow pubescence vittae and transverse band; body beneath dark reddish-brown densely clothed with pale yellow pubescence; legs uniformly reddish brown; antennae dark brown, apical of first segment sparsely covered with white pubescence, and apical of second segment densely clothed with white pubescence.

(♀) Length: 15 mm, width: 5 mm.

(♂) Length: 13 mm, width: 4 mm.

Description: Head with the front longer than wide, equal in width with prothorax, vertex broad, feebly concave, occiput weakly convex at middle of base, frons slightly triangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, densely punctuated, densely clothed with recumbent, pale yellow hairs on gena, and yellowish pubescence around eyes and margin of frons, sparsely clothed with short, inconspicuous brown hairs on median part, ornamented with narrow, longitudinal yellow pubescence vittae, two dorso-laterally, and two on median; gena fairly shorter than inferior eyelobe; eyes and mandible black, maxillary and labial palpal reddish brown; antennae slender, about as long as the body.

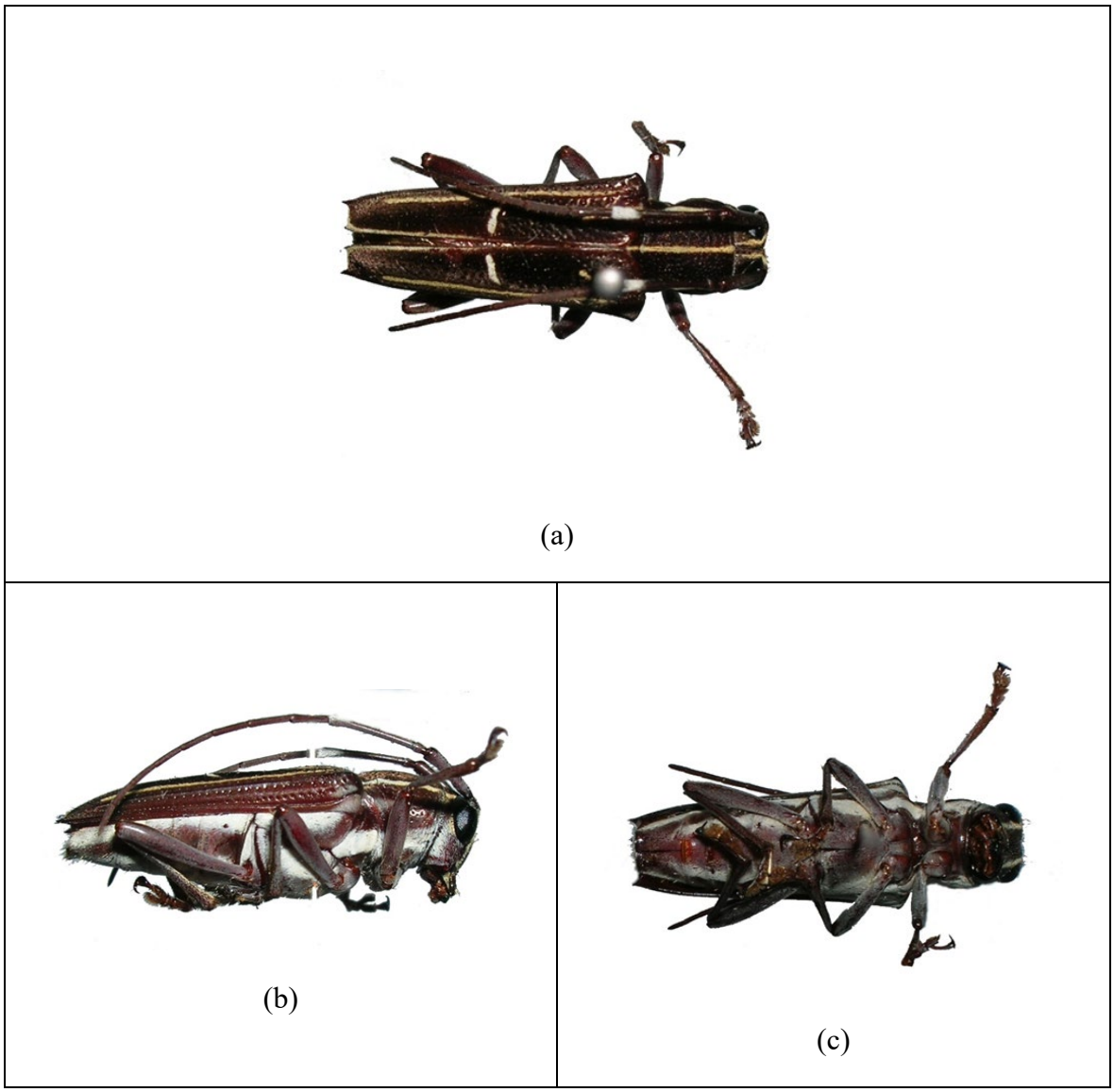
Prothorax longer than wide, sides feebly, arcuately rounded anteriorly, constricted at base and apex, strongly constricted behind middle; surface finely, densely punctuated, scarcely punctuate at sides, the punctures nearly concealed by the pubescence at sides, densely clothed with short, erect, dark brown hairs, and ornamented with five, longitudinal yellow pubescence vittae, one of which narrow on median, dorso-lateral pair broad, and lateral pair shorter and inconspicuous. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely covered with yellow recumbent hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short, spine at the sutural margin and a longer at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically; each elytron densely covered with short, erect, dark brown hairs, ornamented with three, narrow, longitudinal, yellow pubescence vittae, one along sublateral close to lateral carina extending from base to near apex, one which extending from base medially, slightly bend toward suture at basal fourth, and one along sutural margin extending from base to apex; each elytron also decorated with a narrow transverse yellow pubescence band at middle, connecting with sublateral vitta, touching suture, but not touching margin, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with pale yellow pubescence, leaving dark brown portions on inner part of metasternal episternum, metasternum, ventro-lateral and centres of abdominal sternites.

Distribution: Borneo, W. Malaysia.

Known habitats / behaviour: Caught during flight at hilltop of logged over forest.



(a)

(b)

(c)

Figure 4.18: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea extensa* Pascoe, 1858.

16. *Glenea fatalis* Pascoe, 1867a:382 [*Glenea*]

biapicalis J. Thomsom, 1879:11 [*Glenea*]

fuscofemorata Breuning, 1958c:281 [*Glenea*] {Note 1}

infrapartealba Breuning, 1958c:281 [*Glenea*] {Note 1}

Materials examined: 2 specimens (1 ♀, 1 ♂).

(FRC Coll.) – Sarawak, Matang, Mt. Serapi (alt. 3000 ft.), 21.X.1980, Mercer and Lippa (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, 21.VI.1909 (♀).

Diagnosis: Above uniformly dark, ornamented with five pair of yellow pubescence dots on disc, and one pair of yellow pubescence spots on apex of elytra; body beneath densely clothed with white pubescence; legs yellowish brown; antennae uniformly dark.

(♀)Length: 15 mm, width: 4.6 mm.

(♂)Length: 15 mm, width: 4.6 mm.

Description: Head with the front longer than wide, equal in width with prothorax; vertex broadly concave, occiput strongly convex at middle of base, frons with a fine longitudinal furrow extending from epistoma to occiput; surface coarsely, sparsely, irregularly punctuated, rather densely clothed with pale yellow pubescence on gena and around the eyes, sparsely clothed with short, inconspicuous pale yellow hairs on median part; mandible black, maxillary and labial palpal yellowish brown, mentum dark reddish brown; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, sides feebly, arcuately rounded anteriorly, vaguely constricted behind middle; surface densely, coarsely, irregularly punctuated, scarcely punctuate at sides, densely clothed with recumbent dark brown hairs dorsally, ventral and lateral densely furnished with white pubescence, decorated with two fine longitudinal pale yellow pubescence vittae anteriorly to the point before base dorso-laterally. Dark brown scutellum transverse late obovatus, rounded at apex, broad, feebly concave dorsally, and distinctly concave anteriorly, sparsely clothed with short, recumbent dark brown hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures and densely furnished with short , recumbent white hairs, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short sutural and a longer marginal spine; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, disc clothed with dark brown pubescence, each elytron ornamented with yellow pubescence spot near apex, and yellow pubescence dots as follow: one behind the middle of basal fourth at the middle of elytron, one before the middle of basal third at sublateral, one just behind the middle of disc, one at sublateral of apical third, and one which nearly oblong at sublateral behind the middle of apical third, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with whitish pubescence.

Distribution: Borneo, Sumatra, W. Malaysia.

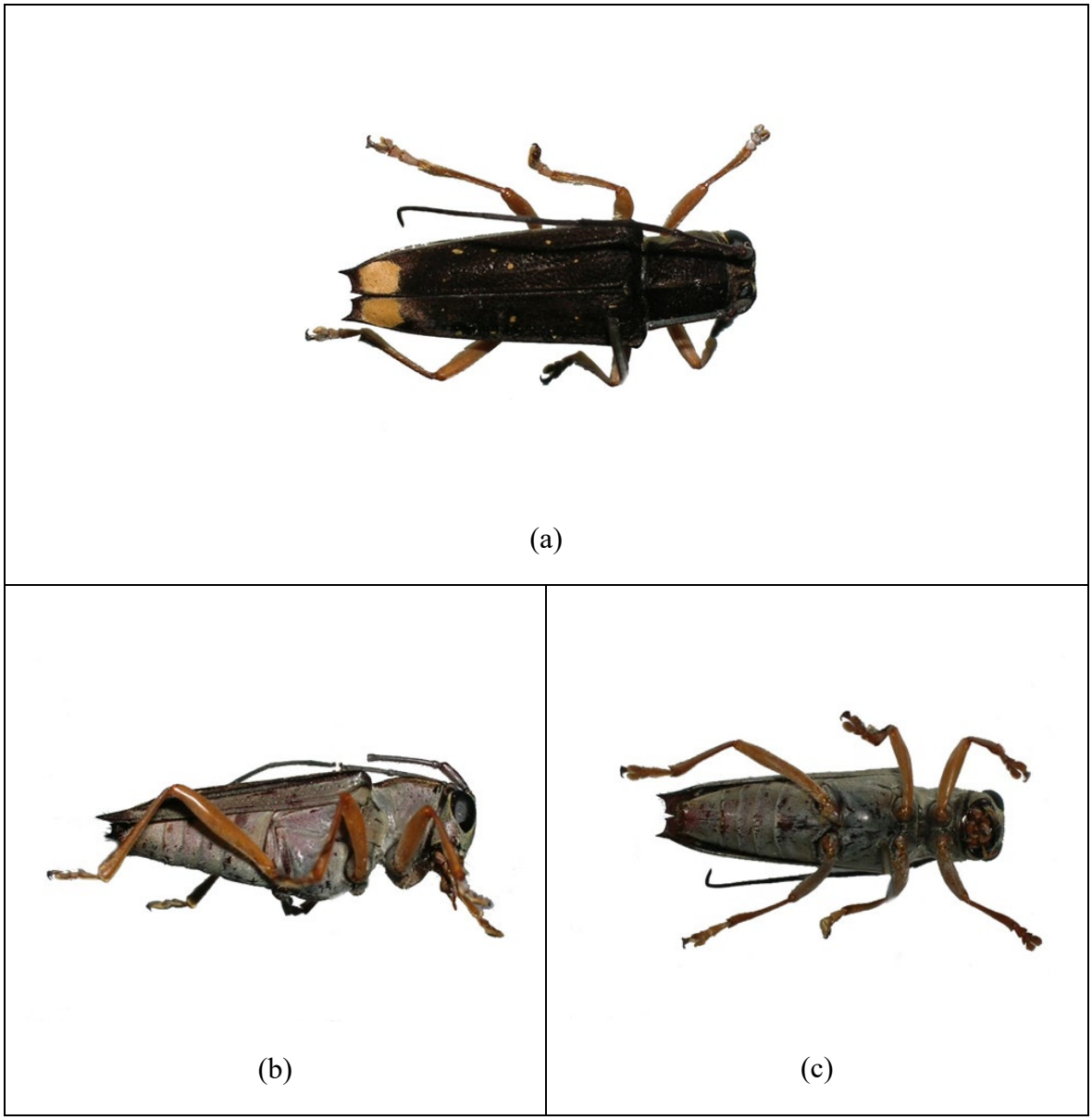


Figure 4.19: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea fatalis* Pascoe, 1867.

17. *Glenea funerula funerula* (J. Thomson, 1857d:141) [*Stibara*]

accessoria Breuning, 1958c:282 [*Glenea*] {Note 1}

Materials examined: 8 specimens (5 ♀, 3 ♂).

(FRC Coll.) – Sarawak, Belaga, Bukit Semalong, 14.IV.1985, Lippa Akeng (♂).

(Sarawak Museum Coll.) – Sarawak, Penrissen, V.1899 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Melinau, Mt. Mulu, XI.1910 (♀); Sarawak, Retuk, 16.V.1914 (♀); Sarawak, Retuk, 16.V.1914 (♀); Sarawak, Mt. Merinjak, 26.V.1914 (♂); Sarawak, Mt. Merinjak, 26.V.1914 (♂).

Diagnosis: Body above uniformly dark, decorated with snowy white pebescence spots, broad band blotches, and dots; body beneath sparsely clothed with white pubescence; femora reddish-brown, tibiae and tarsal dark brown, sparsely covered with moderately long, erect, testaceous and white hairs; antennal scape, first and second segments dark brown, the following joints dark.

(♀) Length: 15 mm, width: 5 mm.

(♂) Length: 13 mm, width: 4 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex feebly concave, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with white and pale yellow hairs around the eyes and gena, hairless on median part of frons, occiput sparsely clothed with short, recumbent and erect, inconspicuous dark hairs; the eyes and mandible black, maxillary and labial palpal

ochraceus; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, feebly constricted behind middle, sides feebly, arcuately rounded anteriorly; surface finely, sparsely punctuated, feebly punctured at sides, the punctures nearly concealed by the pubescence, densely covered with erect and recumbent, velvety black hairs apically, and densely covered with snowy white, broad, transverse band pubescence basally on pronotum, forming a collar. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely covered with short and recumbent dark hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, lower row of the punctures decorated with a longitudinal, white pubescence vitta extending from base to apex, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short, erect and recumbent, velvety black hairs, ornamented with snowy white pubescence as follows: a blotch behind middle of elytron, a dot at sublateral before middle of apical fourth, and a spot near apex, the pubescence nearly hiding the punctures in fresh specimens.

Body beneath dark reddish-brown, rather sparsely, irregularly clothed with short, recumbent, whitish pubescence, leaving reddish-brown portions on interior part of metepisternal, basal sides of first to fourth, and apical centre of abdominal sternites.

Distribution: Borneo, Sumatra, W. Malaysia

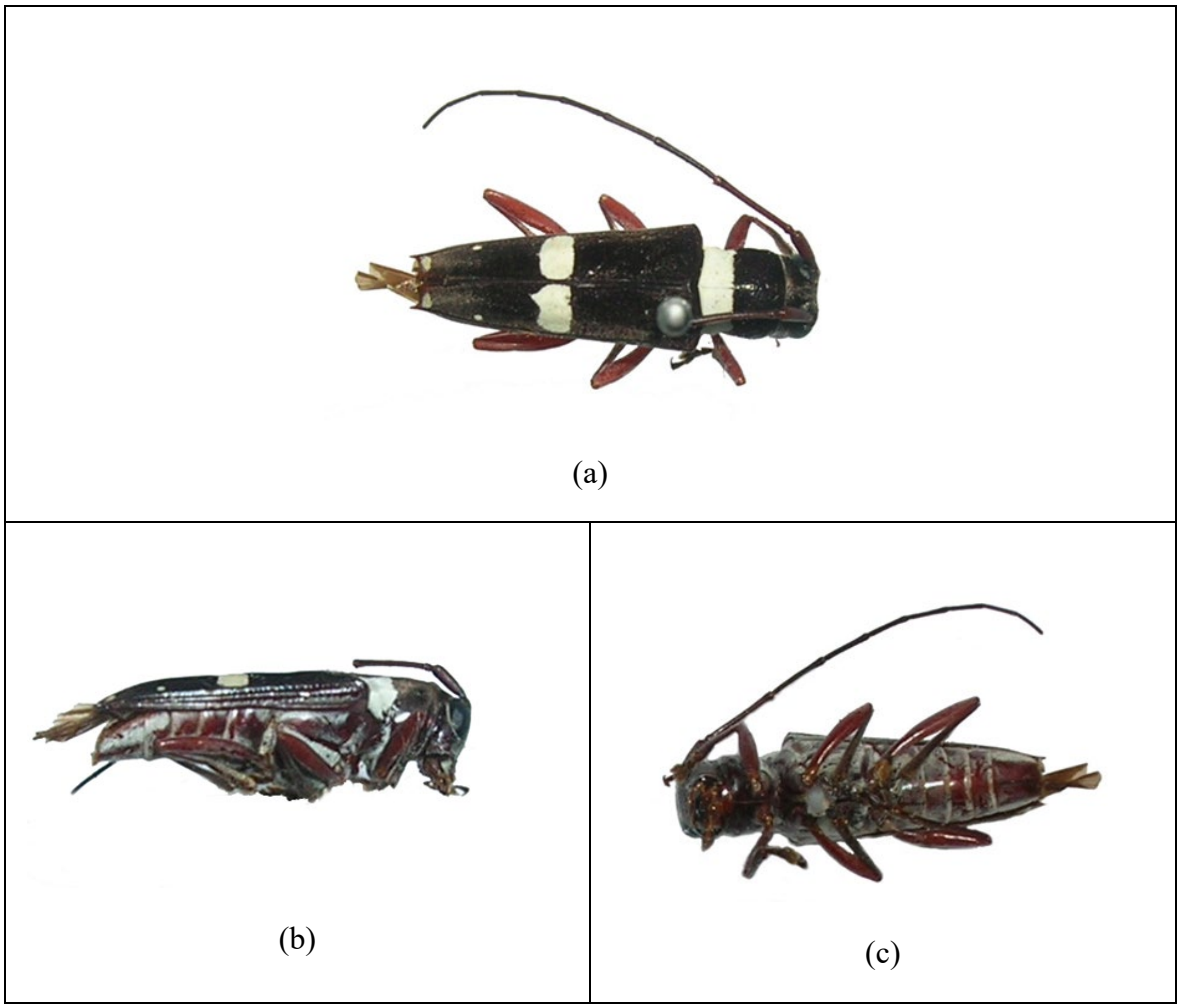


Figure 4.20: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea funerula funerula* J. Thomson, 1857.

18. *Glenea interrupta* Thomson, 1860

Materials examined: 13 specimens (12 ♀, 1 ♂).

(FRC Coll.) – Sarawak, Sibu, Panasu Camp, 2.XI.1997, SFD Ento. Team (♀); Sarawak, Sibu, Retus Permanent Forest, 29.VI.1979, SFD Ento. Team (♀); Sarawak, Lingga, Kian Seng Sawmill, 10.IX.1979, Mercer and Yeo (♀).

(Sarawak, Museum Coll.) – Sarawak, Kuching, Matang Road, 2.XII.1909 (♀);Sarawak, Kuching, Matang Road, 18.XII.1909 (♀);Sarawak, Kuching, Matang Road, 16. II.1910 (♀);Sarawak, Kuching, 26.VII.1899 (♀);Sarawak, Kuching, 8.III.1900 (♀);Sarawak, Kuching, 1.X.1899 (♀);Sarawak, Kuching, 26.VI.1899 (♀);Sarawak, Kuching, 17.III.1903 (♀);Sarawak, Kuching, 4th Mile Rock Road, 8.V.1909 (♀);Sarawak, Kuching, 15.I.1898 (♂).

Diagnosis: Body above uniformly dark brown, decorated with, longitudinal, white pubescence vittae; body beneath largely covered with white and pale yellow pubescence; femora and tibiae dark reddish-brown, tarsal black; antennae uniformly dark brown.

(♀) Length: 11 mm, width: 3.5 mm.

(♂) Length: 10 mm, width: 3 mm.

Description: Head with the front as long as wide, equal in width prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with white recumbent hairs, sparsely at median of frons, and ornamented on occiput with two narrow, whitish pubescence vittae divided at

middle by a longitudinal furrow; eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, almost parallel at apical half and narrowed from bedind to middle, sides vaguely, arcuately rounded anteriorly, feebly constricted before base; surface finely, densely, irregularly punctuated, scarcely, sparsely punctuate at sides, the punctures nearly concealed by the pubescence; sparsely clothed with short, recumbent, inconspicuous, with a few long, erect dark brown hairs intermixed, and ornamented with three, rather broad, longitudinal, white pubescence vittae, one along median, and two along dorso-lateral. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely covered with white pubescence, forming a small white spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically; each elytron rather densely clothed with short, recumbent, dark brown hairs, ornamented with white pubescence as follows: a narrow vitta along sutural margin extending from base to apical margin, a narrow, short, which slightly bend toward submedial, longitudinal vitta along median of basal fourth to near middle of basal third, a narrow vitta along sublateral extending from base to a more or less distinct apical spot, a narrow vitta along deflexed sides extending from base to near apex, a spot at middle of disc, and a median spot of apical fourth, the pubescence nearly hiding the punctures in good specimens.

Body beneath rather sparsely, irregularly clothed with short, recumbent, whitish pubescence, rather densely clothed on metasterna episternum, and the sides of abdominal segments; femora and tibiae sparsely clothed with short, erect, white hairs, tarsal sparsely covered with long, erect black hairs.

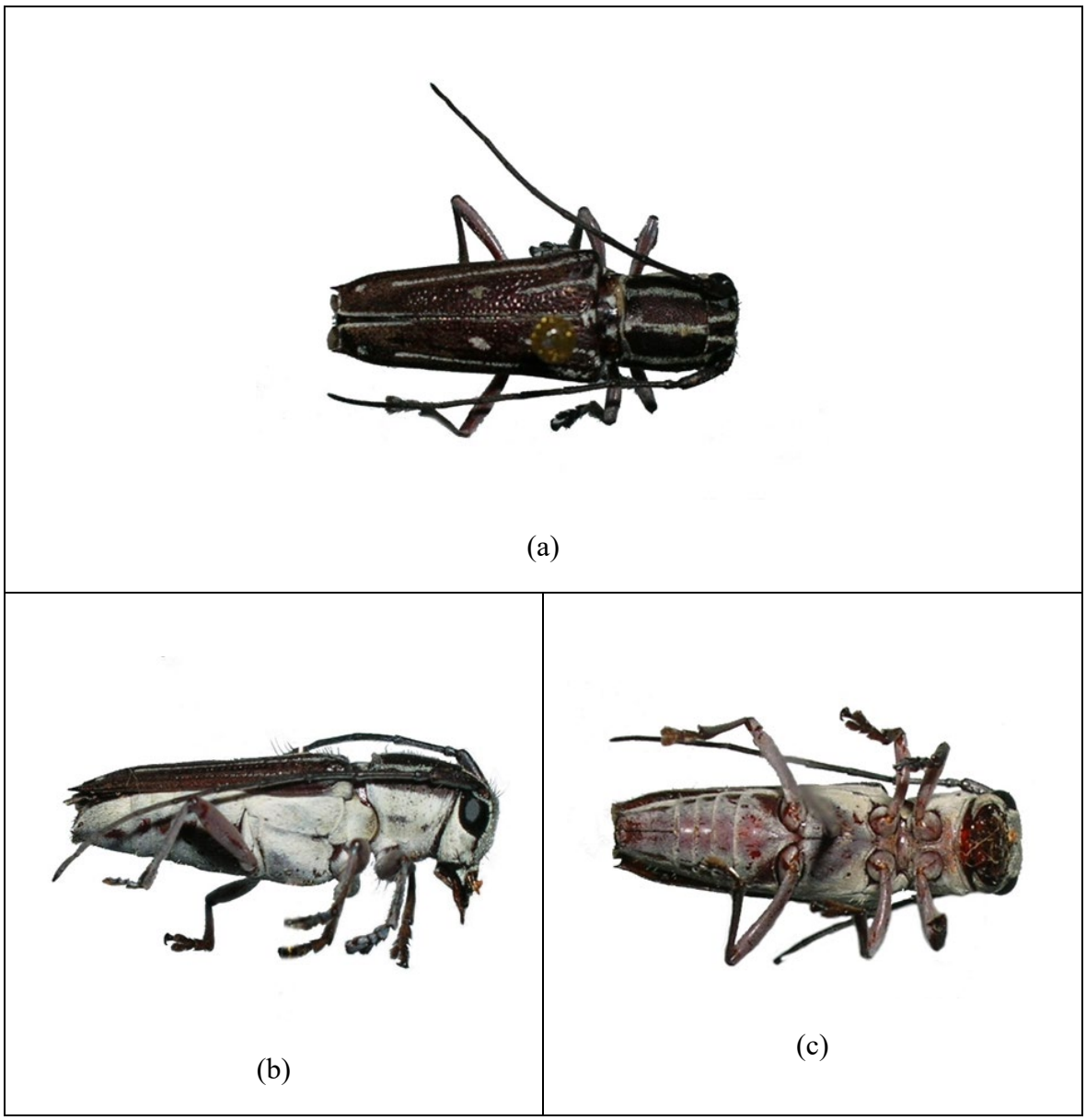


Figure 4.21: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea interrupta* Thomson, 1860.

19. *Glenea iresine* Pascoe, 1867a:406 [*Glenea*]

Materials examined: 9 specimens (7 ♀, 2 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, 21.II.1911 (♂); Sarawak, Kuching, Matang Road, 25.I.1911 (♂); Sarawak, Kuching, 20.II.1900 (♀); Sarawak, Kuching, 15.II.1902 (♀); Sarawak, Kuching, Matang Road, 5.I.1910 (♀); Sarawak, Kuching, Matang Road, 14.XII.1910 (♀); Sarawak, Kuching, Matang Road, 21.VI.1909 (♀); Sarawak, Retuk, Ulu Sadong, 16.V.1914 (♀); No label (♀).

Diagnosis: Body above uniformly dark bluish metallic, ornamented with inconspicuous white pubescence dots on pronotum, and inconspicuous longitudinal white pubescence vittae and transverse bands on elytra; body beneath uniformly dark bluish metallic, densely covered with white pubescence; basal of femora and tarsal of hind legs ochraceous, femora third quarter apically, tibie, and tarsal of front and middle legs black, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae uniformly dark..

(♀) Length: 11-14 mm, width: 2.5-3.5 mm.

(♂) Length: 10-12 mm, width: 2-3 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad and concave, occiput strongly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with inconspicuous, recumbent and erect black hairs, with sparsely white hairs on lower part of gena; the eyes and mandible black, maxillary and labial

palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, weakly constricted behind middle; surface finely densely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with dark pubescence, mixed with black setulous hairs, and ornamented with a white pubescence dot at base on median. Scutellum transverse late obovatus, rounded at the apex, broad and nearly flat, and entirely covered with dark pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence, and ornamented with white pubescence as follows: three narrow and inconspicuous longitudinal vittae, one along upper punctures row of deflexed sides extending from middle of basal fourth to middle of elytron, one along sublateral extending from middle of basal fourth to middle of elytron, and one which shorter along median of posterior half of basal fourth; a obliquely incomplete and inconspicuous transverse band extending from sutural margin between basal fourth and third to submedial just before middle of disc; dark pubescence at the apex sparsely mixed with short and recumbent white hairs; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark bluish metallic, densely clothed with white pubescence on posterior half of metepisternal, and apical sides of first and second abdominal segments, leaving dark bluish portions on others area; the external mucro at the apex of moderately length in male.

Distribution: Borneo.

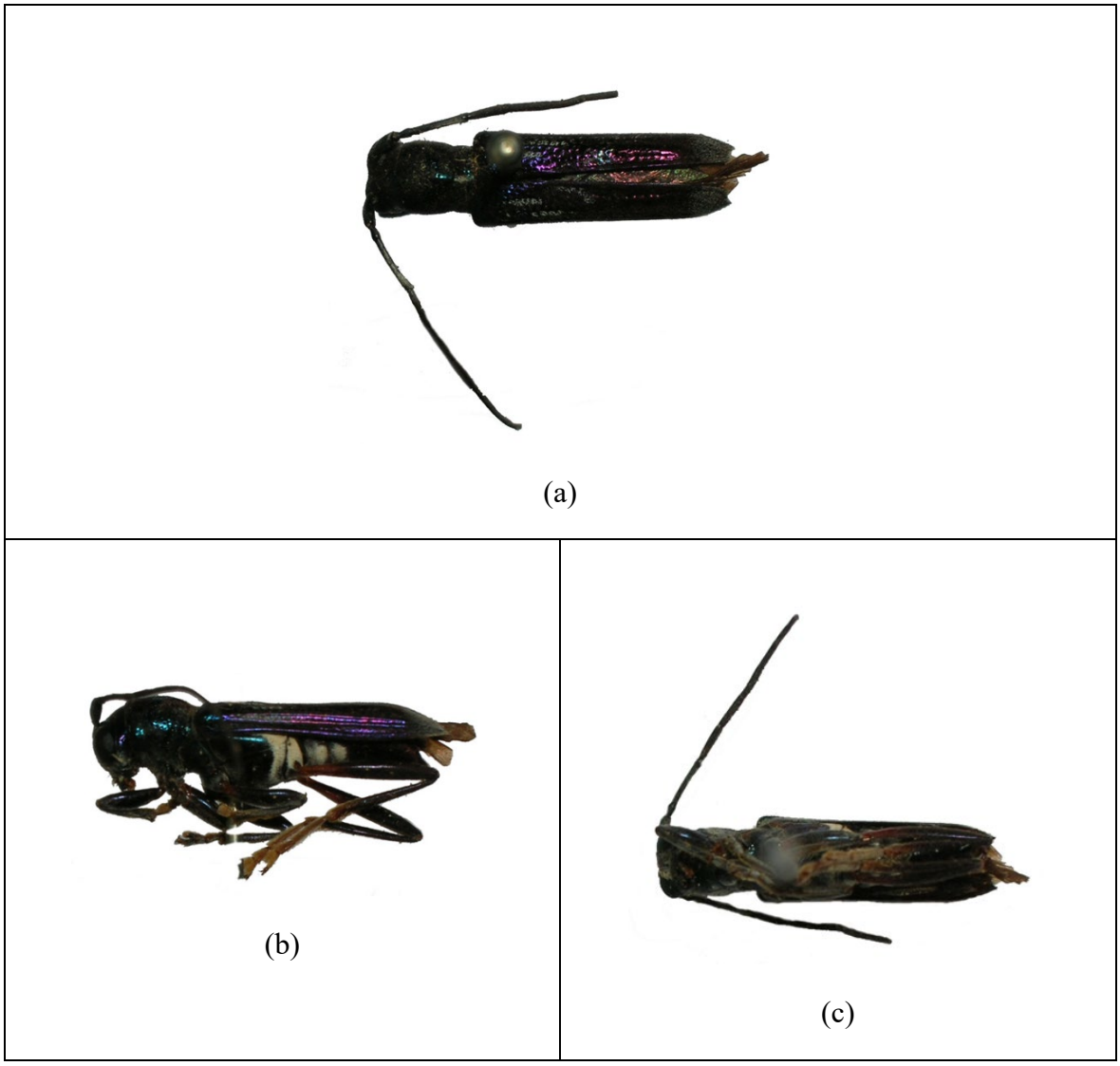


Figure 4.22: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea iresine* Pascoe, 1867.

20. *Glenea latevittata* Aurivillius, 1920:395 [*Glenea*]

Materials examined: 12 specimens (6 ♀, 6 ♂).

(FRC Coll.) – Sarawak, Matang, Mt. Serapi (alt. 3000 ft.), 20.V.1982, A. A. Hamid (♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, 15.II.1899 (♀); Sarawak, Kuching, VII.1899 (♀); Sarawak, Kuching, Matang Road, 5.V.1914 (♀); Sarawak, Kuching, Matang Road, 25.II.1910 (♀); Sarawak, Kuching, Matang Road, XII.1909 (♀); Sarawak, Kuching, 13.V.1909 (♂); Sarawak, Kuching, 6.V.1900 (♂); Sarawak, Kuching, 10.III.1914 (♂); Sarawak, Kuching, Matang Road, 1.V.1914 (♂); Sarawak, Kuching, Matang Road, 4.V.1914 (♂); Sarawak, Kuching, Matang Road, 29.IV.1914 (♂).

Diagnosis: Body above uniformly dark brown, decorated with yellow pubescence spots on elytra and head, a blotch on pronotum, and narrow, longitudinal vittae on elytra; body beneath densely clothed with pale yellow pubescence; femora ochraceous, tibiae dark reddish-brown, sparsely clothed with white, recumbent hairs, pro and mesotarsal dark brown, metatarsal rather densely clothed with white, recumbent hairs; antennae uniformly dark brown.

(♀) Length: 11 mm, width: 3 mm.

(♂) Length: 10 mm, width: 2.5 mm.

Description: Head with front as long as wide, equal in width with prothorax, vertex feebly flattened, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely

clothed with pale yellow, recumbent hairs, rather densely clothed around the eyes and margin of frons, sparsely mixed with long, erect, dark hairs on median part, ornamented with a yellow pubescence spot on median of occiput; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, sides feebly, arcuately rounded anteriorly, nearly parallel-sided at apical half and strongly constricted behind middle toward base; surface finely, densely punctuated, the punctures nearly concealed by the pubescence; pronotum dark brown, ornamented with yellow pubescence spread at middle. Scutellum transverse late obovatus, rounded at apex, broad, nearly flat, covered with yellow pubescence, forming a yellow spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, dark brown elytron densely clothed with short, recumbent, dark brown hairs, but ornamented with two narrow, longitudinal, yellow pubescence vittae, one which ill-defined along sutural margin, and one along sublateral near lateral carina extending just behind middle of disc to half of apical fourth, and yellow pubescence spots, one on middle of disc, and one which larger near apex, the pubescence nearly hiding the punctures in good specimens

Body beneath dark reddish-brown, densely clothed with pale yellow pubescence on pro and metasternal episternum, and apical sides of abdominal segments, sparsely clothed on metasternum and centre of fifth abdominal segments, leaving dark reddish-brown portions of centres of first to fourth abdominal segments.

Distribution: Borneo.

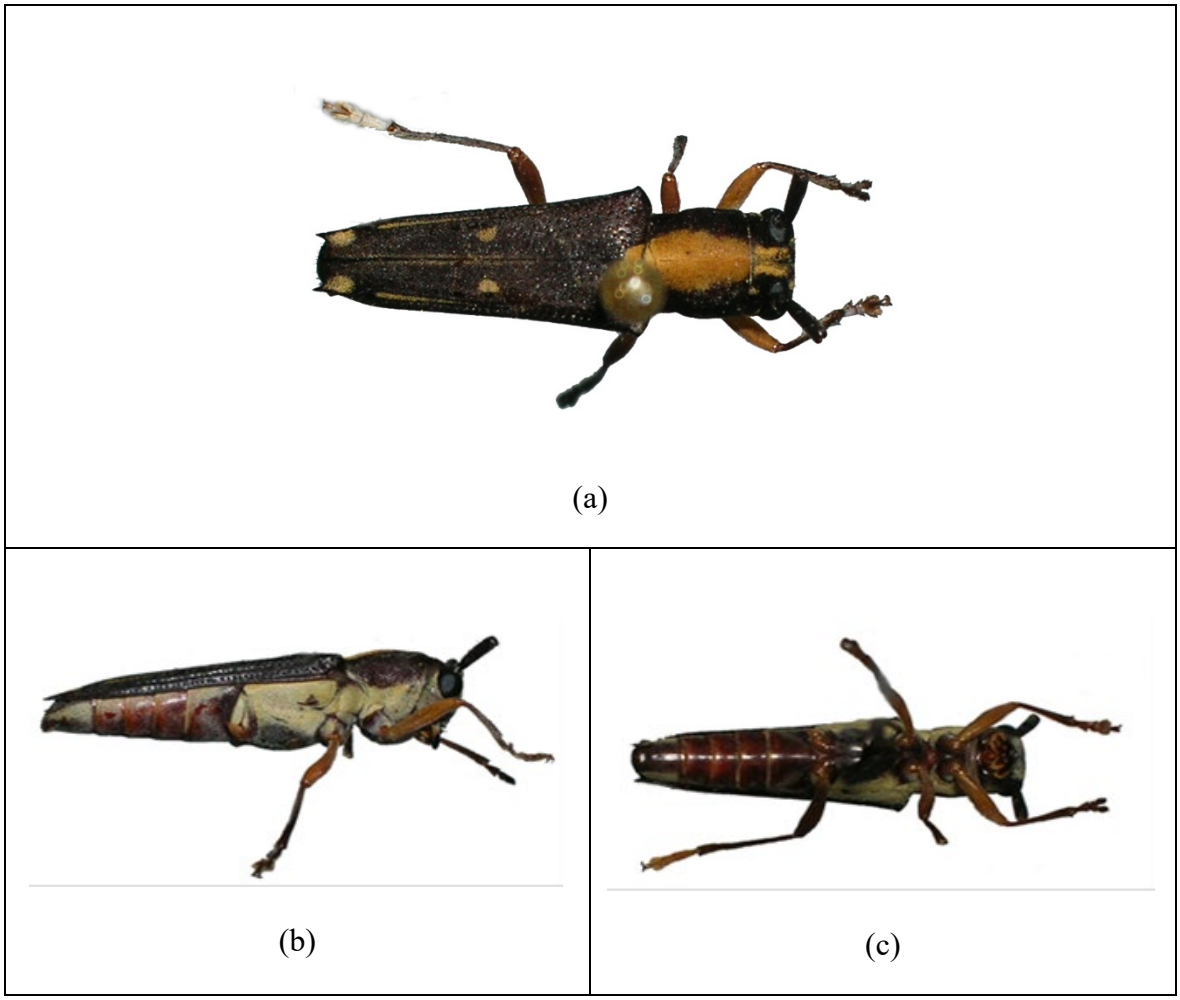


Figure 4.23: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea latevittata* Aurivillius, 1920.

21. *Glenea laudata* Pascoe.

Materials examined: 10 specimens (5 ♀, 5 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, IV.1899 (♀); Sarawak, Kuching, 11.XI.1899 (♀); Sarawak, Kuching, 25.V.1900 (♀); Sarawak, Kuching, VI.1899 (♀); Sarawak, Banting, Kerpok Hill, 25.V.1909 (♀); Sarawak, Lawas, 27.VIII.1909 (♂); Sarawak, Liu Matu, Ulu Baram, XI.1914 (♂); Sarawak, Limbang, VI.1911 (♂); Sarawak, Sadong, VIII.1902 (♂); Sarawak, Kuching, Matang Road, 30.VII.1909 (♂).

Diagnosis: Head, pronotum, and posterior half of elytra uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a yellow pubescence spot on occiput, and yellow pubescence transverse bands and spots on elytra; body beneath uniformly dark, sparsely clothed with short greyish pubescence; legs uniformly reddish-brown; antennae uniformly reddish-brown, slightly darker toward basal and apices.

(♀) Length: 13-14 mm, width: 3.5-4.5 mm.

(♂) Length: 13 mm, width: 3.0 -4.0 mm.

Description: Head with the front slightly longer than wide, equal in width with prothorax; vertex broad and nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with inconspicuous whitish grey recumbent hairs on gena, around the eyes and margin of frons, occiput densely clothed with short black hairs, ornamented with a yellow pubescence spot on median; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, sparsely, irregularly punctuated, the punctures nearly concealed by the pubescence, pronotum densely clothed with short dark pubescence. Scutellum transverse late obovatus, rounded at apex, densely clothed with yellow pubescence, except at the sides, where the pubescence is black.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, posterior half of elytra densely clothed with short black pubescence, and anterior half densely clothed with short brown hairs, each elytron ornamented with transversely yellow pubescence at middle of disc, and a yellow pubescent spot near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, sparsely clothed with shorth greyish pubescence, sides of fifth abdominal segments rather densely covered with pale yellow pubescence; the external mucro at the apex of moderately length in male.

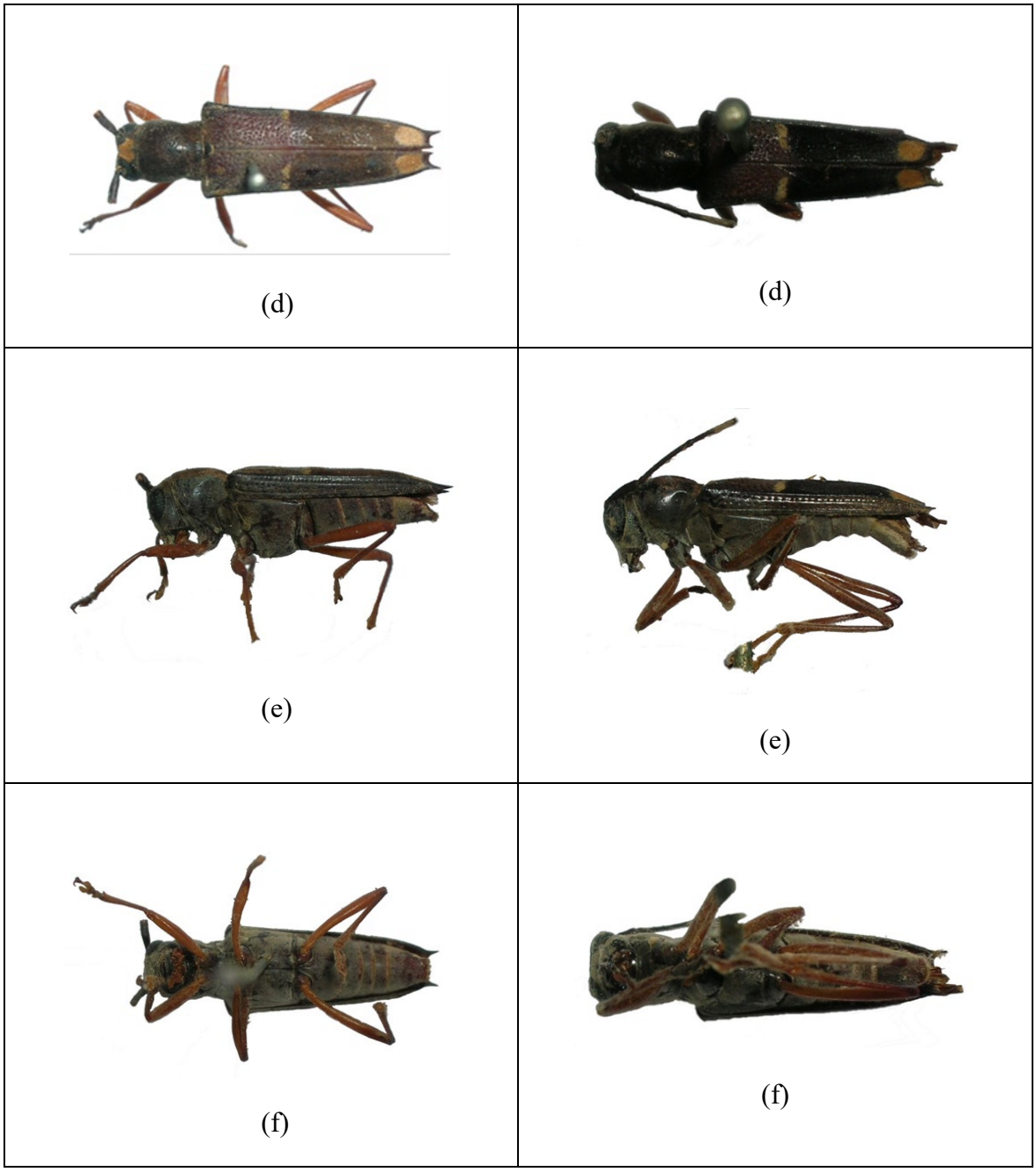


Figure 4.24: a) Dorsal view (female), b) Lateral view (female), c) Ventral view (female), d) Dorsal view (male), e) Lateral view (male), and f) Ventral view (male) of species *Glenea laudata* Pascoe.

22. *Glenea manto* Pascoe, 1866a:262 [*Glenea*]

collaroides Breuning, 1958c:285 [*Glenea*] {Note 1}

Materials examined: 13 specimens (12 ♀, 1 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, 2.III.1911 (♂); Sarawak, Kuching, 1.VII.1903 (♀); Sarawak, Kuching, 4.IV.1902 (♀); Sarawak, Kuching, 9.III.1900 (♀); Sarawak, Kuching, Matang Road, V.1910 (♀); Sarawak, Kuching, Matang Road, 9.V.1910 (♀); Sarawak, Kuching, Matang Road, 31.V.1910 (♀); Sarawak, Kuching, Matang Road, 6.III.1911 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Penrissen, V.1899 (♀); Sarawak, Penrissen, 17.V.1899 (♀); Sarawak, Kuching, 4th Mile Rock Road, 11.III.1911 (♀); Sarawak, Kuching, 4th Mile Rock Road, 13.IV.1909 (♀).

Diagnosis: Body above uniformly black, with a short black pubescence, ornamented with ochraceous yellow pubescence blotch at the posterior half or rather more of the prothorax, a large median patch of ochraceous yellow pubescence common to botch elytra, and a ochraceous yellow pubescence spots at the apex of each elytron; body beneath densely covered with pale yellow pubescence; legs uniformly reddish-brown or slightly testaceous; antennae uniformly dark.

(♀) Length: 13mm, width: 3.5 mm.

(♂) Length: 10 mm, width: 2.5 mm.

Description: Head with the front as long as wide, slightly smaller than prothorax, vertex broad and feebly flattened, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely covered with short dark pubescence on occiput, gena and median part of frons, both sides of margin of frons densely clothed with pale yellow pubescence,

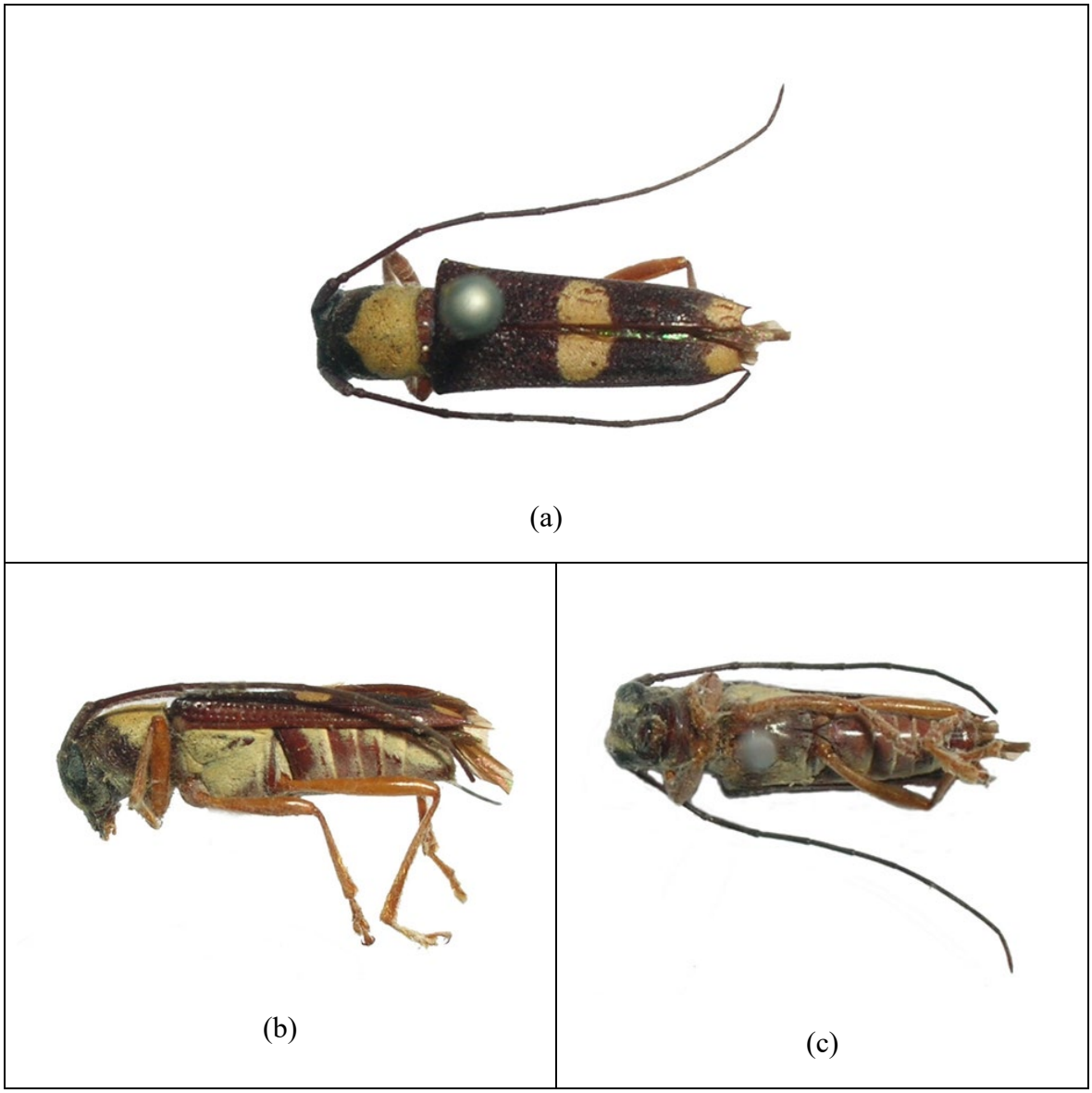
forming the two stripes in front; the eyes and mandible black, maxillary and labial palpal testaceous; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures concealed by the pubescence, pronotum densely clothed with short black pubescence anteriorly, but ornamented with ochraceous yellow pubescence blotch at the posterior half or rather more. Scutellum transverse late obovatus, rounded at the apex, broad and nearly flat, densely covered with short dark pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent black hairs, and ornamented with ochraceous yellow pubescence as follows: a large median patch common to both elytra and a spot at the apex of each elytron; the pubescence nearly hiding the punctures in good specimens.

Body beneath reddish-brown, densely clothed with short pale yellow pubescence, sparser on metasternum, basal sides of first, second and third, and centres of abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo, Sumatra, Java, W. Malaysia.



(a)

(b)

(c)

Figure 4.25: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea manto* Pascoe, 1866.

23. *Glenea matangensis* Aurivillius, 1911:223 [*Glenea*]

rufimembris Breuning, 1953a:25 [*Glenea*]

Materials examined: 11 specimens (11 ♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, 29.IV.1914 (♀); Sarawak, Kuching, Matang Road, 5.III.1912 (♀); Sarawak, Kuching, Matang Road, 14.XII.1909 (♀); Sarawak, Kuching, Matang Road, 14.XII.1909 (♀); Sarawak, Kuching, Matang Road, 17.II.1910 (♀); Sarawak, Kuching, Matang Road, 19.II.1910 (♀); Sarawak, Kuching, 4th Mile Rock Road, 20.IV.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 5.IV.1909 (♀); Sarawak, Lawas, 6.IX.1909 (♀); Sarawak, Lawas, 27.VIII.1909 (♀); Sarawak, Kuching, 3.X.1899 (♀).

Diagnosis: Body above uniformly dark brown, ornamented with five whitish blue pubescence spots and dots on each elytron, and a narrow longitudinal whitish blue pubescence vitta on pronotum; body beneath uniformly dark brown, densely covered with white pubescence; femora reddish brown, tibiae and tarsal dark brown, sparsely clothed with short and recumbent whitish blue hairs, mixed with moderately long, erect pale yellow and dark hairs, denser toward apices; posterior of scape, first and second antennal segments sparsely clothed with short and recumbent whitish blue hairs, the following joints uniformly dark.

(♀) Length: 11-13 mm, width: 3 -4 mm.

Description: Head with the front as long as wide, equal in width with the prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with whitish blue pubescence on gena, along margin of

frons and upper part of the eyes, sparsely covered with inconspicuous dark pubescence on median of frons, mixed with white hairs, densely covered with short dark pubescence on occiput; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides vaguely, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, densely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum sparsely clothed with inconspicuous recumbent dark brown hairs, ornamented with a narrow longitudinal whitish blue pubescence vitta along median. Scutellum trapezoidal, broad, feebly concave, densely clothed with pale yellow pubescence, except of at the sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each black elytron densely covered with short and recumbent dark brown hairs, ornamented with whitish blue pubescence as follows: four spots, one at middle of basal fourth, one at middle of elytron, one between apical fourth and third at sublateral, and one near apex; two dots, one at sublateral of basal fourth at middle, and one at sublateral of basal third; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, rather densely clothed with white pubescence on metepisternal, apical sides of first, and sides of second to fifth abdominal segments, sparsely on metasternum and centres of abdominal segments, leaving dark brown portions on basal sides of first abdominal segments.

Distribution: Borneo.

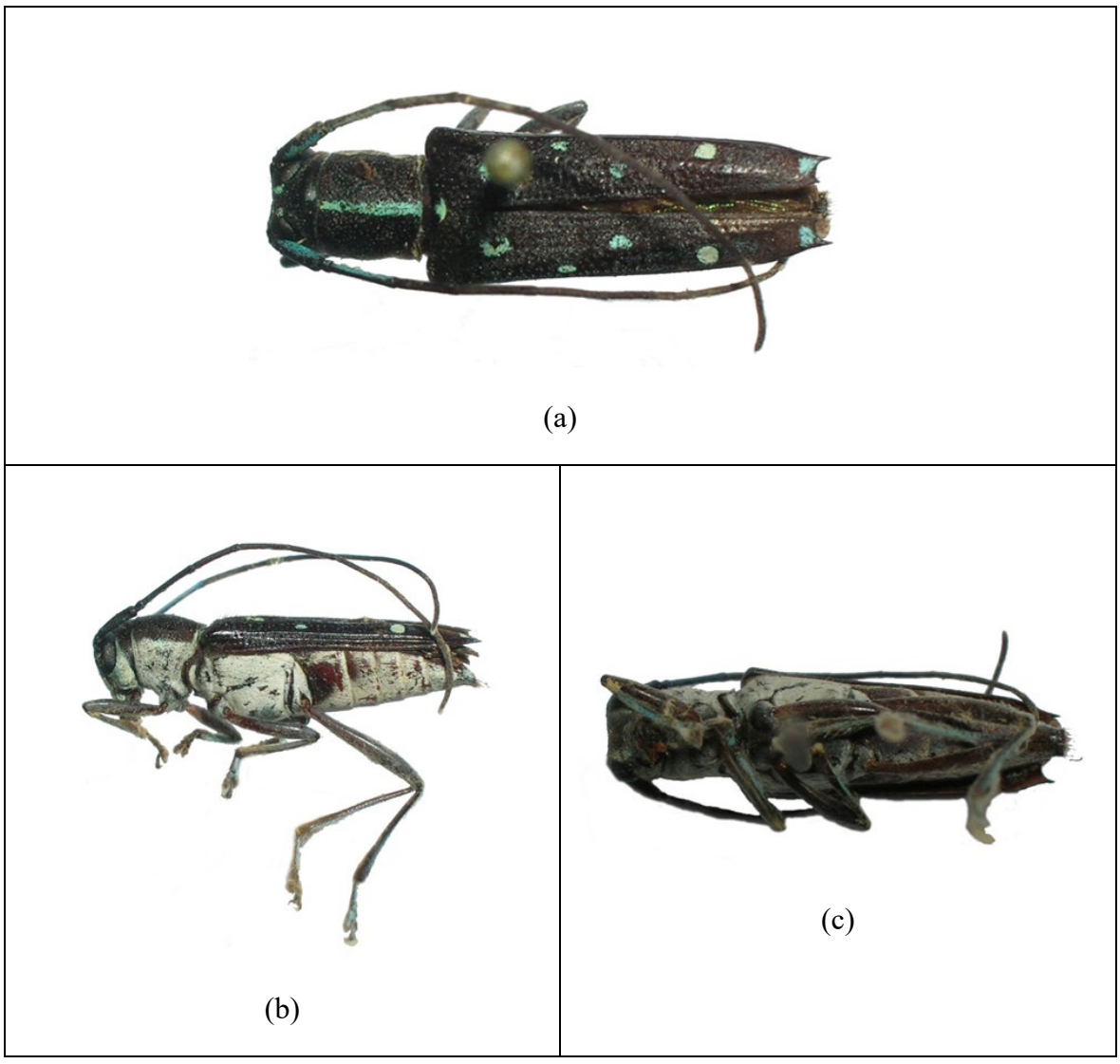


Figure 4.26: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea matangensis* Aurivillius, 1911.

24. *Glenea medea* Pascoe, 1867a:410 [*Glenea*]

Materials examined: 5 specimens (5 ♀).

(Sarawak Museum Coll.) - Sarawak, Kuching, III.1896 (♀); Sarawak, Kuching, 7.V.1913 (♀); Sarawak, Kuching, 10.II.1899 (♀); Sarawak, Kuching, 7.V.1900 (♀); No label (♀).

Diagnosis: Body above uniformly dark with slightly metallic blue, ornamented with white six pubescence spots on each elytron, three longitudinal white pubescence vittae on pronotum, and two stripes in front and occiput of head; body beneath dark brown with slightly bluish, densely covered with white pubescence; femora hind legs uniformly reddish-brown, tibiae and tarsal of front and middle legs dark, sparsely clothed with short and recumbent, and moderately long and erect pale yellow and white hairs intermixed, denser toward apices; antennae entirely dark brown.

(♀) Length: 30 mm, width: 9 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, vertex broad and feebly concave, occiput convex at middle of base, frons slightly triangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with short black pubescence, and ornamented with two slightly broad longitudinal white pubescence vittae extending from margin of frons throught vertex and median of occiput, posterior half of lower part of gena densely covered with white pubescence, forming a spot on both side; the eyes and mandible black, first to third of maxillary palpal and first and second of labial palpal segments dark brown, the following segments dark; gena fairly shorter than the inferior eyelobe; antennae slender, shorter than the body, extending just behind the middle of elytra.

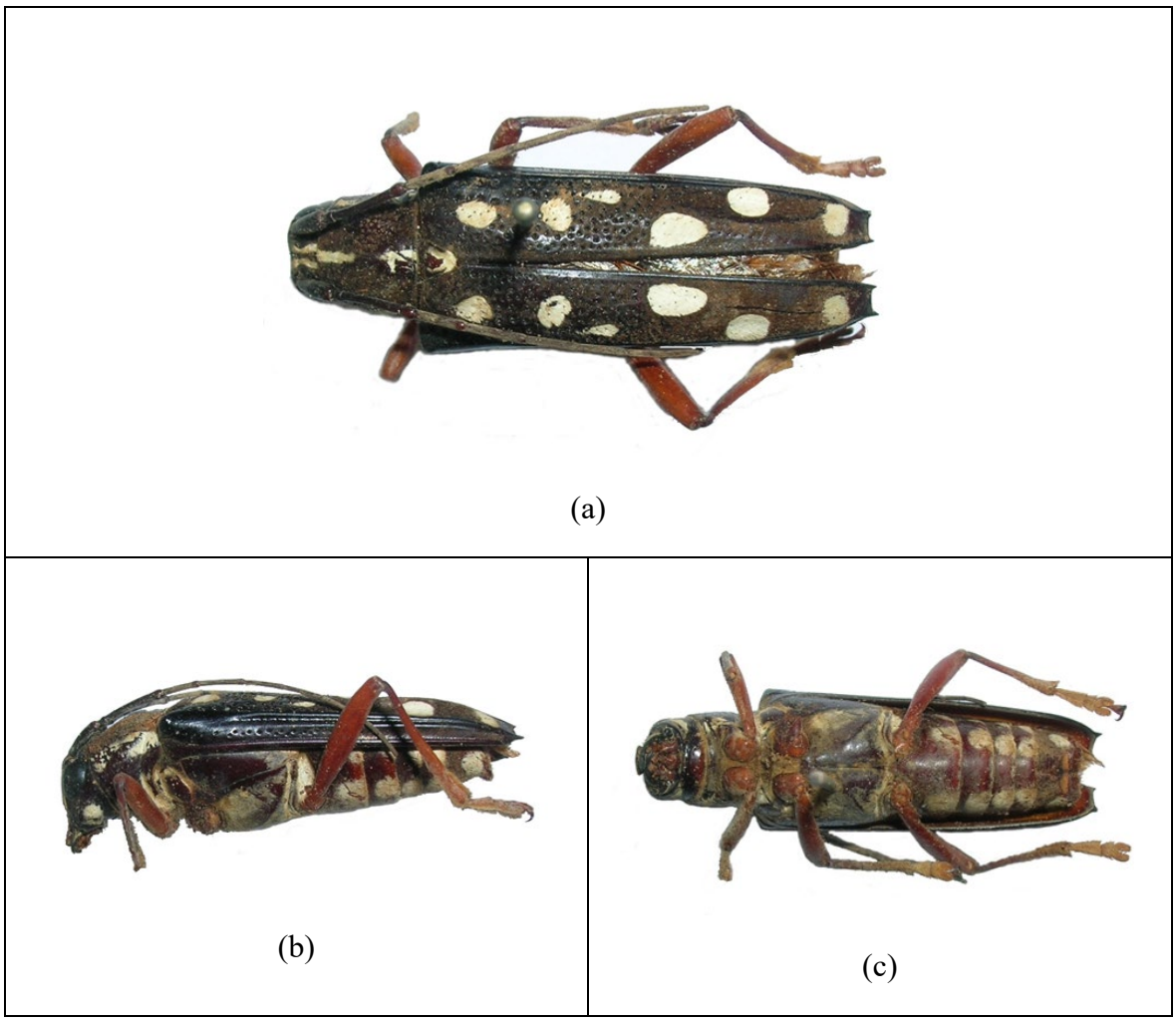
Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, feebly constricted behind middle; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short dark pubescence, and ornamented with three longitudinal white pubescence vittae, one which narrow along median, and a pair which broader laterally. Scutellum triangular, slightly rounded at the apex, feebly concave, and densely covered with white pubescence, except at the sides, where the pubescence is black.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence, and ornamented with white pubescence as follows: six spots, one at the middle of basal fourth, one between basal fourth and third at middle, one which smallest and elongated at sublateral of basal third, one at submedial just behind middle of elytron, one at sublateral between apical fourth and third, and one near apex; the upper punctures row of deflexed sides of each elytron also decorated with a narrow longitudinal white pubescence vitta extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown with slightly bluish, densely clothed with white pubescence on metepisternal and apical sides of abdominal sternites, sparser on metesternum

and centres of abdominal segments, and leaving dark brown portions on basal of ventro-lateral, and centre of fifth abdominal segments.

Distribution: Borneo.



(a)

(b)

(c)

Figure 4.27: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea medea* Pascoe, 1867.

25. *Glenea melia* Pascoe, 1867a:385 [*Glenea*]

Materials examined: 2 specimens (1 ♀, 1 ♂).

(Sarawak Museum Coll.) – Borneo, Kalimantan, Pontianak, 1899 (♂); Borneo, Kalimantan, Pontianak, 1899 (♀).

Diagnosis: Body above uniformly dark with slightly metallic blue, ornamented with the narrow longitudinal white pubescence vittae on head, pronotum and elytra, two white pubescence dots on each elytron, and a narrow tranverse bands near apex of each elytron; body beneath dark reddish-brown on first to fourth abdominal segments, dark bluish on metasternum and fifth abdominal segments, and clothed with white pubescence; femora uniformly dark reddish-brown, tibiae and tarsal dark brown, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae uniformly dark.

(♀) Length: 20 mm, width: 5 mm.

(♂) Length: 16 mm, width: 3.5 mm.

Description: Head with the front slightly longer than wide, slightly smaller than prothorax, vertex broad and feebly flattened, occiput convex at middle of base, frons rectangular, slightly oblong, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with white pubescence on lower part of gena, around the eyes and along margin of frons, median part of frons sparsely clothed with short and inconspicuous dark and white hairs intermixed, occiput densely clothed with short black pubescence, and ornamented with four longitudinal white pubescence vittae, a narrow pair along median, and a slightly broad pair along dorso-lateral; the eyes and

mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, weakly narrowed at apex, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short black pubescence, and ornamented with three narrow longitudinal white pubescence vittae, one along median, and a pair dorso-laterally. Scutellum slightly triangular, rounded at the apex, broad and feebly concave, densely covered with white pubescence, except at the sides, where the pubescence is black.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence, and ornamented with white pubescence as follows: two narrow longitudinal vittae, one along sutural margin extending from base to apical fourth, and one along sublateral extending from middle of basal fourth to apical fourth; two dots, one between basal fourth and third at median, and one just behind middle of disc at median; and a transverse band near apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with white pubescence on metepisternal, and apical sides of abdominal sternites, leaving dark bluish portions on metasternum and fifth abdominal segments, and dark reddish-brown portions on centres of first to fourth abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo.

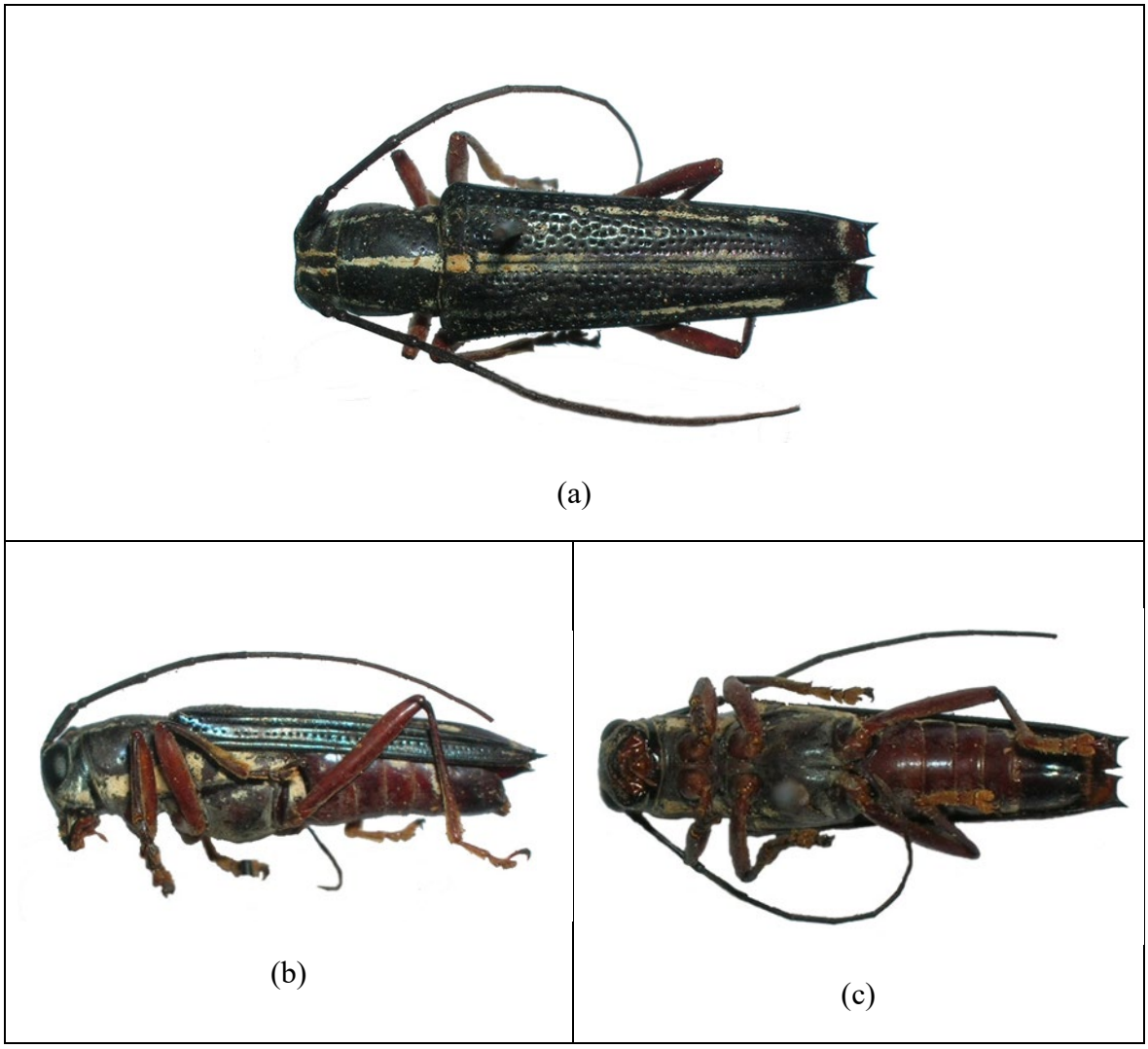


Figure 4.28: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea melia* Pascoe, 1867.

26. *Glenea myrsine* Pascoe, 1867a:367 [*Glenea*]

areca Pascoe, 1867a:369 [*Glenea*]

cryllis J. Thomson, 1879:17 [*Glenea*]

malaccensis Breuning, 1956l:752 [*Glenea*] {Note 1}

Materials examined: 15 specimens (13 ♀, 2 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 16.V.1913 (♂); Sarawak, Kuching, Matang Road, 7.II.1910 (♂); Sarawak, Kuching, 12.III.1900 (♀); Sarawak, Kuching, 20.X.1899 (♀); Sarawak, Kuching, 10.VIII.1899 (♀); Sarawak, Kuching, IV.1899 (♀); Sarawak, Kuching, 6.X.1899 (♀); Sarawak, Kuching, Matang Road, 24.VII.1909 (♀); Sarawak, Kuching, Matang Road, 14.IV.1900 (♀); Sarawak, Kuching, Matang Road, 14.XII.1910 (♀); Sarawak, Kuching, Matang Road, 10.II.1910 (♀); Sarawak, Kuching, Matang Road, 8.VI.1910 (♀); Sarawak, Kuching, Matang Road, 20.III.1911 (♀); Sarawak, Kuching, Matang Road, 27.VI.1914 (♀); Sarawak, Mt. Sibau, VI.1902 (♀).

Diagnosis: Body above uniformly dark brown, ornamented with white pubescence spots on elytra and longitudinal white pubescence vittae on pronotum; body beneath densely covered with white pubescence; femora uniformly reddish-brown, tibiae and tarsal dark reddish-brown, sparsely clothed with short and recumbent, and moderately long and erect white hairs intermixed, denser toward apices; antennal scape, first and second segments sparsely clothed with short and recumbent white hairs, third and fourth segments dark brown, the following joints densely clothed with white pubescence.

(♀) Length: 10-12 mm, width: 3-4 mm.

(♂) Length: 9-10 mm, width: 2-3 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad and feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with white pubescence on gena and margin of frons, median part of frons sparsely clothed with short and recumbent white hairs, occiput densely clothed with short and recumbent black hairs, and ornamented with two narrow longitudinal white pubescence vittae divided by a fine longitudinal furrow at the middle; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

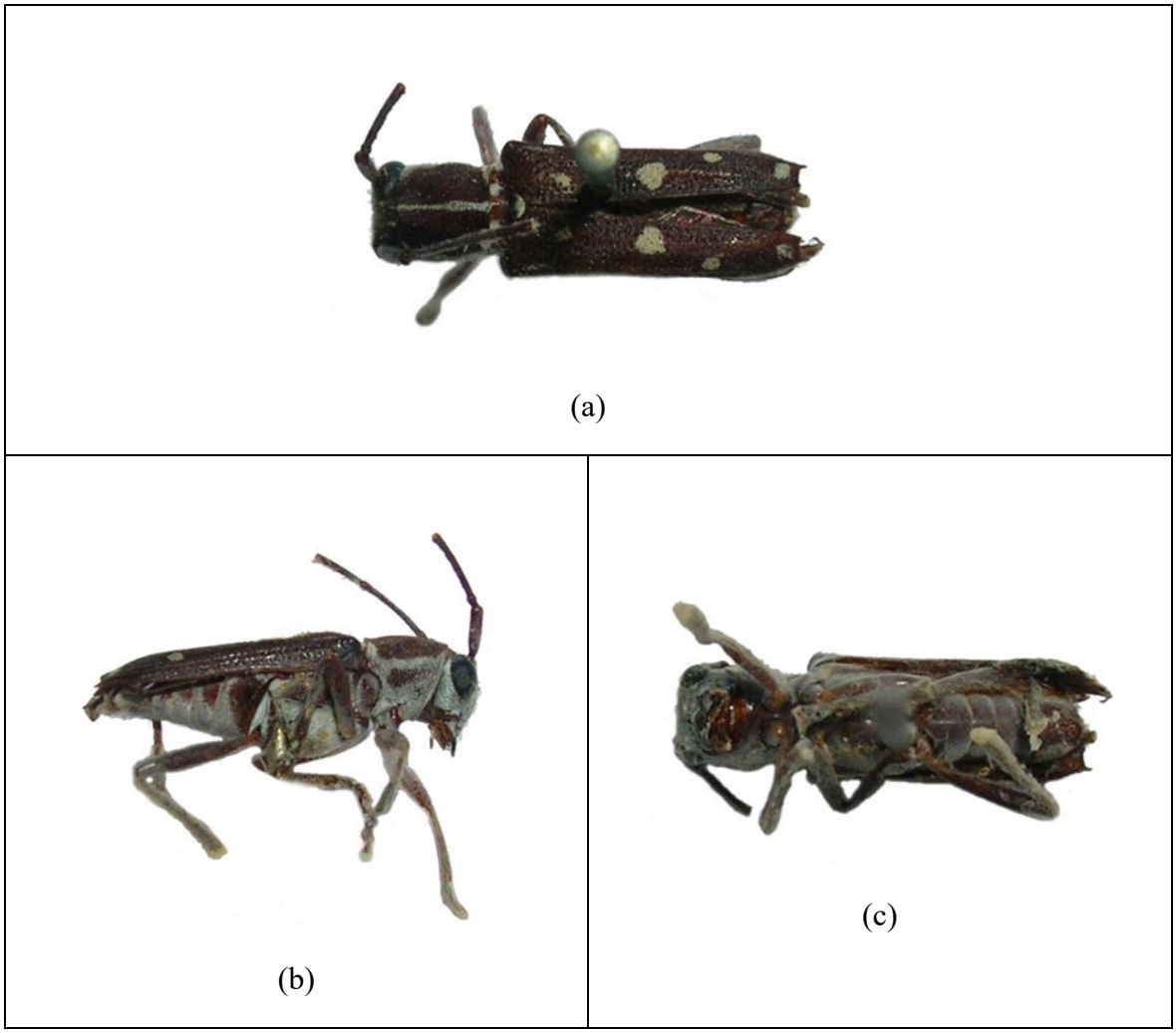
Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, weakly constricted behind middle; surface finely densely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent black hairs, and ornamented with three longitudinal white pubescence vittae, one which narrow along median, and a pair which broader laterally. Scutellum transverse late obovatus, rounded at the apex, broad and nearly flat, densely covered with dark pubescence, except at the apex, where the pubescence is whitish, forming a white dot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly

punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, and ornamented with white pubescence as follows: two spots, one at the middle of elytra, and one near apex; three dots, one which elongated at sublateral of basal fourth, one between basal fourth and third at middle, and one at sublateral between apical fourth and third; and lower punctures row of deflexed sides sparsely clothed with inconspicuous longitudinal white pubescence vittae basal halfly; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with white pubescence on metasternum, apical sides and centres of abdominal sternites, leaving black portions on interior of metepisternal and basal sides of abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo, W. Malaysia



(a)

(b)

(c)

Figure 4.29: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea myrsine* Pascoe, 1867.

27. *Glenea ochraceovittata ochraceovittata* J. Thomson, 1865b:565 [*Glenea*]

bakeri Aurivillius, 1925b:517 [*Glenea*]

borneotica Breuning, 1950c:179 [*Glenea*]

discotriangularis Breuning, 1956l:757 [*Glenea*]

Materials examined: 7 specimens (6 ♀, 1 ♂).

(Sarawak Museum Coll.) - Sarawak, Saribas, V.1926 (♂); Sarawak, Mt. Merinjak (alt. 2200ft.), 26.V.1914 (♀); Sarawak, Kuching, Matang Road, 2.II.1912 (♀); Sarawak, Kuching, Matang Road, 2.VII.1915 (♀); Sarawak, Kuching, Matang Road, 14.II.1911 (♀); Sarawak, Kuching, Matang Road, 10.XI.1915 (♀); Sarawak, Kuching, X.1906 (♀).

Diagnosis: Body above uniformly dark brown, darker in female, ornamented with ochraceous yellow pubescence vittae, spots at apex and obliquely tranverse bands on elytra; body beneath densely covered with short white pubescence; legs uniformly dark brown; antennae entirely dark brown.

(♀) Length: 10-14 mm, width: 2.5-4 mm.

(♂) Length: 12 mm, width: 3.5 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad and feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with pale yellow pubescence on gena, around the eyes and margin of frons, median part of frons sparsely clothed with short and

inconspicuous dark brown hairs, occiput densely clothed with dark brown pubescence, and ornamented with two narrow longitudinal ochraceous yellow pubescence vittae along median divided by a fine longitudinal furrow at the middle; the eyes and mandible black, maxillary and labial palpal dark reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with dark brown pubescence, and ornamented with a narrow longitudinal ochraceous yellow pubescence vitta along median. Scutellum transverse late obovatus, rounded at the apex, broad and nearly flat, densely covered with ochraceous yellow pubescence, except at the basal sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, and ornamented with ochraceous yellow pubescence as follows: four longitudinal vittae, one along upper punctures row of deflexed sides extending from base to apex, one along sublateral of anterior half of disc extending from near base and touching transverse bands at middle of disc, one along median of basal

fourth, and one which inconspicuous along sutural margin extending from base to apex; and a spot near apex sublaterally; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with whitish pubescence, sparser on metasternum and centres of abdominal sternites, leaving dark brown portions on sides of first, basal sides of second, and ventro-lateral of abdominal segments; the external mucro at the apex of moderately length in male.

Distribution: Borneo.

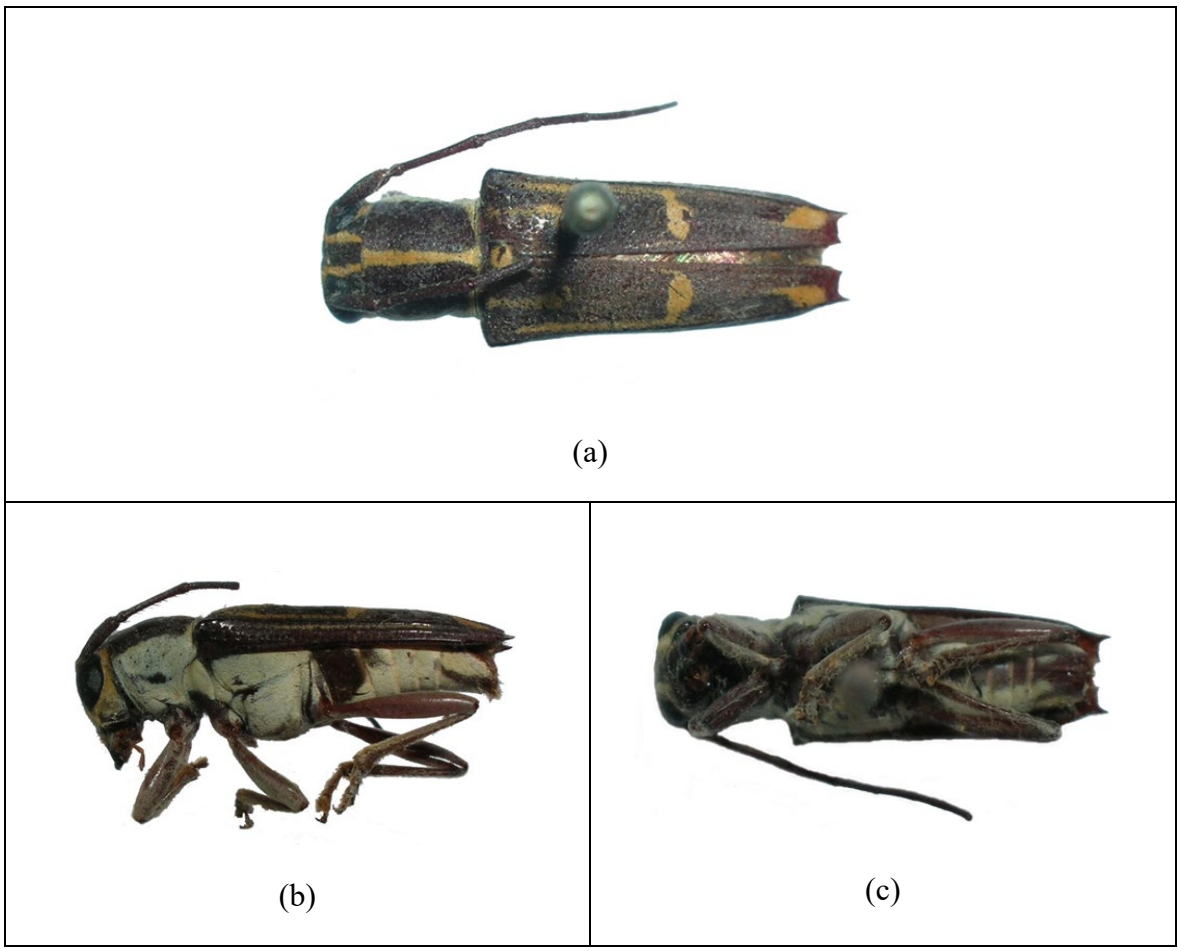


Figure 4.30: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea ochraceovittata ochraceovittata* J. Thomson, 1865.

28. *Glenea pulchella* Pascoe, 1858a:260 [*Glenea*]

vesta Pascoe, 1866a:260 [*Glenea*] {Note 51}

vestalis Heller, 1934:284 [*Glenea*]

postmediopunctata Breuning, 1956f:196 [*Glenea*] {Note 1}

preapiceconjuncta Breuning, 1956f:197 [*Glenea*] {Note 1}

transversevittata Breuning, 1956f:197 [*Glenea*] {Note 1}

Materials examined: 16 specimens (15 ♀, 1 ♂).

(FRC Coll.) – Sarawak, Kapit, Sg. Mujong, 9.IV.1989, SFD Ento. Team (♀).

(Sarawak Museum Coll.) – Sarawak, Mt Merinjak, 29.V.1914 (♀); Sarawak, Mt Merinjak, 29.V.1914 (♀); Sarawak, Mt Merinjak, 29.V.1914 (♀); Sarawak, Kuching, Matang Road, 21.VI.1909 (♀); Sarawak, Kuching, Matang Road, 5.III.1911 (♀); Sarawak, Kuching, Matang Road, 14.II.1911 (♀); Sarawak, Kuching, Matang Road, 17.XI.1910 (♀); Sarawak, Kuching, 13.XI.1900 (♀); Sarawak, Kuching, 17.IV.1900 (♀); Sarawak, Kuching, II.1899 (♀); Sarawak, Kuching, IV.1900 (♀); Sarawak, Kuching, 20.III.1900 (♀); Sarawak, Retuk, Ulu Sadong, 21.VI.1909 (♀); Sarawak, Baram, 13.X.1910 (♀); Sarawak, Kuching, VI.1899 (♂).

Diagnosis: Body above uniformly dark reddish-brown, ornamented with sulphureus pubescence blotches on elytra; body beneath densely clothed with sulphureus pubescence; legs uniformly reddish brown; antennal scape and first segment black, the following joints reddish-brown.

(♀) Length: 14 mm, width: 3.7 mm.

(♂) Length: 13.5 mm, width: 3.5 mm.

Description: Head with the front as long as wide, slightly broader than prothorax, vertex broad, feebly flattened, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with recumbent, sulphureus hairs on gena and along margin of frons, sparsely clothed with short, erect and recumbent, pale yellow brownish hairs on median part; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided, sides feebly, arcuately rounded; surface finely, sparsely irregularly punctuated, feebly punctuated at sides, the punctures concealed by pubescence at sides and beneath, densely clothed with sulphurous pubescence at sides and beneath, leaving dark brown late obtriangular portion on pronotum. Scutellum trapezoidal, feebly concave, entirely cevered with sulphureus pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with sutural and marginal spines; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer, sparser and obsolete toward apices, dark reddish- brown elytron densely covered with short, recumbent, dark brown hairs, and sparsely mixed with erect, long dark hairs, ornamented with three sulphureus pubescence blotches, one transversely at base, one large median patch common to both elytra, and one on submedial at middle of apical fourth

common to both elytra, each deflexed side also decorated with sulphureus pubescence dot at middle of basal fourth, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown, densely covered with sulphurous pubescence on prosternal and anterior half of metasternal episternum, apical half of first, and second to fourth abdominal sternites, leaving dark brown portions on posterior half of metasternal episternum, basal of first, and fifth abdominal sternites.

Distribution: Borneo, Sumatra, Java, Philippines, W. Malaysia, Moluccas.

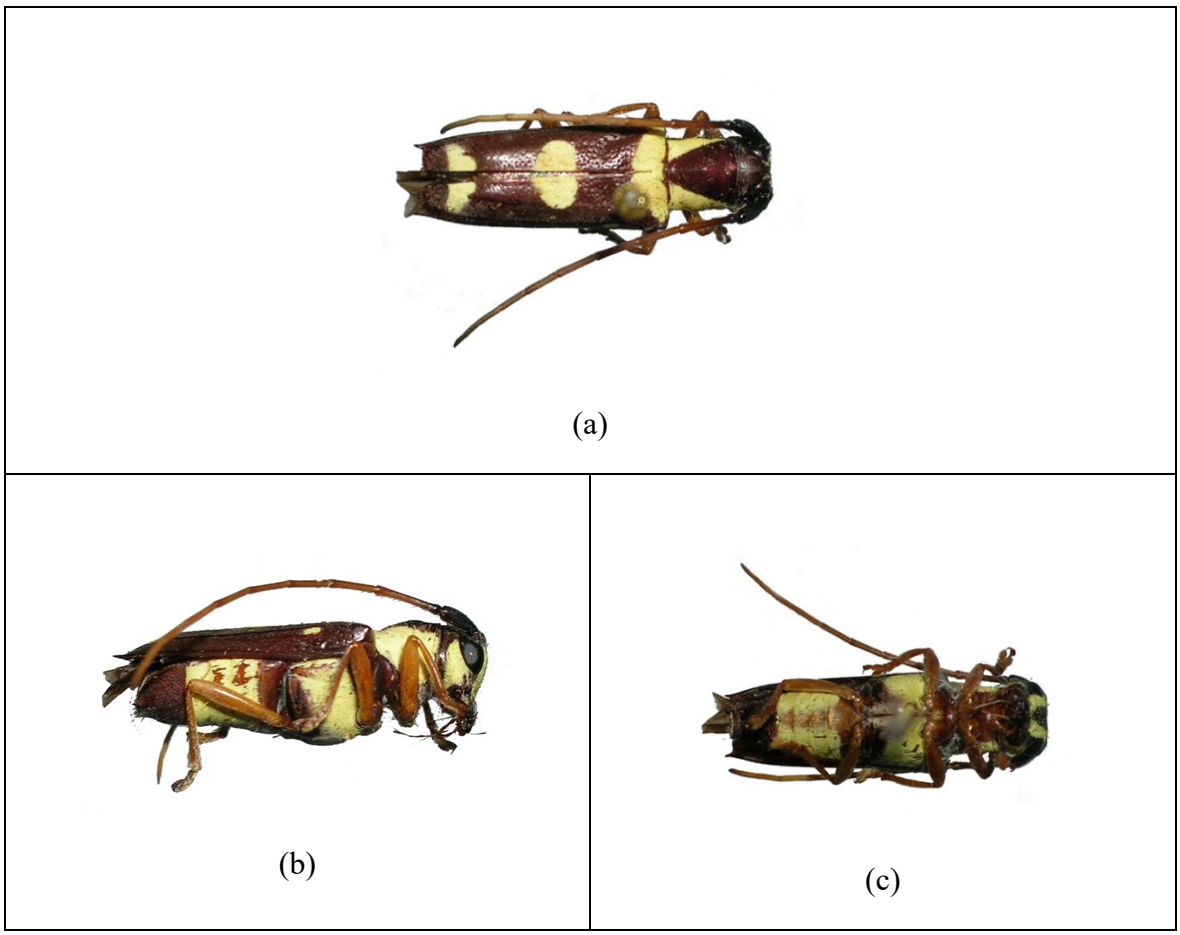


Figure 4.31: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea pulchella* Pascoe, 1858.

29. *Glenea pustulata pustulata* J. Thomson, 1865b:564 [*Glenea*]

adelia Pascoe, 1867a:367 [*Glenea*]

cleanthe J. Thomson, 1879:15 [*Glenea*]

Materials examined: 19 specimens (14 ♀, 5 ♂).

(FRC Coll.) – Sarawak, Semengoh, 8.XII.1981, Alexander and Haidir (♀); Sarawak, Bintulu, UPM Campus Sarawak, 20.I.1984, Zolkarnain (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 14.XII.1899 (♀); Sarawak, Kuching, 20.VI.1899 (♀); Sarawak, Kuching, 7.V.1900 (♀); Sarawak, Kuching, 20.VI.1900 (♀); Sarawak, Kuching, 23.IV.1900 (♀); Sarawak, Kuching, 6.X.1899 (♀); Sarawak, Kuching, 26.IV.1899 (♀); Sarawak, Penrissen, 19.V.1899 (♀); Sarawak, Kuching, Matang Road, 16.I.1911 (♀); Sarawak, Limbang, IV.1910 (♀); Sarawak, Mt. Sirambu, I.1912 (♀); No label (♀); No label (♀); Sarawak, Kuching, 1.IV.1903 (♂); Sarawak, Kuching, V.1900 (♂); Sarawak, Mt. Lingga, 18.V.1909 (♂); Sarawak, Mt. Murud, XII.1914 (♂).

Diagnosis: Above uniformly dark brown, ornamented with whitish pubescence; body beneath clothed with white pubescence; antennae dark; legs dark brown.

(♀) Length: 14-17 mm, width 4-6 mm.

(♂) Length: 13 mm, width 3 mm.

Description: Head nigritus, with front longer than wide, equal in width with prothorax, vertex slightly broad, occiput weakly convex at middle of base, frons with a fine longitudinal furrow extending from epistoma to occiput; surface finely sparsely punctured,

densely clothed with whitish pubescence along the sides, round the eyes; sparsely clothed with short, inconspicuous hairs on the median part, but ornamented with two narrow, longitudinal whiyish pubescence on the vertex and occiput; gena slightly shorter than inferior eyelobe; antennae slender, fairly longer than body.

Prothorax nigritus, distinctly longer than wide, slightly arcuately rounded anteriorly at the sides, constricted before base and at apex; surface densely, coarsely, irregularly punctured, punctures feebly at sides, ornamented with three broad, longitudinal, whitish pubescence vittae, one median and one on each side, at sides broader but slightly shorter than median. Scutellum tranverse late obovatus, rounded at apex, densely clothed with whitish pubescence.

Elytra broader than prothorax at base, nearly two time as long as basal width, strongly carinate at deflexed at side, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuate basally, the punctures become finer, sparser and obsolete toward apices, each dark brownish elytron ornamented with five large, whitish pubescence spots as follow: one at he middle of elytron at basal forth, one at he middle of elytron at basal third, one at sublateral of elytron just behind the middle, one ellipticus spot at the submedial of elytron at apical third, and one near apex; each elytron also decorated with two small whitish pubescence dots as follow: one near lateral carina at base, and one near lateral carina at basal third, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark brown, densely clothed with white pubescence, predominating outer margin of sternum and inner part of sternal episternum; the external mucro at the apex of moderately length.

Distribution: Borneo, Sumatra, Java.

Close to *Glenea myrsine*.

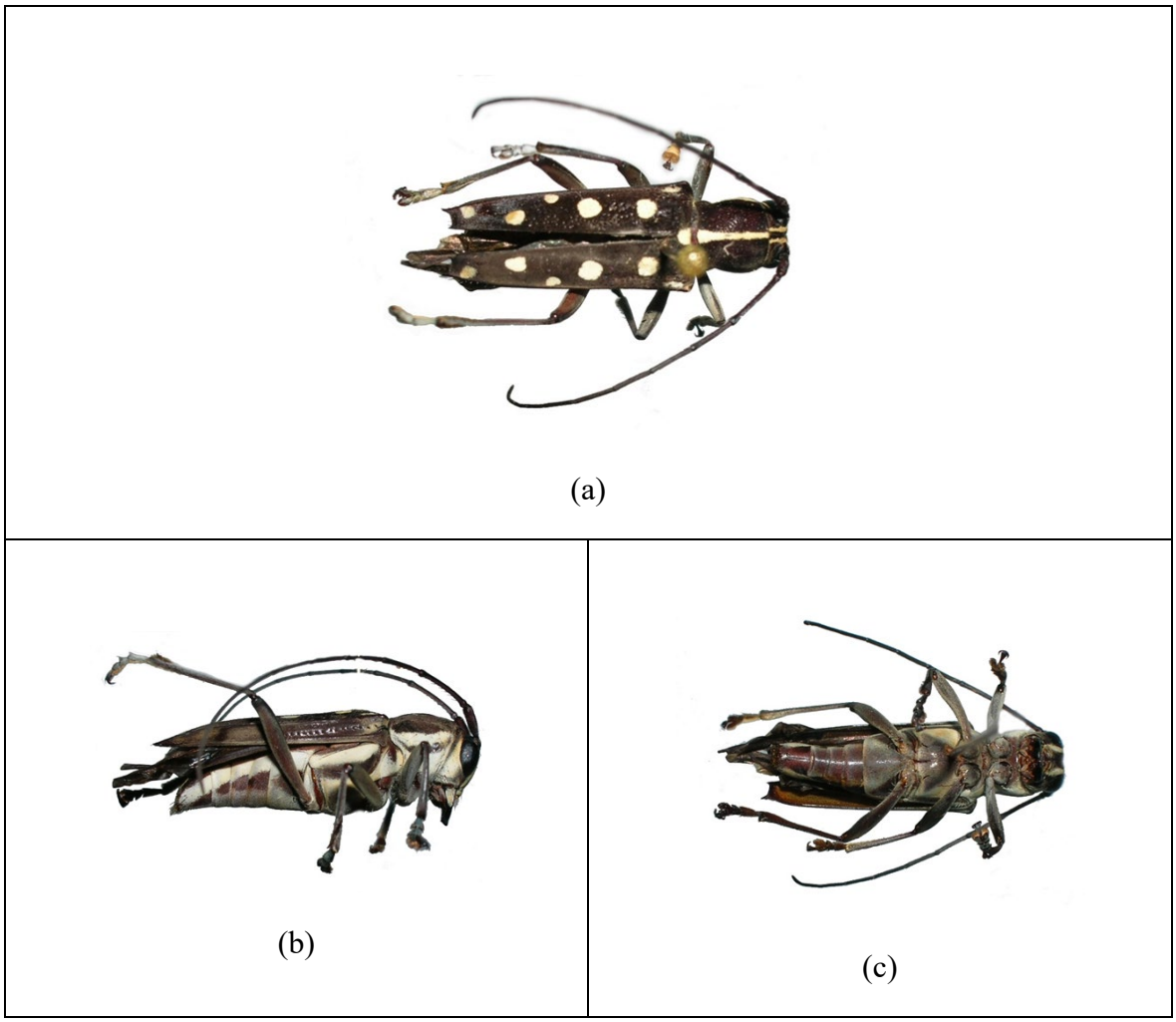


Figure 4.32: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea pustulata pustulata* J. Thomson, 1865.

30. *Glenea rufifrons* Aurivillius, 1920:396 [*Glenea*]

Materials examined: 2 specimens (1 ♀, 1 ♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 4th Mile Rock Road, 12.IV.1904 (♂); Sarawak, Kuching, 12.IV.1904 (♀).

Diagnosis: Body above uniformly black except orange in colour on head and notum; body beneath covered with yellowish pubescence; basal half of femora orange-coloured, the rest black, sparsely clothed with moderately long and erect pale yellow hairs, mixed with short white pubescence; antennae uniformly black.

(♀) Length: 15 mm, width: 4.5 mm.

(♂) Length: 13 mm, width: 3.5 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, vertex broadly concave, occiput convex at middle of base, frons rectangular, slightly oblong, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, the punctures concealed by the pubescence, densely covered with orange-coloured pubescence on frons, around the eyes, vertex and extending along median of occiput, forming a slightly broad longitudinal vitta, occiput covered with short and recumbent dark metallic hairs, gena sparsely clothed with orange and pale yellow pubescence; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

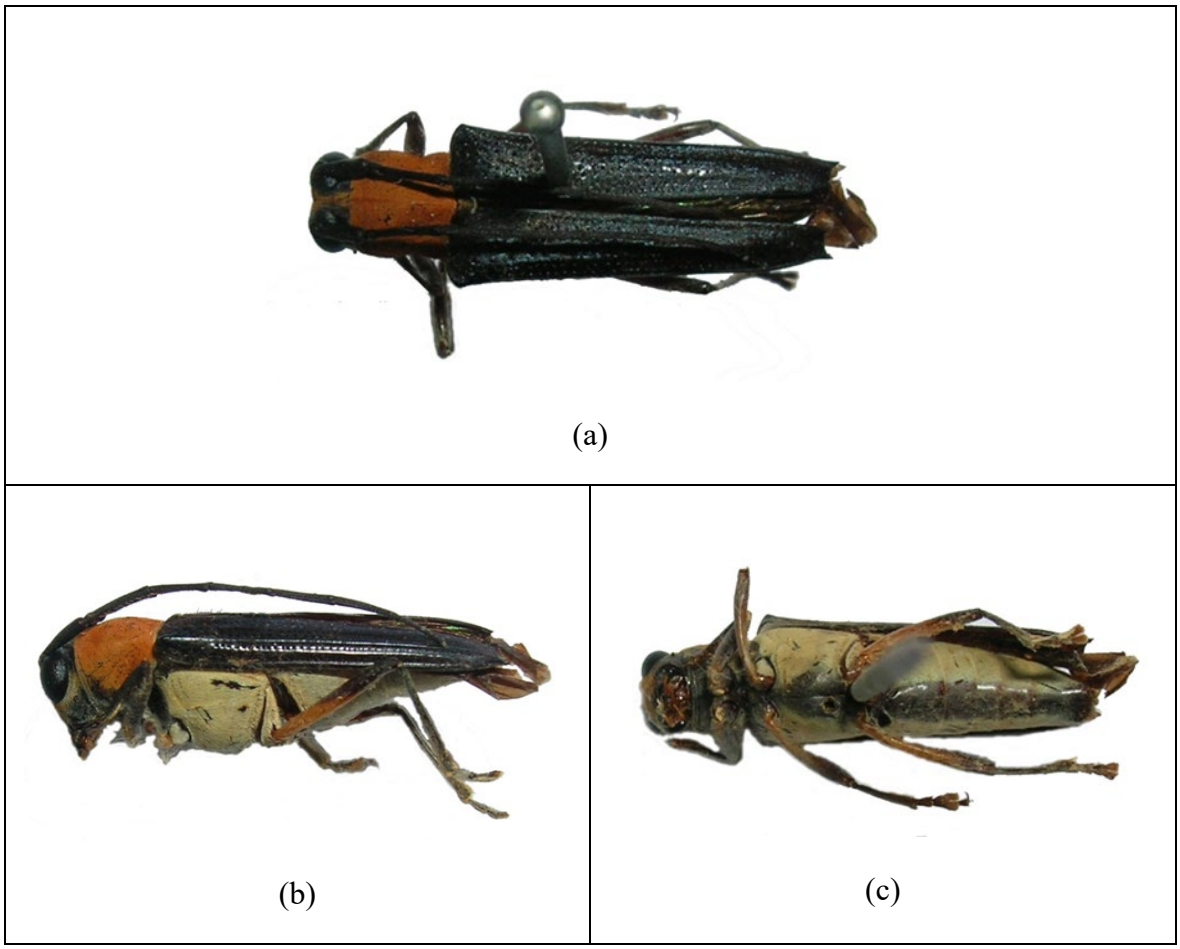
Prothorax slightly longer than wide, almost parallel-sided at apical half and weakly narrowed at apex, sides feebly, arcuately rounded anteriorly, strongly constricted behind

middle; surface finely, sparsely punctuated, feebly punctuated at the sides, the punctures concealed by the pubescence, pronotum densely clothed with short and orange-coloured pubescence. Scutellum transverse late obovatus, rounded at the apex, nearly flat in male, but feebly concave in female, densely covered with dark pubescence in male, but sparsely covered with orange-coloured pubescence along median and sparsely with pale yellow at the apex in female.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, tapering posteriorly, apex of each elytron arcuately emaginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent velvety black pubescence; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely clothed with pale yellow pubescence, sparser at the centre of metasternum and centres of abdominal sternites; the external mucro at the apex of moderately length in male.

Distribution: Borneo.



(a)

(b)

(c)

Figure 4.33: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea rufifrons* Aurivillus, 1920.

31. *Glenea saperdoides saperdoides* J. Thomson, 1860:50 [*Glenea*]

humerovittata Breuning, 1950t:383 [*Glenea*] {Note 1}

Materials examined: 11 specimens (11 ♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, 4th Mile Rock Road, 7.IV.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 20.IV.1909 (♀); Sarawak, Kuching, 4th Mile Rock Road, 20.IV.1909 (♀); Sarawak, Kuching, 21.VI.1899 (♀); Sarawak, Kuching, 16.IX.1899 (♀); Sarawak, Kuching, 28.XII.1899 (♀); Sarawak, Kuching, 25.IX.1899 (♀); Sarawak, Kuching, Matang Road, 13.I.1910 (♀); Sarawak, Mt. Murud, XII.1914 (♀); Sarawak, Mt. Murud, XII.1914 (♀); Sarawak, Mt. Murud, XII.1914 (♀).

Diagnosis: Body above uniformly dark brown, ornamented with longitudinal tawny yellow pubescence vittae on head, pronotum and elytra; body beneath densely clothed with pale yellow pubescence; femora uniformly reddish-brown, tibiae and tarsal dark reddish-brown, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae uniformly dark.

(♀) Length: 12-14 mm, width: 3.5-4 mm.

Description: Head with the front as long as wide, equal in width with prothorax, vertex broad and feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with pale and tawny yellow pubescence on gena, around the eyes and margin of frons, median part of frons sparsely clothed with short and inconspicuous pale yellow hairs, occiput densely clothed with short dark brown pubescence, and ornamented with four narrow longitudinal tawny yellow pubescence vittae, two along

median divided by a fine longitudinal furrow at the middle, and a pair along dorso-lateral; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, feebly constricted behind middle; surface finely densely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short dark brown pubescence, and ornamented with three narrow longitudinal tawny yellow pubescence vittae, one along median, and a pair along dorso-lateral. Scutellum transverse late obovatus, rounded at the apex, broad, feebly concave, and densely covered with tawny yellow pubescence, except at the basal sides, where the pubescence is dark.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short dark brown pubescence, and ornamented with tawny yellow pubescence as follows: three narrow longitudinal vittae, one sutural margin extending from base to apices, one along median of basal fourth, and one along sublateral extending from base to apical fourth; and a spot at the middle of disc; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark reddish-brown, densely clothed with pale yellow or whitish pubescence on metepisternal and sides of abdominal sternites, leaving dark reddish-brown portions on metasternum and centres of abdominal segments.

Distribution: Borneo, W. Malaysia.

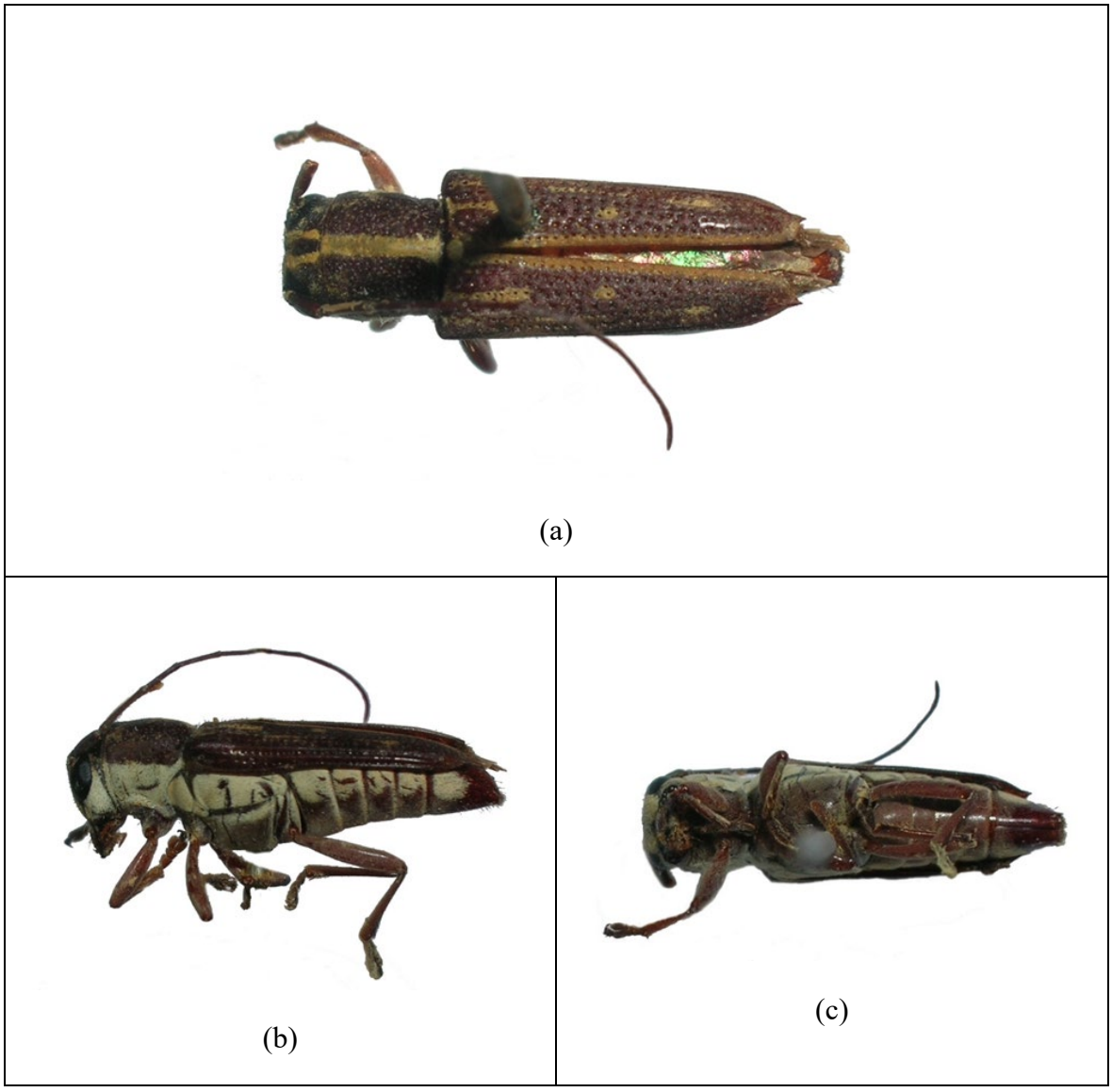


Figure 4.34: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea saperdoides saperdoides* J. Thomson, 1860.

32. *Glenea sejuncta* Pascoe, 1867a:387 [*Glenea*]

Materials examined: 4 specimens (4 ♂).

(FRC Coll.) – Sarawak, Kapit, Ulu Putai, 12-14.V.2001, SFD Ento. Team (♂); Sarawak, Semengoh, 1.XII.1980, Mercer et al. (♂); Sarawak, Samunsam Wildlife Sanctuary, 18.IX.1982, Lippa Akeng (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 26.6.1899 (♂).

Diagnosis: Above uniformly dark reddish-brown, decorated with longitudinal yellow pubescence vittae and transverse band; body beneath dark reddish-brown densely clothed with pale yellow pubescence; legs uniformly reddish brown; antennae uniformly dark brown.

(♂) Length: 12 – 13.5 mm, width: 3.7 – 4.5 mm.

Description: Head with the front longer than wide, equal in width with prothorax, vertex broad, feebly concave, occiput weakly convex at middle of base, frons slightly rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, densely punctuated, densely clothed with recumbent, pale yellow hairs on gena, and yellowish pubescence around eyes and margin of frons, sparsely clothed with short, inconspicuous brown hairs on median part, ornamented with narrow, longitudinal yellow pubescence vittae, two dorso-laterally, and two on median; gena fairly shorter than inferior eyelobe; eyes and mandible black, maxillary and labial palpal reddish brown; antennae slender, fairly longer than the body.

Prothorax longer than wide, sides feebly, arcuately rounded anteriorly, constricted at base and apex, strongly constricted behind middle; surface finely, densely punctuated,

scarcely punctuate at sides, the punctures nearly concealed by the pubescence at sides, densely clothed with short, erect, dark brown hairs, and ornamented with five, longitudinal yellow pubescence vittae, one of which narrow on median, dorso-lateral pair broad, and lateral pair shorter and inconspicuous. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, densely covered with yellow recumbent hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short, spine at the sutural margin and a longer at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically; each elytron densely covered with short, erect, dark brown hairs, ornamented with three, narrow, longitudinal, yellow pubescence vittae, one along sublateral close to lateral carina extending from base to near apex, one which extending from base medially, slightly bend toward suture at basal fourth, and one along sutural margin extending from base to apex; each elytron also decorated with a narrow transverse yellow pubescence band at middle, not touching sublateral vitta, and not touching sutural margin, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with pale yellow pubescence, leaving dark brown portions on metasternum, ventro-lateral and centres of abdominal sternites.

Distribution: Borneo.

Known habitats / behaviour: Caught during flight at engkabang plantations.

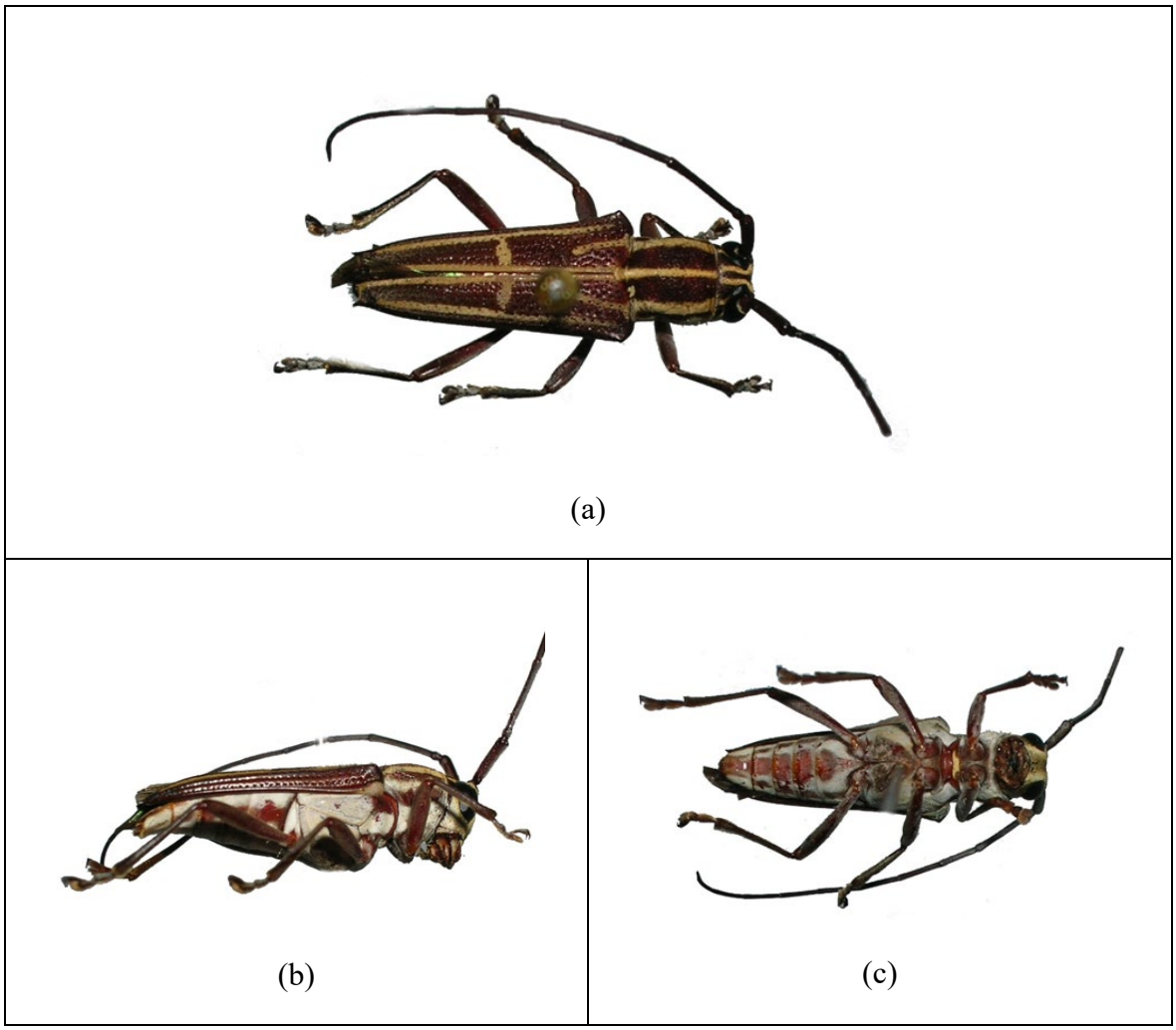


Figure 4.35: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea sejuncta* Pascoe, 1867.

33. *Glenea subsimilis thetis* Thomson

Materials examined: 1 specimen (♀).

(Sarawak Museum Coll.)– Sarawak, Limbang, VI.1911 (♀).

Diagnosis: Body above uniformly dark with slightly metallic blue, ornamented with five white pubescence spots on each elytron and a white longitudinal pubescence vitta on pronotum; body beneath dark bluish, densely covered with white pubescence; legs uniformly dark bluish; antennae entirely dark.

(♀) Length: 25 mm, width: 8 mm.

Description: Head with the front as long as wide, slightly smaller than prothorax, vertex broad and feebly flattened, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with white pubescence on gena and margin of frons, median part of frons sparsely clothed with short and recumbent white hairs, occiput densely clothed with short and recumbent black hairs, inconspicuous on median part of frons; the eyes and mandible black, first to third of maxillary palpal and first to second labial palpal segments dark brown, the following segments dark; gena fairly shorter than the inferior eyelobe; antennae slender, shorter than the body, extending just behind the middle of elytra.

Prothorax slightly longer than wide, almost parallel-sided at the middle, feebly constricted at base and apex, sides feebly, arcuately rounded anteriorly; surface finely densely punctuated, feebly punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short black pubescence, and ornamented with a slightly narrow longitudinal white pubescence vitta along median. Scutellum transverse late

obovatus, rounded at the apex, broad and feebly concave, densely covered with white pubescence, except at the sides, where the pubescence is black.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short black pubescence, and ornamented with white pubescence as follows: five spots, one which oblong at middle of basal fourth, one between basal fourth and third at middle, one at middle of elytron, one at sublateral just behind middle of apical third, and one obliquely transverse at middle of apical fourth crossing from near sutural margin to epipleuron of deflexed sided; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark bluish, densely clothed with white pubescence on metepisternal, apical sides of first to fourth abdominal sternites, leaving dark bluish portions on metasternum, interior part of metepisternal, basal centres of first to fourth, centres, and fifth abdominal segments.

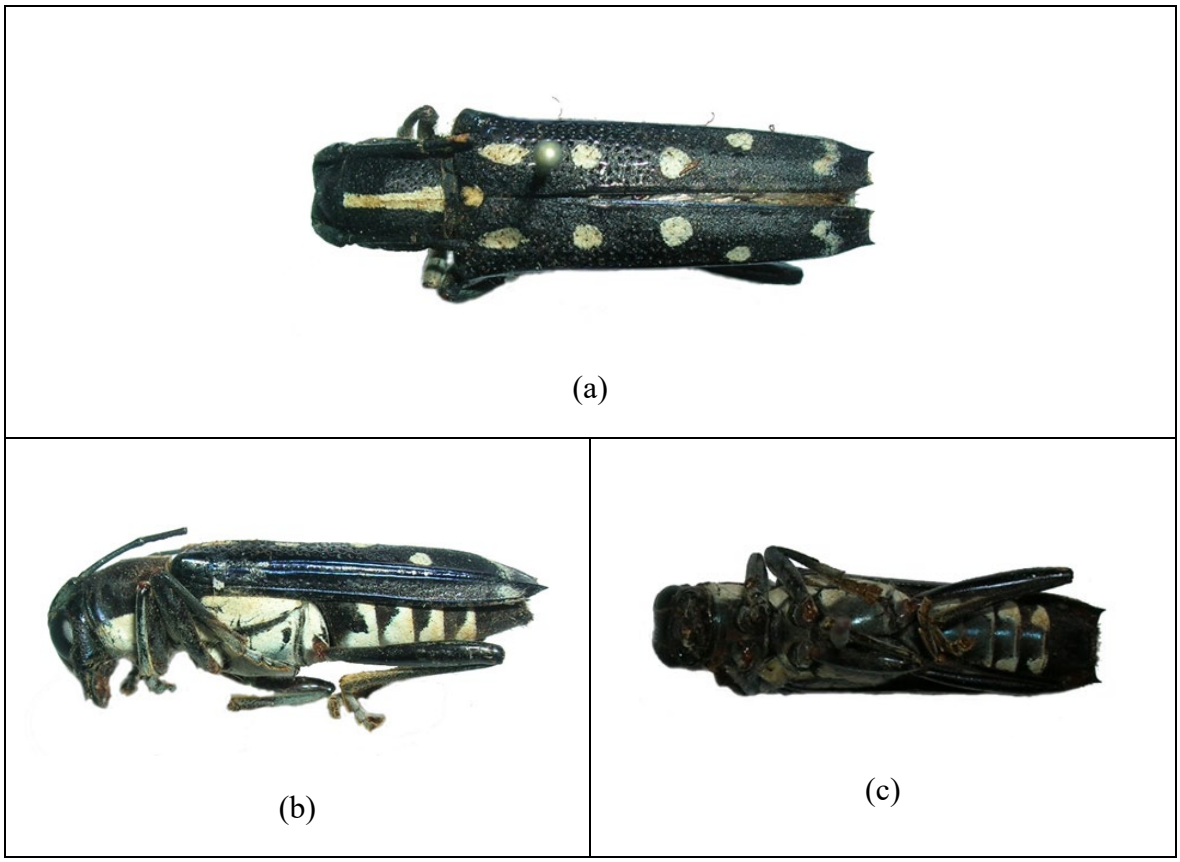


Figure 4.36: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea subsimilis thetis* Thomson.

34. *Glenea trivittata* Aurivillius, 1911:222 [*Glenea*]

Materials examined: 4 specimens (2 ♀, 2 ♂).

(Sarawak Museum Coll.) – Sarawak, Mt. Sirambu, I.1912 (♂); Sabah, Mt. Kinabalu (alt. 3000 ft.), 19.IX.1913 (♂); Sarawak, Kuching, Matang Road, 12.VIII.1911 (♀); Sarawak, Kuching, Matang Road, 12.VIII.1911 (♀).

Diagnosis: Body above uniformly dark bluish metallic, densely covered with short black pubescence, and ornamented with white pubescence spots, dots, stripes and transverse bands; body beneath dark bluish metallic, covered with white pubescence; front and middle legs, femora and tibiae of hind legs dark bluish metallic, meanwhile tarsal of hind legs reddish-brown, sparsely clothed with short and recumbent white hairs, mixed with moderately long erect white hairs; antennae uniformly dark bluish metallic.

(♀) Length: 20 mm, width: 4.5 mm.

(♂) Length: 20 mm, width: 4.5 mm.

Description: Head with front longer than wide, frons triangularis, slightly smaller than prothorax, vertex feebly concave, occiput convex at middle of base, frons with a narrow, smooth, longitudinal carina extending from epistoma to vertex, and a fine, longitudinal furrow extending from vertex to occiput; surface finely, sparsely punctuated, densely clothed with white pubescence on gena which under eyelobes, and along the margin of frons, decorated with two narrow, longitudinal white pubescence vittae along median, and two broader longitudinal white pubescence vittae dorso-laterally, sparsely clothed with short and inconspicuous dark hairs on median part; the eyes and mandible black, maxillary and labial

palpal dark reddish-brown; gena fairly shorter than the inferior eyelobes; antennae slender, about as long as the body.

Prothorax slightly longer than wide, margin wider at base, narrowed anteriorly, sides scarcely, arcuately rounded anteriorly; surface sparsely, coarsely, irregularly punctuated, vaguely punctuated at sides, the punctures nearly concealed by the pubescence, densely clothed with short velvety black pubescence, ornamented with five longitudinal white pubescence vittae, one which narrow along median, a pair which broad dorso-laterally, and a pair which narrow and inconspicuous along lateral. Scutellum triangular, slightly rounded at apex, nearly flat, but concave anteriorly, densely covered with dark pubescence, except at the apex half posteriorly, where the pubescence is white.

Elytra broader than prothorax, slightly narrowed basally, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically; each dark bluish metallic elytron densely clothed with short velvety black pubescence, and ornamented with two white pubescence vittae as follows: two short and narrow longitudinal vittae, one along median of basal fourth, and one which longer along sublateral of basal fourth; five spots, one which obliquely transverse at middle of disc, one between basal fourth and third at median, one at sublateral of basal third just behind basal fourth, one at sublateral of apical third, and one which oblong and tapering anteriorly at submedial of apical third; a dot between apical fourth and third at

submedial; and a transverse band near apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with white pubescence, leaving dark bluish metallic portions on interior part of metepisternal, metasternum, basal sides and centres of abdominal sternites; the external mucro at the apex of moderately length in male.

Distribution: Borneo.

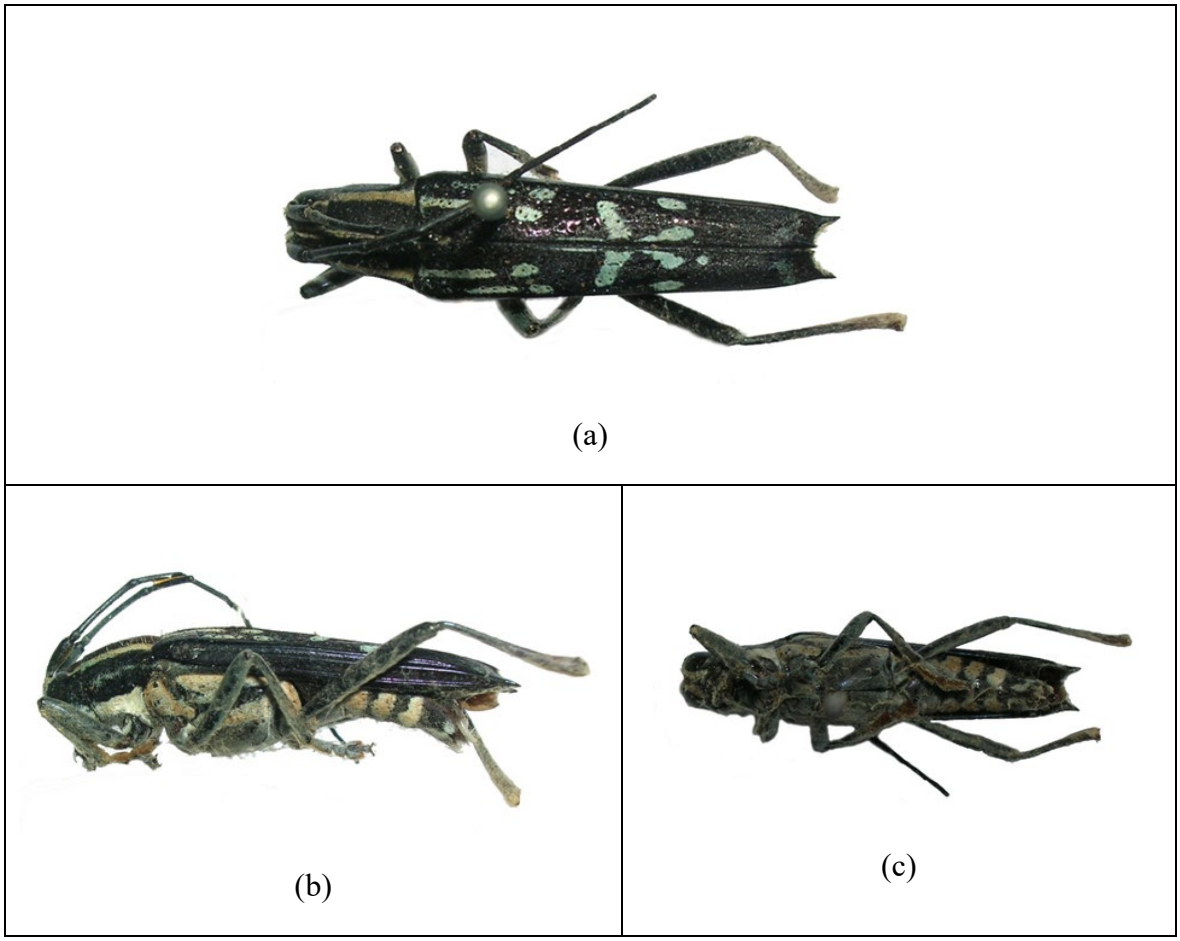


Figure 4.37: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea trivittata* Aurivillius, 1911.

35. *Glenea* (*AcutoGlenea*) Breuning

numerifera J. Thomson, 1865b:561 [*Glenea*]

Materials examined: 2 specimens (1♀,1♂).

(FRC Coll.) – Sarawak, Niah, 24.II.1979, A.A. Hamid (♂); Sarawak, Niah, 24.II.1979, A.A. Hamid (♀).

Diagnosis: Body above uniformly dark reddish-brown, decorated with testaceous pubescence vittae and spots; body beneath densely covered with pale yellow pubescence; femora testaceous, tibiae and tarsal dark reddish-brown, sparsely covered with pale yellow and white, moderately long, erect and recumbent hairs; antennae uniformly dark brown.

(♀) Length: 12.4 mm, width: 3.7 mm.

(♂) Length: 11.3 mm, width: 3.4 mm.

Description: Head with the front longer than wide, slightly equal in wide with prothorax, vertex slightly narrow, feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with pale yellow pubescence on gena and margin of frons, sparsely clothed with short, inconspicuous brown hairs on median of frons, occiput decorated with two, broad, longitudinal testaceous pubescence divided by longitudinal furrow on median; the eyes and mandible black, maxillary and labial palpal ochraceus; gena fairly shorter than inferior eyelobe; antennae slender, fairly longer than body.

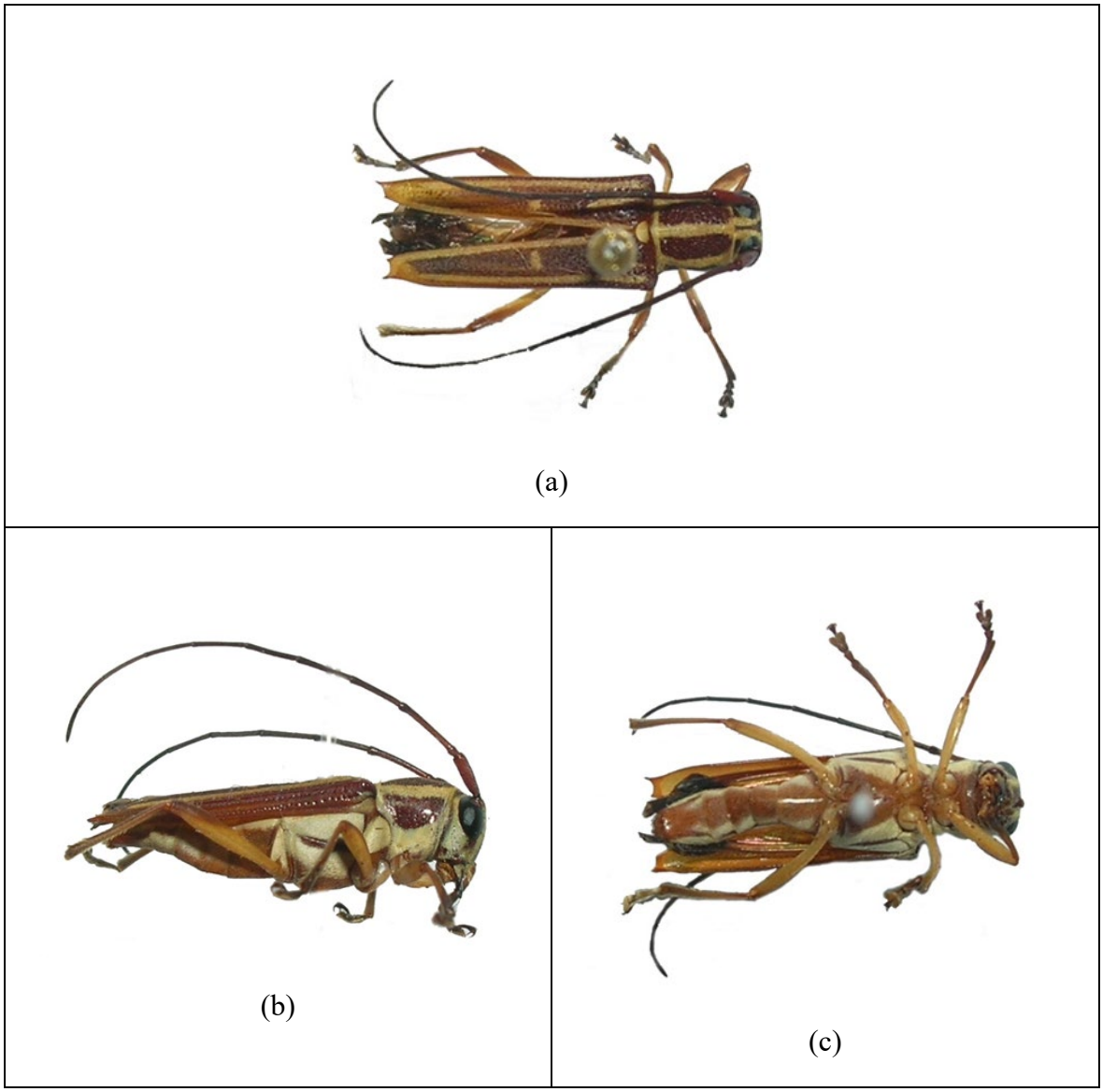
Prothorax slightly longer than wide, almost parallel-sided at apical half and slightly narrow from behind to middle, feebly constricted behind middle, sides arcuately rounded anteriorly; surface densely, coarsely, irregularly punctuated, feebly punctuated at sides, the punctures nearly concealed by the pubescence, pronotum densely covered with short, erect dark brown hairs, decorated three broad, longitudinal testaceous pubescence, one along median, and a pair along dorso-lateral, related to each other with narrow transverse bands at apex and base. Scutellum transverse late obovatus, rounded at apex, slightly broad, feebly concave, densely clothed with testaceous pubescence, forming a small spot.

Elytra broader than prothorax at base, nearly one and half time as long as basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures and sparsely covered with pale yellow pubescence spot at base, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with short, erect and recumbent dark brown hairs, ornamented with three, longitudinal, testaceous pubescence vittae as follows: one along sutural margin, one along lateral margin, connected at apex of elytron, and one along median of basal fourth, slightly bend toward submedial; and also decorated with a testaceous pubescence spot, slightly transverse at middle of elytron, the pubescence nearly hiding the punctures in good specimens.

Body beneath brown, densely clothed with pale yellow pubescence, leaving brown portions on interior of metepisterna, posterior half of metasternum, interior basal sides and

centres of abdominal segments; the pubescence nearly hiding the punctures in fresh specimens; the external mucro at the apex of moderately length in male.

Distribution: Borneo {Note 5}, Sumatra, W. Malaysia.



(a)

(b)

(c)

Figure 4.38: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*AcutoGlenea*) *numerifera* J. Thomson, 1865.

36. *Glenea* (*CitrinoGlenea*) Breuning

citrina J. Thomson, 1865b:566 [*Glenea*]

Materials examined: 1 specimen (♀).

(Sarawak Museum Coll.) - Sarawak, Kuching, Matang Road, XII.1911 (♀).

Diagnosis: Body above uniformly yellow, covered with short yellow pubescence, decorated with short black pubescence spots on each elytra and prothorax; body beneath densely covered with yellow pubescence; legs uniformly reddish-brown, tibiae darker, sparsely clothed with short and recumbent, and moderately long and erect pale yellow hairs intermixed, denser toward apices; antennae entirely dark.

(♀) Length: 12 mm, width: 4.5 mm.

Description: Head with the front as long as wide, slightly equal in width with prothorax, vertex broad and flat, occiput convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with yellow pubescence on gena, around the eyes and along margin of frons, sparsely clothed with short, inconspicuous yellow and dark hairs on median of frons, but occiput densely clothed with short black pubescence; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, shorter than the body, extending just behind the middle of elytra.

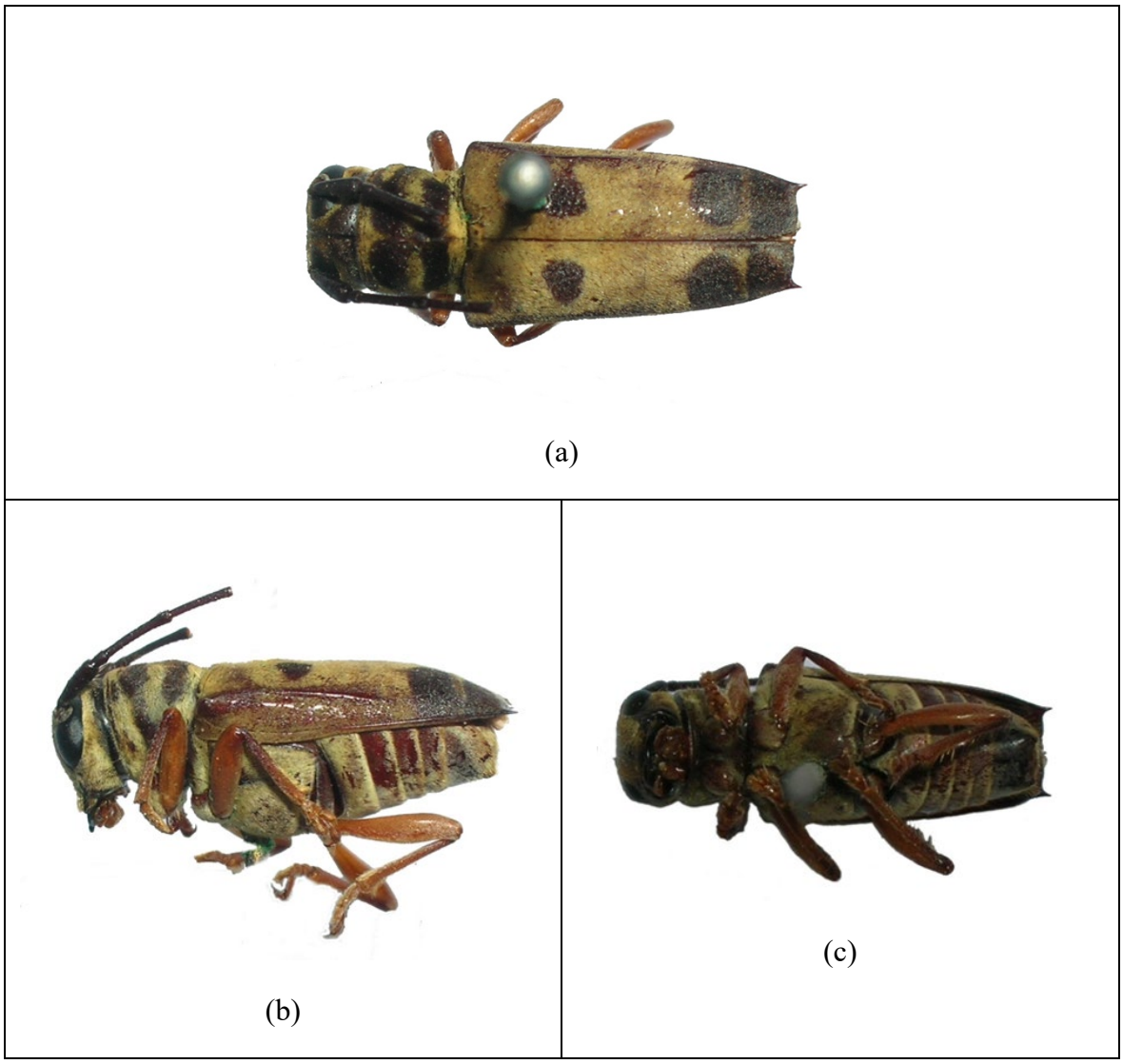
Prothorax as long as wide, almost parallel-sided at middle and constricted at base and apex, strongly constricted behind middle, sides feebly, arcuately rounded anteriorly; surface finely sparsely punctuated, feebly punctuated at the sides, the punctures nearly concealed by

the pubescence, pronotum densely clothed with short yellow pubescence, and ornamented with two rather broad transverse short black pubescence bands near base and apex around pronotum, but scarcely divided along the median with narrow longitudinal yellow pubescence vittae. Scutellum trapezoidal, broad, nearly flat and densely covered with yellow pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, lateral carinae incomplete and moderately deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely irregularly punctuated basally, the punctures becoming finer, sparser and obsolete toward apices, each elytron densely clothed with short yellow pubescence, and ornamented with black pubescence as follows: a spot between basal fourth and third at middle; two blotches, one half anteriorly of apical fourth but not touching the sutural margin, and one cevered entirely half posteriorly of apical fourth, common to both elytra; the pubescence hiding the punctures in good specimens.

Body beneath dark reddish-brown with, densely clothed with yellow pubescence on metasternum, metepisternal, sides of first and fifth, and apical of second to fourth abdominal sternites, leaving the others area dark reddish-brown.

Distribution: Borneo {Note 5}, Sumatra, Java, W. Malaysia.



(a)

(b)

(c)

Figure 4.39: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*CitrinoGlenea*) *citrina* J. Thomson, 1865.

37. *Glenea* (*MacroGlenea*) Aurivillius {key to species: Hudepohl, 1996:16}

elegans (Olivier, 1795:15) [*Saperda*]

chalybaea (Illiger, 1800:138) [*Saperda*]

pictus (Fabricius, 1801:306) [*Stenocorus*]

delia J. Thomson, 1860:48 [*Glenea*]

clytia J. Thomson, 1879:3 [*Glenea*]

Materials examined: 2 specimens (2 ♀).

(FRST Museum Coll.) – Sarawak, Bario, Kelabit Highland, 14.IV.1995, Fatimah Abang (♀).

(Sarawak Museum Coll.) – Sarawak, Kuching, Matang Road, IV.1902 (♀).

Diagnosis: Above uniformly dark bluish metallic, densely covered with short, erect, velvety black pubescence and ornamented with white pubescence spots and stripes; body beneath dark bluish metallic, covered with white pubescence,; front and middle legs, femora and tibiae of hind legs dark bluish metallic, meanwhile tarsal of hind legs reddish brown; antennae uniformly dark bluish metallic, scape and first segment sparsely clothed short, recumbent whit hairs.

(♀) Length: 24 mm, width: 5.5 mm.

Description: Head with front longer than wide, frons triangularis, slightly smaller than prothorax, vertex feebly concave, occiput convex at middle of base, frons with a narrow, smooth, longitudinal carina extending from epistoma to vertex, and a fine, longitudinal

furrow extending from vertex to occiput; surface finely, sparsely punctuated, densely clothed with white pubescence on gena which under eyelobes, and along the margin of frons, decorated with two narrow, longitudinal white pubescence vittae dorso-laterally, sparsely clothed with short, inconspicuous dark hairs on median part; eyelobes and mandible black, maxillary and labial palpal dark reddish-brown.

Prothorax slightly longer than wide, margin wider at base, narrowed anteriorly, sides scarcely, arcuately rounded anteriorly; surface sparsely, coarsely, irregularly punctuated, vaguely punctuated at sides, the punctures nearly concealed by the pubescence, densely clothed with short, erect, velvety black hairs, ornamented with three, slightly narrow, longitudinal white pubescence vittae, one on median, and two dorso-laterally. Scutellum triangular, slightly rounded at apex, nearly flat, but concave anteriorly, dark bluish metallic scutellum densely covered with white pubescence, formed a white spot.

Elytra broader than prothorax, slightly narrowed basally, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically; each dark bluish metallic elytron densely clothed with short, erect, velvety black hairs, ornamented with two, short, narrow longitudinal white pubescence vittae, one along median of basal fourth, and one which longer along sublateral of basal fourth, one obliquely transverse white pubescence spot at middle of disc, and also decorated with five white pubescence spots as follows: one between basal fourth and third medially, one at sublateral of basal third just in front of middle, one which

oblong along sublateral of apical third, one at middle of submedial of apical third, and one nearly transverse near apex at apical fourth, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with white pubescence, leaving dark bluish metallic portions on interior half of metepisterna, basal sides of first, and basal sides and centres of second to fifth abdominal sternites.

Distribution: Borneo, Sumatra, Java, W. Malaysia.

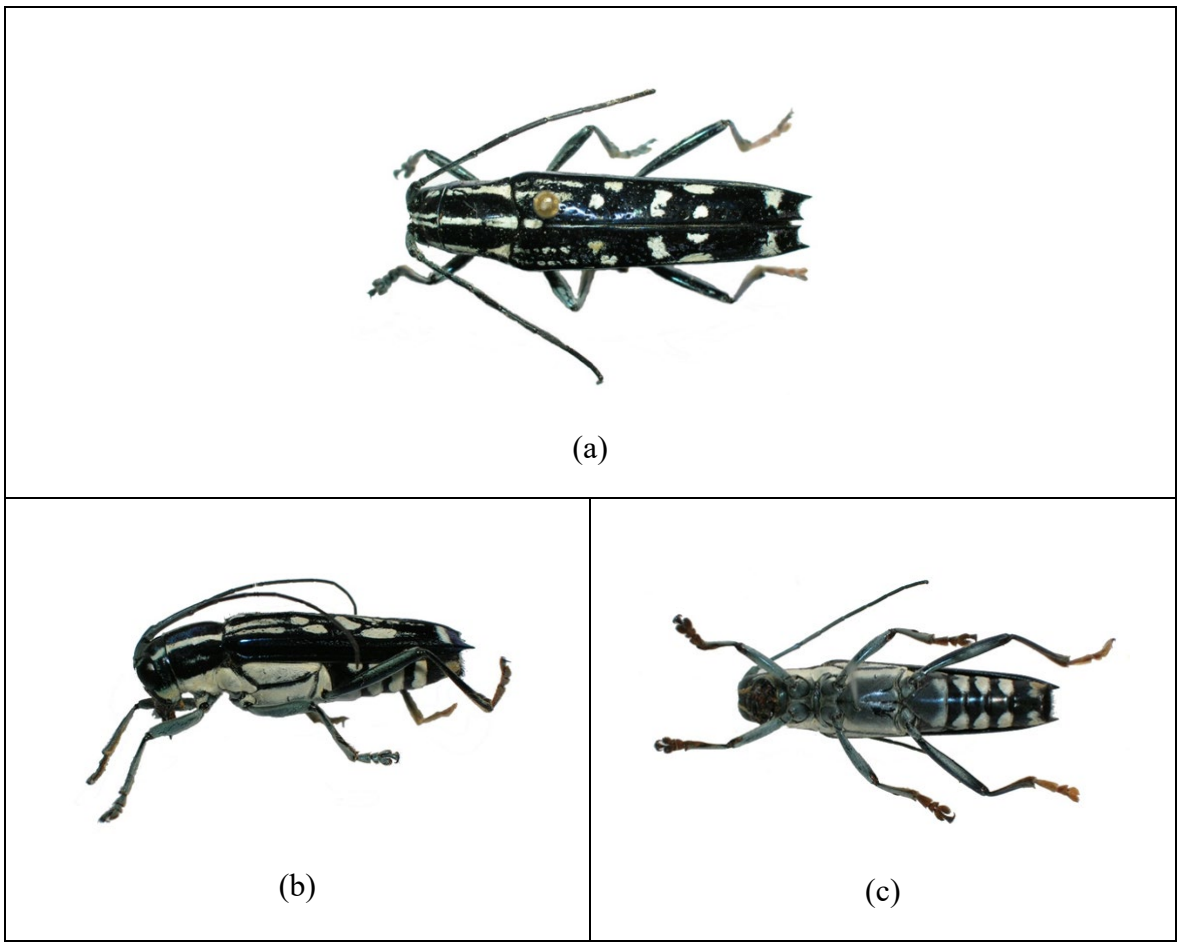


Figure 4.40: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*MacroGlenea*) *elegans* Olivier, 1795.

38. *Glenea* (*MacroGlenea*) Aurivillius {key to species: Hudepohl, 1996:16}

juno J. Thomson, 1865b:560 [*Glenea*]

Materials examined: 11 specimens (5 ♀, 6 ♂).

(FRC Coll.) – Sarawak, Bintulu, Pandan, 14.V.1981, Mercer et al. (♀); Sarawak, Matang, Mt. Serapi (alt. 3000 ft.), 10.V.1989, Joheng and Wong (♂); Sarawak, Kapit, 30.III.1989, SFD. Ento Team (♂).

(Sarawak Museum Coll.) – Sarawak, Kuching, 28.V.1900 (♀); Sarawak, Limbang, IV.1895 (♀); Sarawak, Saribas, V.1926 (♀); No label (♀); Sarawak, Kuching, Matang Road, 22.III.1911 (♂); Sarawak, Saribas, XI.1900 (♂); Sarawak, Kuching, 5.V.1900 (♂); Sarawak, Kuching, 1.IV.1898 (♂).

Diagnosis: Above uniformly dark bluish, ornamented with white pubescence spots and vittae; body beneath dark bluish, covered with white pubescence; legs dark bluish, clothed with short, recumbent white hairs mixed with long, erect white and brown hairs posteriorly; eyes and mandible black, maxillary and labial palpal dark brown; antennae uniformly dark bluish.

(♀) Length: 29 mm, width: 7.7 mm.

(♂) Length: 23 mm, width: 6.3 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, feebly, broadly concave between the antennal tubercles, occiput weakly convex at middle of base; surface sparsely, coarsely, irregularly punctuated, densely clothed with white recumbent hairs at gena which under eyelobes and along margin of frons, sparsely clothed

with short, inconspicuous dark hairs on median part, ornamented with two white pubescence spots dorso-ventrally.

Prothorax distinctly longer than wide, margin wider at base, sides vaguely, arcuately rounded anteriorly, feebly constricted before base; surface densely, coarsely, irregularly punctuated, scarcely punctuated at sides, densely clothed with short, erect velvety dark bluish hairs dorsally, ornamented with five, longitudinal, white pubescence vittae as follows: one which narrow on median but absent at middle, two which broader on lateral, and two which broadest on dorso-lateral. Scutellum triangular, slightly rounded at apex, nearly flat, but concave anteriorly, dark bluish scutellum covered with white pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with sutural and marginal spines; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically, dark bluish elytra densely covered with short, erect dark hairs, and ornamented with three, longitudinal white pubescence vittae on each elytron, one along sutural margin extending from basal third to apical third, one along the middle of basal fourth, and one along sublateral of basal fourth, which longer than those along the middle of basal fourth; each elytron also decorated with three white pubescence spots, one on the middle of disc, one on sublateral of apical third, and one slightly obliquely transverse near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath largely covered with white pubescence, leaving dark bluish portions on posteriorly half of metasternum, basal side of first to fourth, and basal centre of fifth abdominal sternites.

Distribution: Borneo, W. Malaysia.

Behaviour: Attracted to light, caught in flight along railway line.

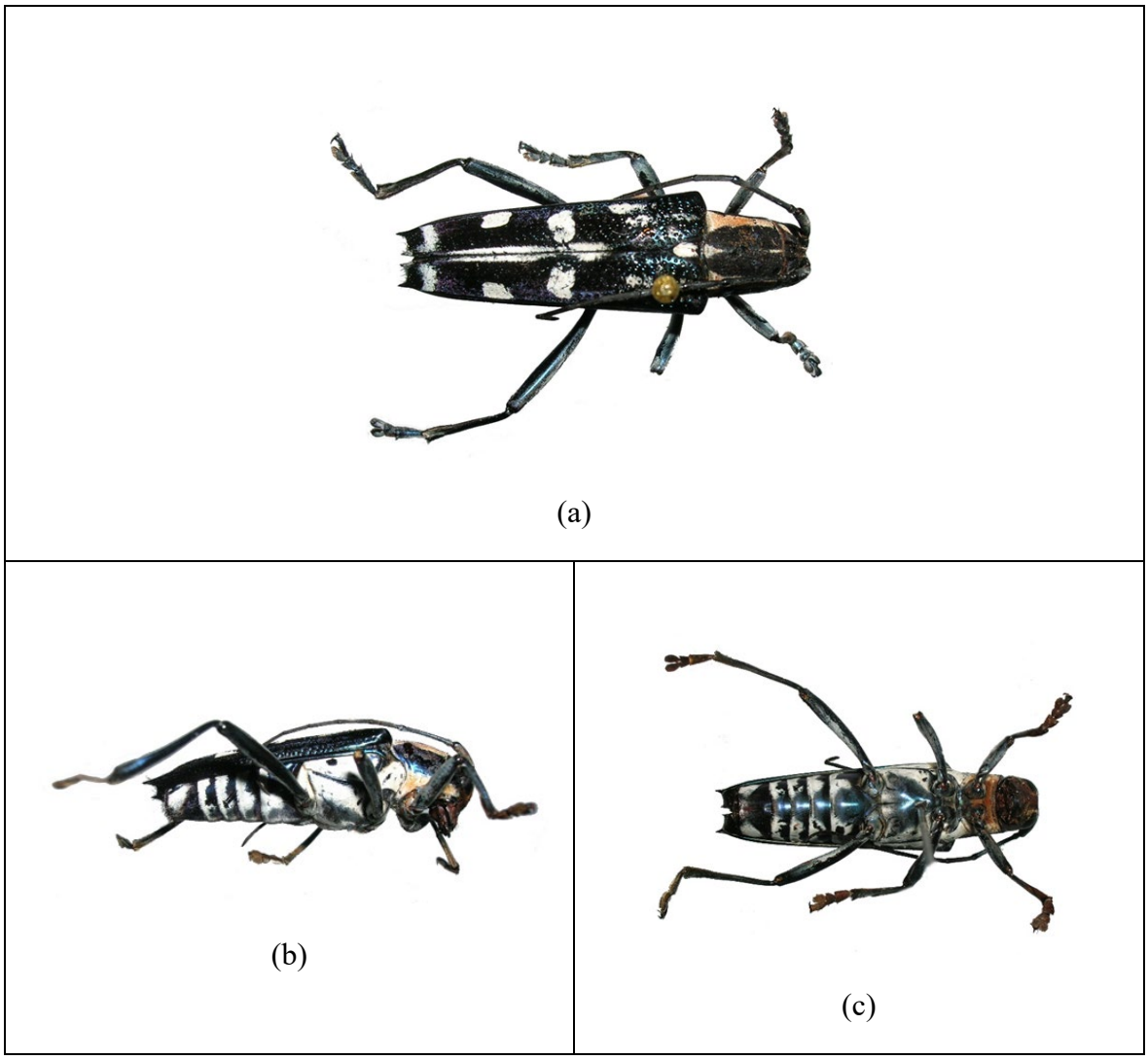


Figure 4.41: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*MacroGlenea*) *juno* J. Thomson, 1865.

39. *Glenea* (*PoeciloGlenea*) Aurivillius

celia Pascoe, 1888:509 [*Glenea*]

cyanescens Pic, 1947c:13 [*Glenea*]

bipuncticollis Breuning, 1958n:890 [*Glenea*] {Note 1}

Materials examined: 5 specimens (2 ♀, 3 ♂).

(FRST Museum Coll.) – Sabah, Qouin Hill, 10.XI.1993, Mohd Azmi Sunda (♀); Sabah, Qouin Hill, 10.XI.1993, Mohd Azmi Sunda (♂); Sabah, Qouin Hill, 5.XII.1993, Palas Ismail (♂).

(Sarawak Museum Coll.) – Sarawak, Mt. Sirambu, I.1912 (♀): Sarawak, Mt. Sirambu, I.1912 (♂).

Diagnosis: Above uniformly bluish white, ornamented with velvety dark pubescence; body beneath bluish white, with the metallic black legs covered with short, recumbent bluish white hairs; antennal scape and first segment bluish white, and the rest dark.

(♀) Length: 18 mm, width: 6.5 mm.

(♂) Length: 17 mm, width: 6.0mm.

Description: Head with the front as long as wide, slightly smaller than prothorax, vertex feebly flattened in female but concave in male, occiput weakly convex at the middle of base, frons with a fine longitudidal furrow extending from epistoma to occiput; eyes, maxillary and labial palpal black; surface finely, sparsely punctuated, densely clothed with

short, recumbent bluish white hairs and mixed with long, erect, dark hairs on median part, ornamented with three black small spots on occiput, one on median, and one on dorso-lateral each; gena fairly shorter than inferior eyelobe; antennae slander, shorter than the body, extending just behind the middle of elytra.

Prothorax as wide as long, arcuately rounded anteriorly, constricted at base and apex, and strongly constricted behind middle; surface finely, densely punctured, feebly punctuated at sides, the punctures nearly concealed by the pubescence, densely clothed with short, bluish white recumbent hairs, decorated with black small spots at the middle of each side of dorso-lateral, and a narrow, black longitudinal, hairless on median, in male middle of median covered with short, bluish white pubescence. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, and densely clothed with bluish whith recumbent hairs at basal third to the apex, meanwhile basal fourth clothed with short, velvety black pubescence, tapering posteriorly, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically, each densely covered with short, bluish white pubescence, ornamented with a short , velvety black blotched at basal half to near base, middle of the blotch decorated with obliquely transversely, short, bluish white pubescence band, half apically ornamented with two, short, velvety black pubescence spots, one just behind middle of apical third, and one near apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath dark metallic, densely covered with short, bluish white pubescence, but leaving greyish black portions on posteriorly of metasternum, and apices of fifth abdominal sternites.

Disrtibution: Borneo, Sumatra, Java.

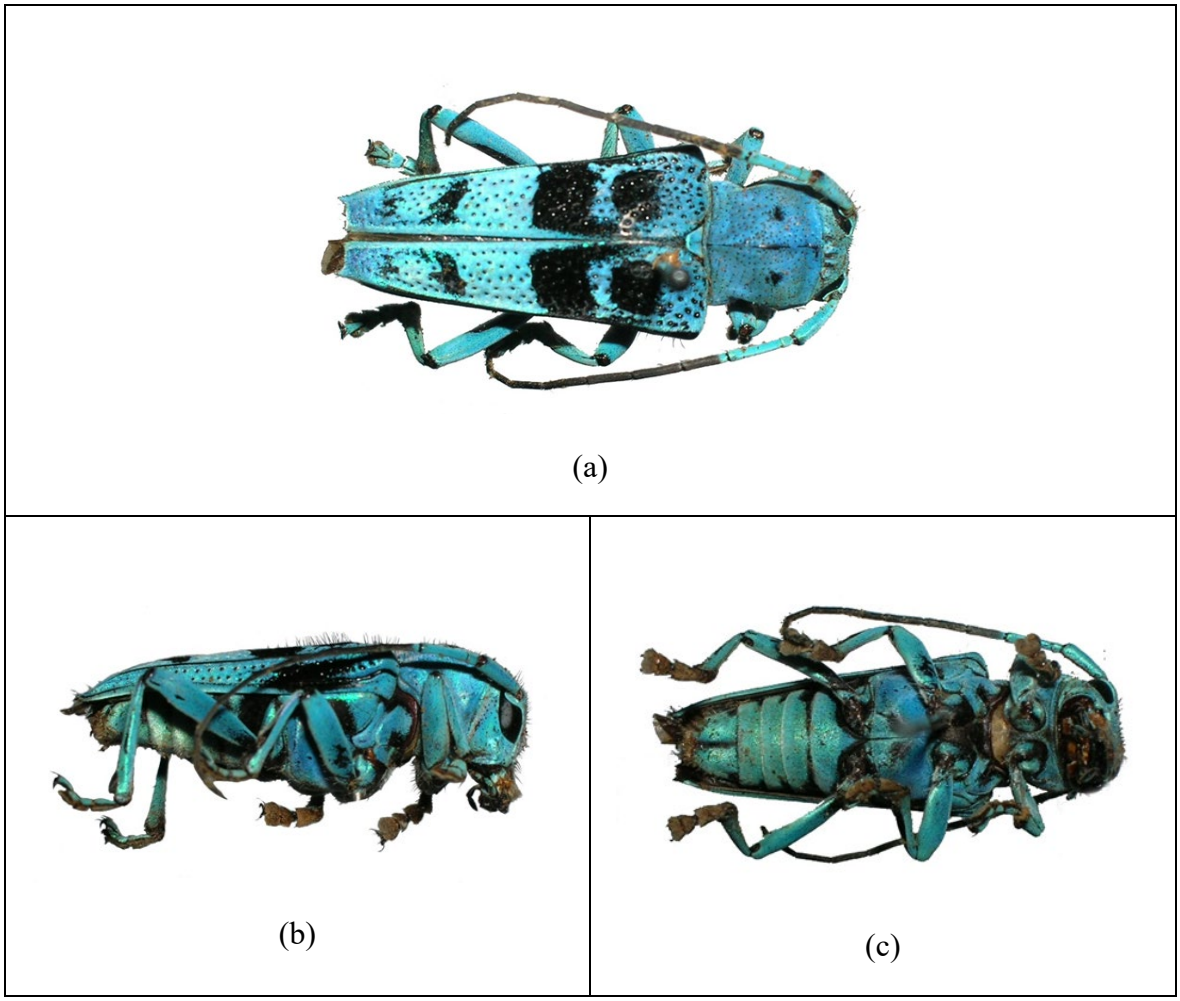


Figure 4.42: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*PoeciloGlenea*) *celia* Pascoe, 1888.

40. *Glenea* (*ReginoGlenea*) Breuning

regina J. Thomson, 1865b:566 [*Glenea*]

neanthes Pascoe, 1866a:259 [*Glenea*]

Materials examined: 6 specimens (6 ♀).

(FRC Coll.) – Sarawak, Matang, Mt. Serapi (alt. 2600 ft.), 25.IV.1979, Mercer and Yeo (♀); Sarawak, Bintulu, Sawai FR., 16.VII.1979, Mercer and Yeo (♀).

(Sarawak Museum Coll.) – Sarawak, Mt. Merinjak, 29.V.1914 (♀); Sarawak, Mt. Merinjak, 15.V.1900 (♀); Sarawak, Mt. Merinjak, 19.VI.1913 (♀); Sarawak, Kuching, IV.1902 (♀).

Diagnosis: Above uniformly aurantius, ornamented with whitish blue spots at densely dark pubescence on elytra and two dark spots on pronotum, body beneath reddish-brown clothed with orange-coloured recumbent hairs; eyes and mandible black, maxillary and labial palpal reddish brown; femora and basal half of tibiae reddish-brown, tarsal black; antennae uniformly dark brown.

(♀) Length: 18 mm, width: 6 mm.

Description: Head with the front longer than wide, slightly smaller than prothorax, broadly concave between the antennal tubercles, occiput convex at middle of base, frons with a fine longitudinal furrow extending from epistoma to occiput; surface sparsely, coarsely, irregularly punctuated, reddesh-brown head sparsely clothed with orange-coloured pubescence on gena and around the eyes, dorsal sparsely clothed with short, recumbent orange-coloured hairs, median part sparsely clothed with short, inconspicuous orange-

coloured hairs; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax as wide as long, sides feebly, arcuately rounded anteriorly, strongly constricted at side behind middle, an elevated ridge on dorso-lateral upfront of constricted area on each side; surface sparsely, coarsely, irregularly punctuated, feebly punctuate at sides, the punctures nearly concealed by the pubescence; reddish-brown prothorax densely clothed with orange-coloured recumbent hairs, ornamented with two black pubescence spots at the middle of dorso-lateral. Scutellum transverse lat obovatus, rounded at apex, broad, nearly flat, reddish-brown scutellum densely clothed with orange-coloured recumbent hairs.

Elytra broader than prothorax at base, nearly two time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point a short distance before apices, then fairly narrowed to obliguely truncate apices with sutural and marginal spines; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically, each very dark brown elytron covered with dark greyish pubescence along sublateral, meanwhile submedial and sutural margin to the point of near apex covered with orange-coloured pubescence which spread broader basally; each elytron ornamented with whitish blue pubescence spots as follows: one rather ill-defined at sublateral near base, one at sublateral behind middle of basal fourth, one in front middle of basal third, one which crescent shape of slightly obliquely transverse just behind the middle of disc, and one at the middle of sublateral of apical fourth, the pubescence nearly hiding the punctures in good specimens.

Body beneath reddish brown, densely clothed with short, recumbent orange-coloured hairs, the hairs sparser at metasternum, centre of first to fourth, and fifth abdominal segments, external mucro at the apex of moderately length.

Distribution: Borneo

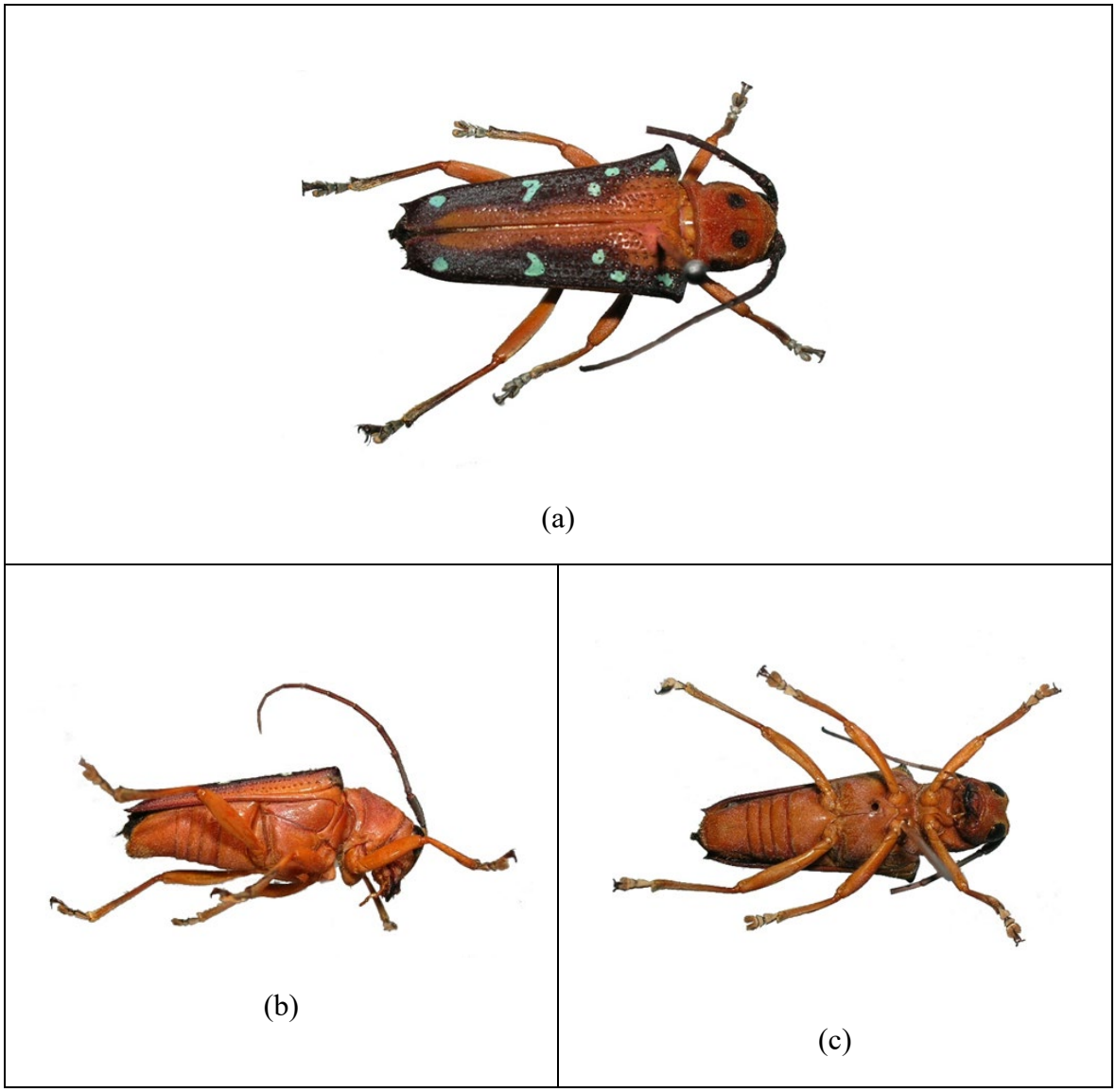


Figure 4.43: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*ReginoGlenea*) *regina* J. Thomson, 1865.

41. *Glenea* (*StiroGlenea*) Aurivillius {key to species: Hudepohl, 1996:24}

angerona angerona J. Thomson, 1865:565 [*Glenea*]{Note 50}

intermedipes Bruening 1971e:45 [*Glenea*] {Note 1} (replacement name for *Glenea* (*StiroGlenea*) *angerona* Thomson and *intermedia* Breuning, 1969)

intermedia Breuning, 1969i:669 [*Glenea*] {Note 1} (pre-occupied by *Glenea diverselineata intermedia* Breuning, 1968)

Materials examined: 13 specimens (10 ♀, 3 ♂).

(FRST Museum Coll.) - Sarawak, Jambusan, Bau, 12.VIII.2004, Jailani (♀).

(FRC Coll.) – Sarawak, Miri, Dulit Range, 15.V.1990, SFD Ento. Team (♀); Sarawak, Miri, Dulit Range, 15.V.1990, SFD Ento. Team (♀); Sarawak, Miri, Dulit Range, 15.V.1990, SFD Ento. Team (♂); Sarawak, Kapit, Hose Mt., 25.IX.1987, Sarkawi Umar (♂); Sarawak, Kapit, Sg. Mujong, 14.IV.1989, SFD Ento. Team (♂).

(Sarawak Museum Coll.) – Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Mt. Sibau, VI.1902 (♀); Sarawak, Retuk, Ulu Sadong, 15.V.1914 (♀);

Diagnosis: Above uniformly reddish-brown, except dark head, prothorax, and apex of elytra; body beneath blackish grey, femora and tibiae of front and middle legs reddish brown, tarsal blackish grey, and hind legs blackish grey; antennae uniformly dark greyish.

(♀) Length: 13 mm, width: 4.5 mm.

(♂) Length: 12.4 mm, width: 4.5 mm.

Description: Head with the front as long as wide, equal in width with prothorax; vertex broadly, feebly concave, frons with a fine longitudinal furrow extending from epistoma to occiput; surface finely, densely punctuated, rather densely clothed with moderately long whitish recumbent hairs around eyes and gena, sparsely clothed with short, inconspicuous hairs on median part, and ornamented with two narrow longitudinal whitish pubescence extending from vertex to occiput; gena fairly shorter than inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, slightly arcuately rounded at the sides, constricted before base; surface finely densely punctuated, punctures nearly concealed by the white pubescence, ornamented with five longitudinal white pubescence vittae: median one of which narrow, dorso-lateral pair on disc broad, and lateral pair broadest. Scutellum transverse lat obovatus, rounded at apex, concave anteriorly, densely clothed with black pubescence.

Elytra broader than prothorax at base, nearly two time as long as the basal width, elytra strongly carinate and deflexed at sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly parallel posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with minute sutural and marginal white hair, apex of each elytron arcuately emarginated, furnished with a short spine at the sutural margin and a longer spine at the outer angle; surface sparsely, coarsely, irregularly punctuate basally, the punctures becoming finer and sparser apically, each elytron decorated with a narrowed whitish sutural vitta and ill-defined obliquely transverse band on black disc of apex, the pubescence nearly hiding the punctures in good specimens.

Body beneath rather densely cover with white pubescence, leaving black portions on interior half of metepisternal and basal sides of first to fourth abdominal segments.

Distribution: Borneo, Java, Nias.

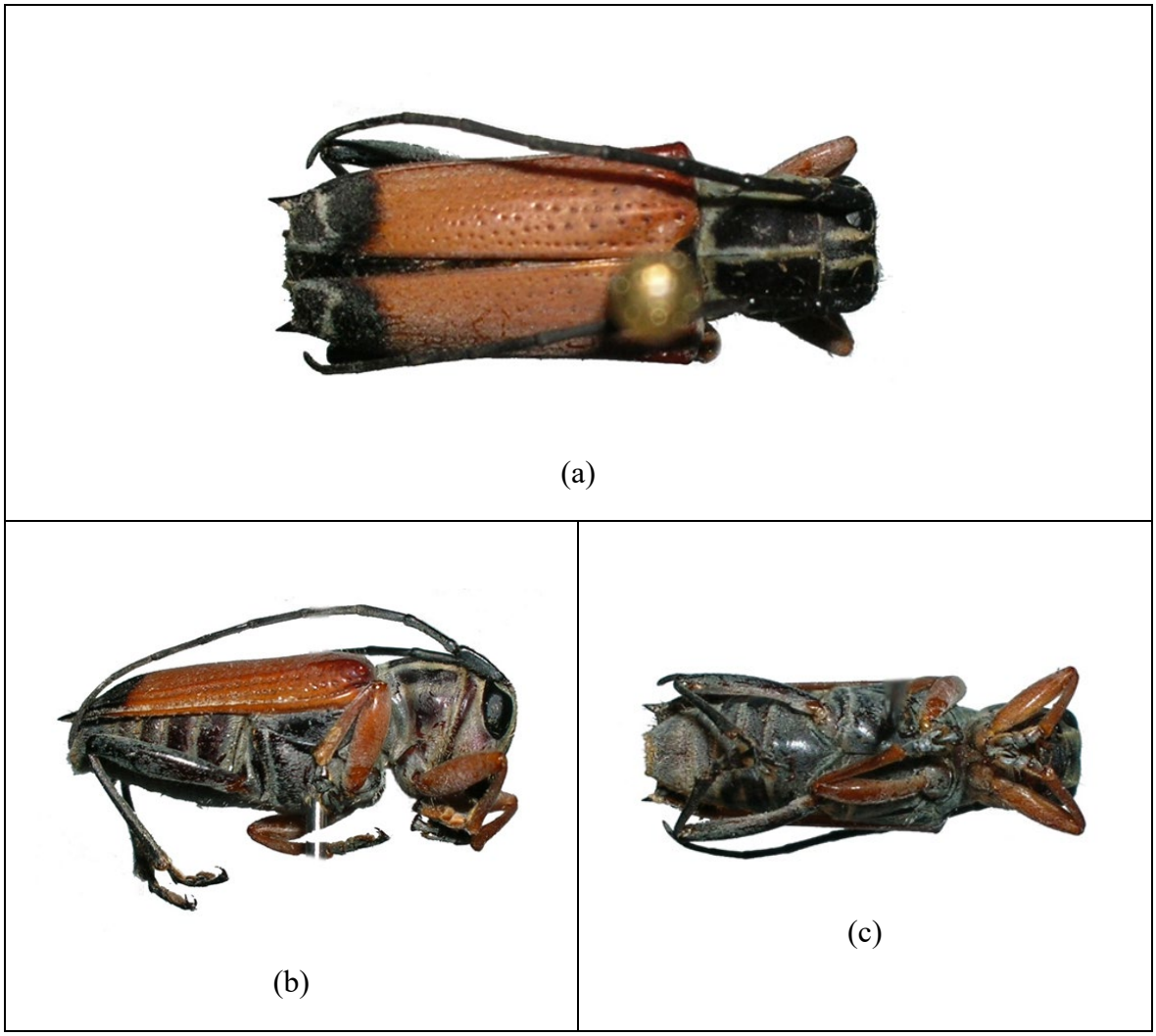


Figure 4.44: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* (*StiroGlenea*) *angerona angerona* J. Thomson, 1865.

42. *Glenea* sp.1 (SFC)

Materials examined: 2 specimens (2 ♀).

(FRC Coll.) – Sarawak, Limbang, 20.X.1985, Haidir Nusi (♀); Sarawak, Limbang, 20.X.1985, Manis Milli (♀).

Diagnosis: Body above uniformly dark brown, decorated with tawny yellow pubescence vittae, spots and dots on head, pronotum, and elytra; body beneath densely clothed with pale yellow pubescence; femora reddish-brown, tibiae and tarsal dark brown, sparsely clothed with erect and recumbent, pale yellow and white hairs; antennae uniformly dark brown.

(♀) Length: 14mm, width: 4.5 mm.

Description: Head with the front as long as wide, slightly smaller than the prothorax, vertex broad, nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with recumbent, tawny yellow hairs on gena, around eyes and margin of frons, sparsely clothed with short, inconspicuous tawny hairs on median of frons, ornamented with longitudinal tawny yellow pubescence vittae on occiput, two which narrow along median divided by longitudinal furrow at the middle, and one which broader along dorso-lateral just behind the eyes on each side; the eyes and mandible black, maxillary and labial palpal dark reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted

behind middle; surface finely, sparsely punctuated, scarcely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short, erect, dark brown hairs, ornamented with three longitudinal, tawny yellow pubescence vittae, one which narrow along median, a pair which broader along dorso-lateral. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, densely clothed with tawny yellow pubescence, sparser at the middle toward base, and leaving black area at the sides and basally.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, base of deflexed sides sparsely covered with pale yellow pubescence spot, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and erect brown hairs, ornamented with four tawny yellow pubescence spots as follows: one at base of elytron, one which smaller between basal fourth and third at the middle, one at the middle of disc, and one which larger at apex; each elytron also decorated with inconspicuous, narrow, elongated and small tawny yellow pubescence dot at middle of sublateral between basal fourth and third; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark reddish-brown, densely clothed with pale yellow pubescence, sparser on posterior half of metasternum, leaving dark reddish-portions on interior of metepisternal and fifth abdominal segment.

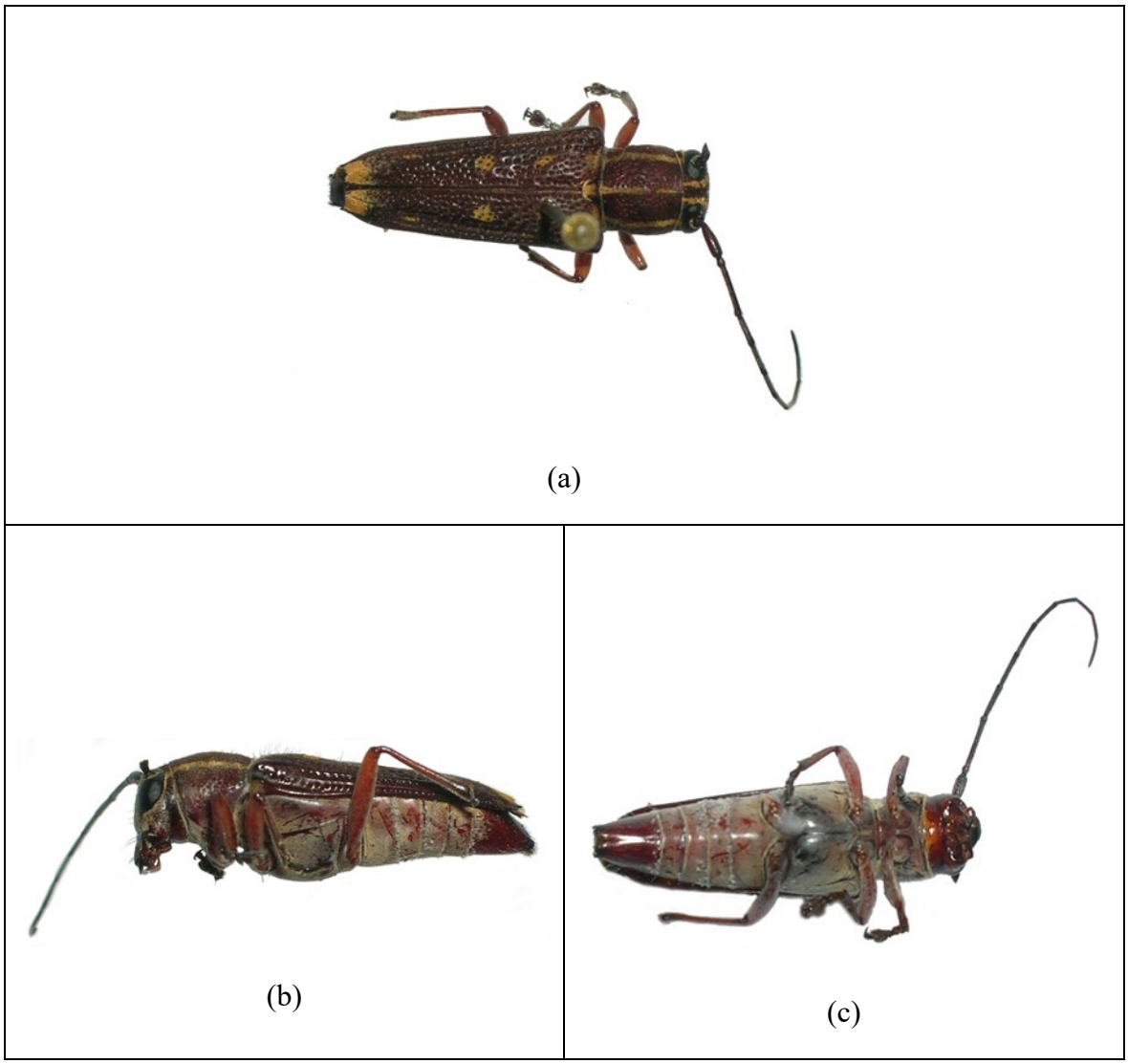


Figure 4.45: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp1.

43. *Glenea* sp.2 (SFC)

Materials examined: 1 specimen (♀).

(FRC Coll.) – Sarawak, Sri Aman, Ubah Ribu, Sg. Engkari, 28.IV.1994, SFD Ento. Team (♀).

Diagnosis: Body above uniformly black, decorated with white pubescence blotches and spots on elytra; body beneath densely covered with white pubescence; pro and mesolegs dark bluish, apical of femora and basal of tibiae of hindlegs dark bluish, the rest reddish-brown, sparsely clothed with erect and recumbent, short, and long , tawny yellow and white hairs intermixed; antennae uniformly dark.

(♀) Length: 20 mm, width: 6 mm.

Description: Head with the front longer than wide, slightly smaller than the prothorax, vertex narrow, scarcely concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with recumbent, tawny yellow hairs on gena, around eyes and margin of frons, rather densely clothed with velvety black pebescence, sparsely clothed with short, inconspicuous black hairs on median of frons; the eyes and mandible black, maxillary and labial palpal dark brown; gena fairly shorter than the inferior eyelobe; antennae slender, shorter than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, sparsely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short, erect,

velvety black hairs. Scutellum transverse late obovatus, rounded at apex, broad, feebly concave, entirely covered with velvety black pubescence.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, tapering posteriorly, then fairly narrowed to obliquely truncate apices with the sutural and marginal spines; surface coarsely, rather sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with velvety black pubescence, and ornamented with white pubescence as follows: a blotch at submedial just behind middle of elytron, a rounded spot at sublateral between apical fourth and third, a obliquely incomplete transverse band near apex crossing from lateral margin toward submedial, but not touching sutural margin, and two inconspicuous white dots, one at middle of basal fourth, and one near lateral carina between basal fourth and third; the pubescence nearly hiding the punctures in good specimens.

Body beneath rather densely clothed with short and recumbent white pubescence, except sparsely on metasternum, and leaving dark portions on interior of metepisternal, basal sides of first and second, basal of third and fourth, and fifth abdominal segments.

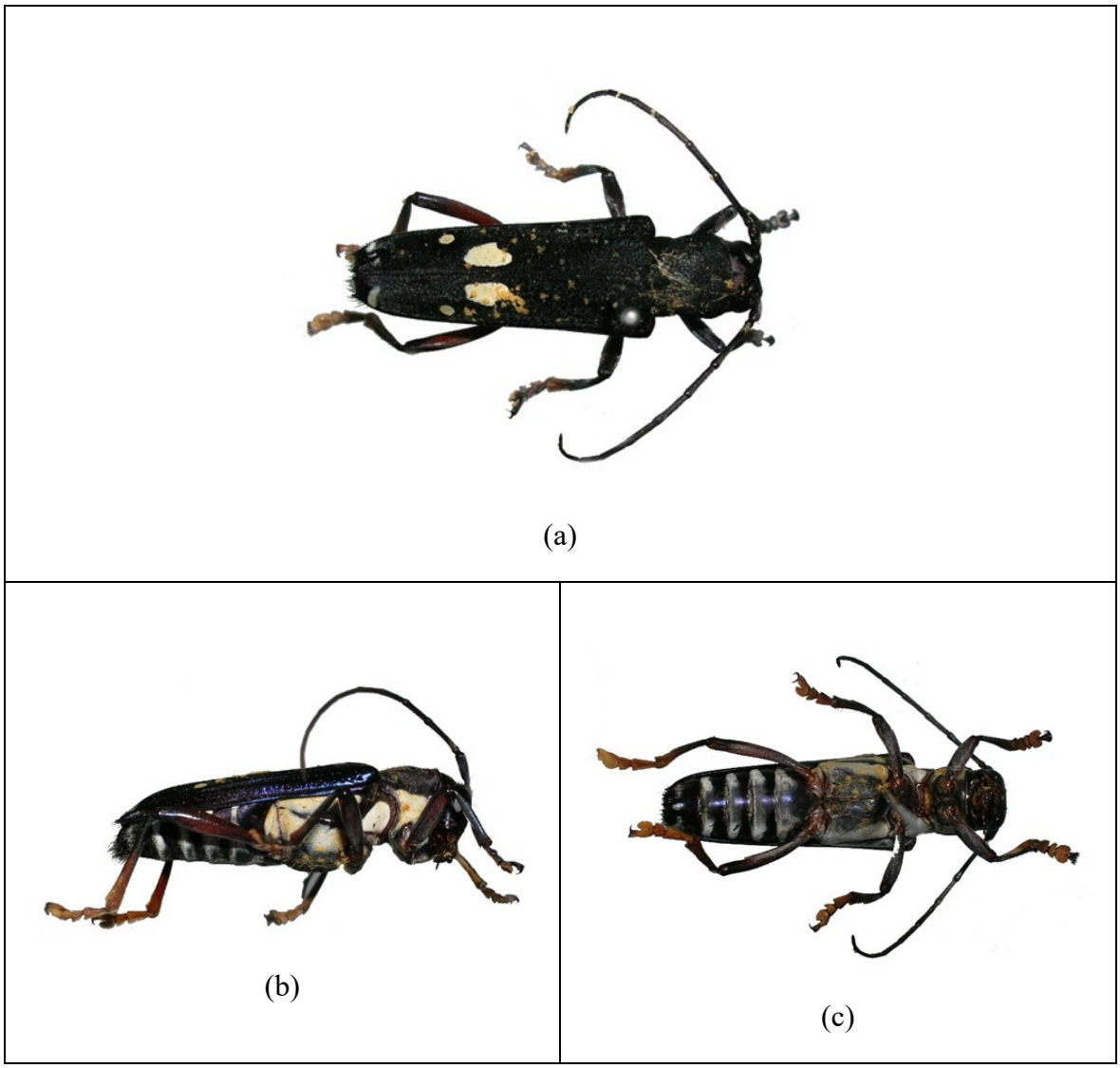


Figure 4.46: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp2.

44. *Glenea* sp.3 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Matang, Mt. Serapi, 17.VIII.1979, SFD Ento. Team (♂).

Diagnosis: Body above uniformly dark, decorated with rather broad and narrow, imperfectly longitudinal white bluish pubescence vittae; body beneath reddish-brown, nearly hairless; femora reddish-brown, tibiae and tarsal dark; antennae uniformly dark.

(♂) Length: 18 mm, width: 5 mm.

Description: Head with the front longer than wide, slightly smaller than the prothorax, vertex narrow, scarcely concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with short and recumbent white hairs around eyes and margin of frons, sparser on gena and median of frons, ornamented with four narrow, longitudinal whitish pubescence vittae, two along median divided by longitudinal furrow at the middle, one along dorso-lateral on each side; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, weakly narrowed from middle to apex, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely, sparsely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum ornamented with four broad, longitudinal white bluish pubescence vittae, two along median divided by a black longitudinal portion, swollen at the middle, and one along dorso-lateralon each side. Scutellum transverse late ovovatus, rounded at apex,

broad, nearly flat, sparsely covered with white bluish pubescence along margin of scutellum, except at the basal.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron ornamented with white bluish pubescence as follows: two longitudinal vittae extending from base to apex along two longitudinal punctures rows at deflexed sides, one along sutural margin extending from base to apex, one which incomplete vittae along sublateral, which is leaving dark portions at basal third, one which also incomplete vittae along median of disc, leaving dark portion at basal third, which decorated with a white bluish spot at middle of that dark portion; the pubescence nearly hiding the punctures in good specimens.

Body beneath reddish-brown, sparsely clothed with short and recumbent tawny yellow hairs at apical of abdominal segments, others area nearly hairless; the external mucro at the apex of moderately length in male.

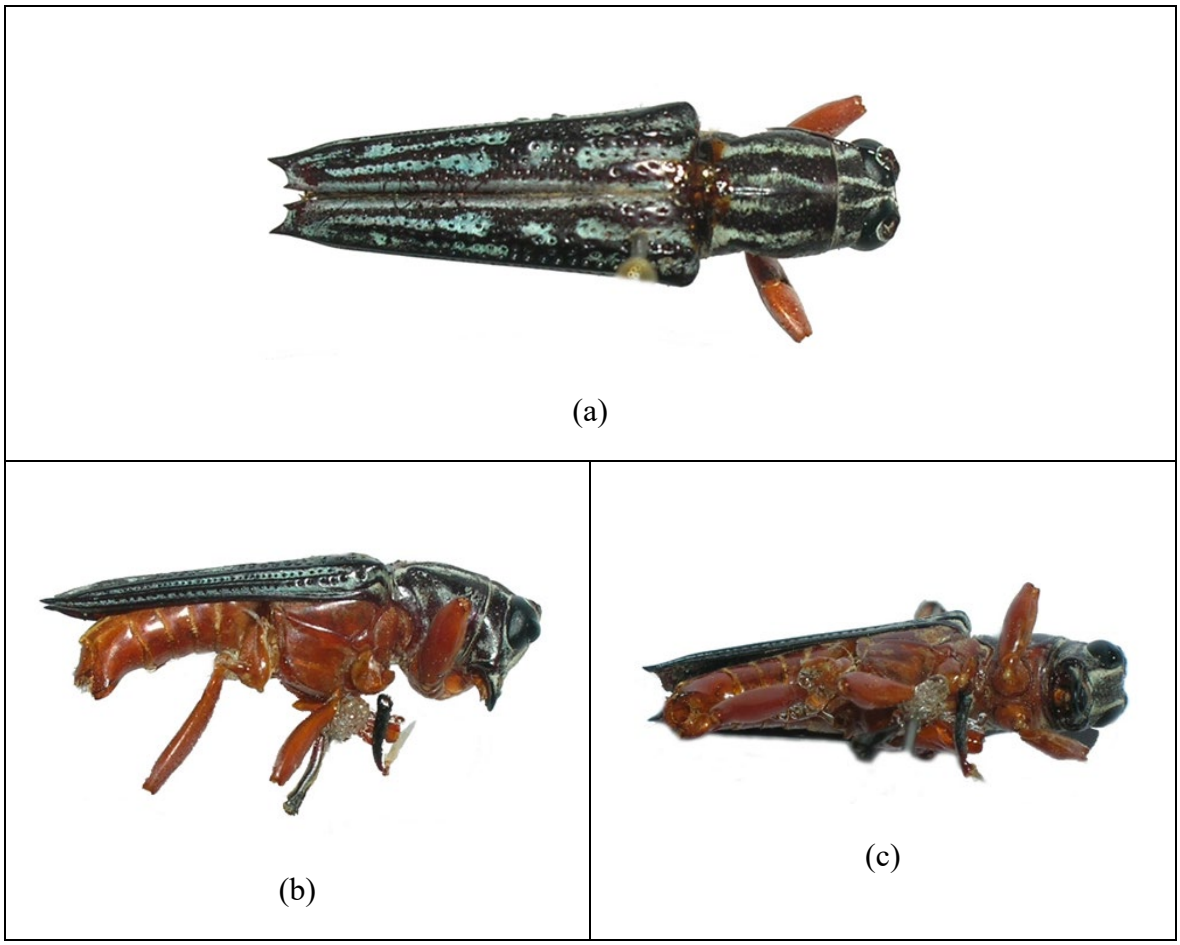


Figure 4.47: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp3.

45. *Glenea* sp.4 (SFC)

Materials examined: 1 specimen (♀).

(FRC Coll.) – Sarawak, Miri, Dulit Range, 15.V.1990, SFD Ento. Team (♀).

Diagnosis: Body above uniformly dark greyish-brown, ornamented with pale yellow pubescence vittae and transverse bands; body beneath densely clothed with pale yellow pubescence; legs uniformly dark, sparsely clothed with short and recumbent, and erect and long, pale yellow and white hairs; rather densely toward apices; antennae uniformly dark.

(♀) Length: 15mm, width: 5 mm.

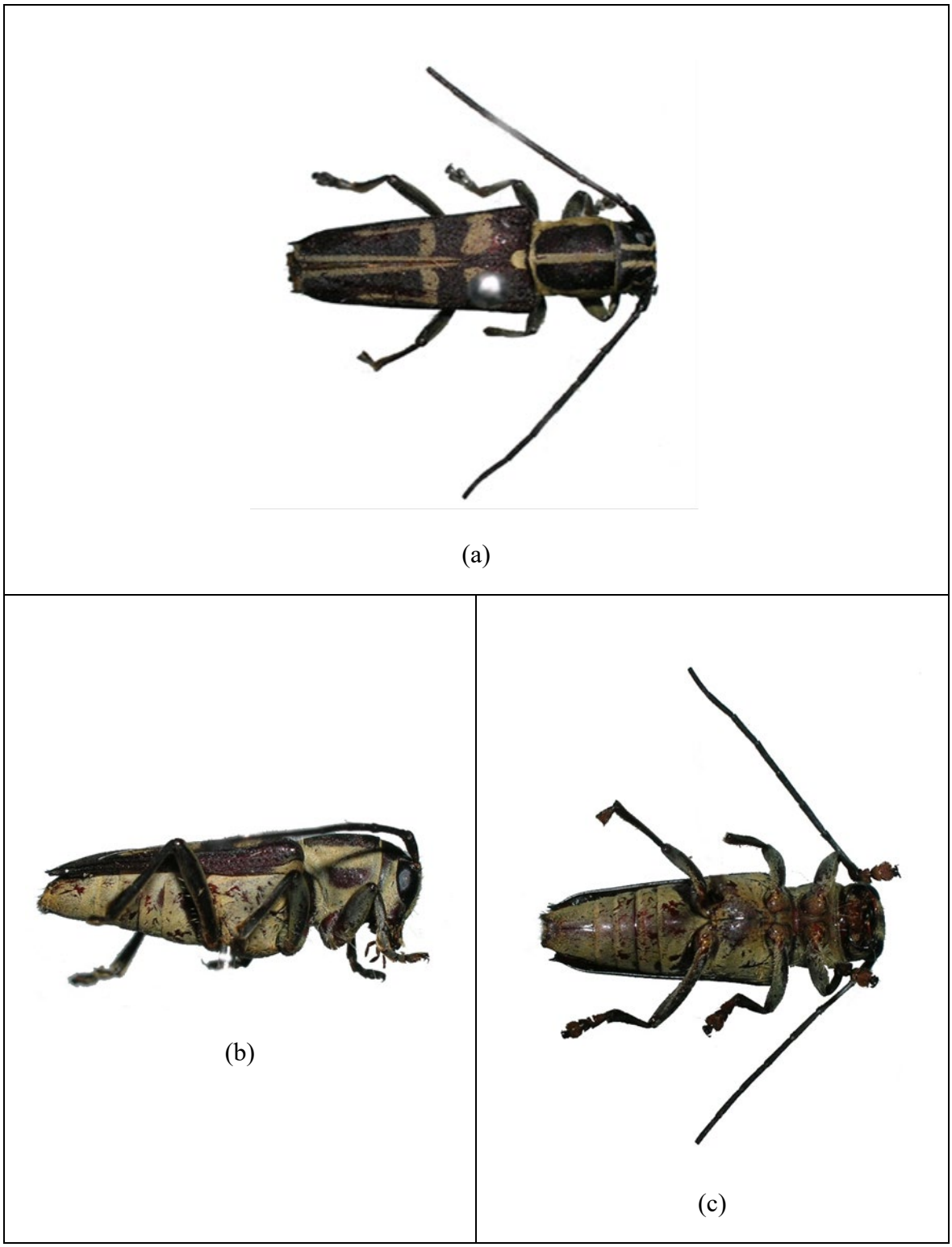
Description: Head with the front as long as wide, slightly smaller than the prothorax, vertex broad, nearly flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with recumbent, pale yellow hairs on gena and margin of frons, sparsely clothed with short, inconspicuous pale yellow and dark brown hairs on median of frons, ornamented with two narrow longitudinal yellow pubescence vittae on occiput along median, divided by longitudinal furrow at the middle, the other areas densely covered with short and recumbent dark brown hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax as wide as long, almost parallel-sided at apical half and narrow from behind to middle, sides feebly, arcuately rounded anteriorly, feebly constricted behind middle; surface finely, sparsely punctuated, scarcely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent

dark brown hairs, ornamented with three longitudinal, pale yellow pubescence vittae, one which narrow along median, a pair which broader along dorso-lateral, the vittae connected at the base with a narrow transverse band. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, densely clothed with pale yellow recumbent hairs, forming a spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather sparsely irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, ornamented with pale yellow pubescence as follows: a spot at base of each deflexed side, a transverse band, rather broad at middle of basal fourth, a transverse band which narrower just before middle of elytron, a longitudinal vitta along sutural margin extending from basal third to apex, and a longitudinal vittae along median of sublateral at apical third; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with short and recumbent pale yellow pubescence, sparser metasternum.



(a)

(b)

(c)

Figure 4.48: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp4.

46. *Glenea* sp.5 (SFC)

Materials examined: 1 specimen (♀).

(FRC Coll.) – Sarawak, Limbang, Limbang Trading Camp, 15.X.1985, Mahmud Merdek (♀).

Diagnosis: Body above uniformly dark brown, ornamented with longitudinal white pubescence vittae, and pale yellow pubescence blotches on elytra; body beneath densely clothed with pale yellow pubescence; femora and tibiae reddish-brown, tarsal dark brown, sparsely clothed with short and recumbent, and long and erect, white and pale yellow hairs intermixed, denser toward apices; antennae uniformly dark.

(♀) Length: 11.2 mm, width: 3.4 mm.

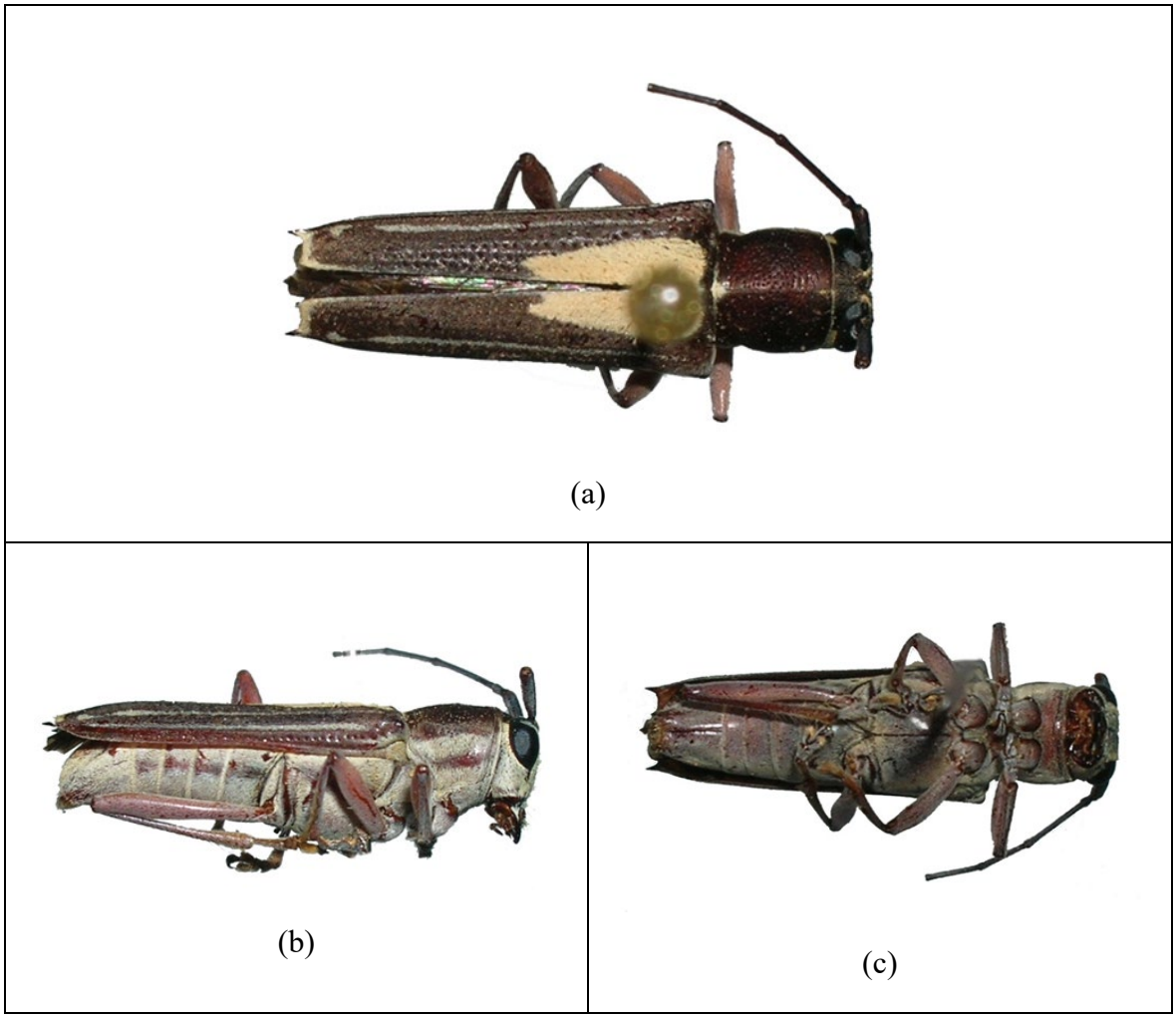
Description: Head with the front as long as wide, slightly smaller than the prothorax, vertex narrow, feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with pale yellow pubescence on gena and margin of frons, sparser on median part of frons, occiput densely clothed with dark brown, short and recumbent hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely, densely punctuated, scarcely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and decorated with pale yellow pubescence spot at middle of

base, and two longitudinal pale yellow pubescence vittae laterally. Scutellum trapezoidal, broad, feebly concave, densely clothed with pale yellow recumbent hairs apices, but basally densely clothed with dark brown recumbent hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather sparsely punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, ornamented with pale yellow pubescence as follows: an elongated blotch which tapering posteriorly common to both elytron along submedial extending from near base toward middle of elytron, two spots, one at base of deflexed sides, and one at sublateral near apex, three narrow longitudinal vittae, one along sutural margin extending from middle toward apices and forming a narrow transverse band at apex, one along median of sublateral extending from base toward middle of apical fourth, and one along upper punctures row of deflexed sides extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath reddish-brown, densely clothed with pale yellow pubescence, but sparser on metasternum, interior of metepisternal, ventro-lateral of first to fourth, and centres of abdominal segments.



(a)

(b)

(c)

Figure 4.49: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp5.

47. *Glenea* sp.6 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Julau, Sg. Ensiring, 17.XII.1993, SFD Ento. Team (♂).

Diagnosis: Body above uniformly black, ornamented with blue pubescence spots and dots on elytra and longitudinal blue pubescence vittae on pronotum; body beneath densely clothed with whitish pubescence; legs uniformly dark, sparsely covered with short and recumbent white and blue hairs, mixed with long and erect hairs apically, denser toward apices; antennae uniformly black.

(♂) Length: 14 mm, width: 3.7 mm.

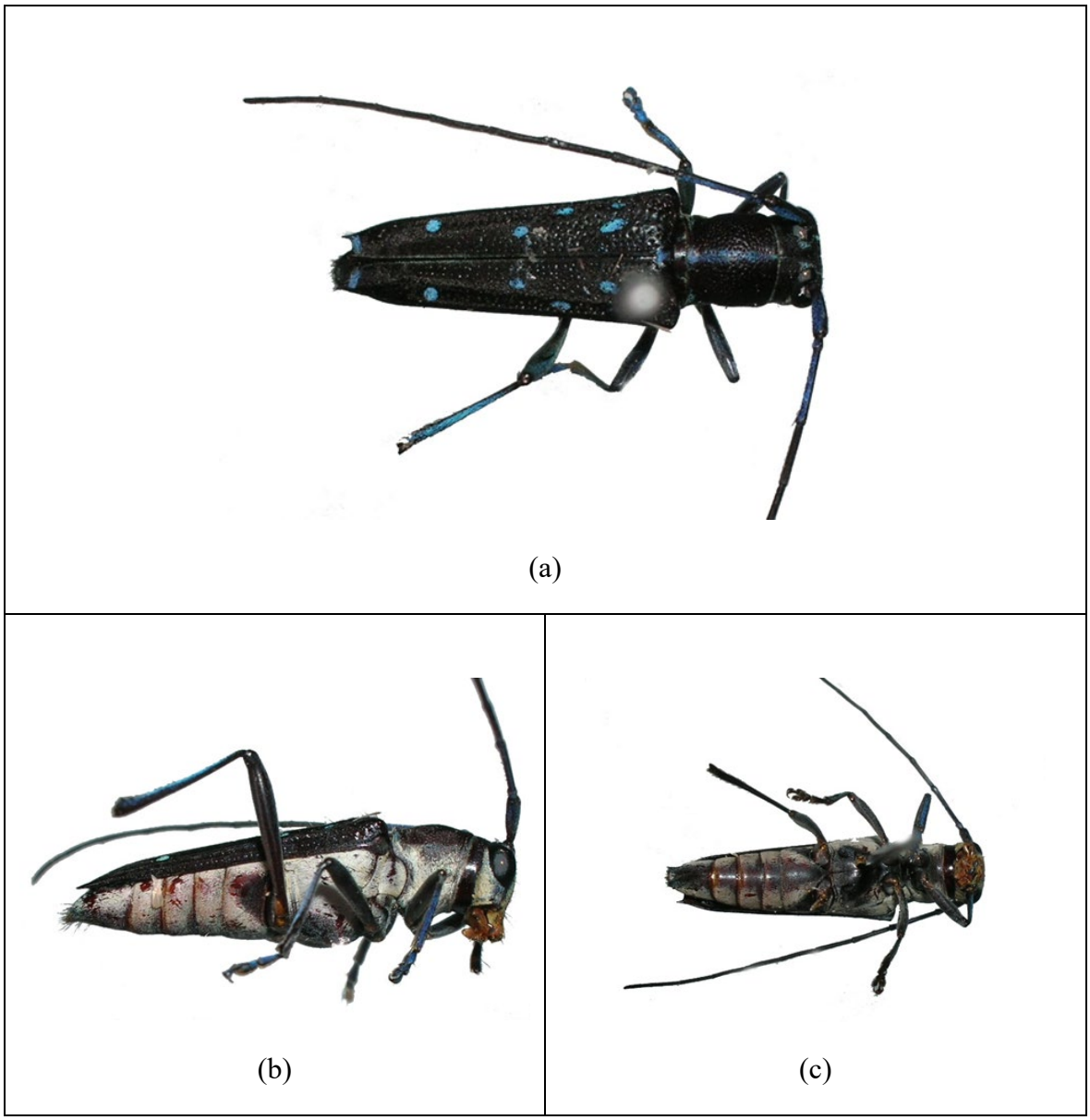
Description: Head with the front as long as wide, slightly broader than the prothorax, vertex narrow, feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, densely clothed with whitish blue pubescence on gena, around eyes and margin of frons, median part of frons and occiput black, clothed with short and inconspicuous hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and weakly narrow from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface finely, sparsely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum black, sparsely clothed with short and recumbent dark hairs, ornamented with a narrow longitudinal blue pubescence vitta along median. Scutellum transverse late ovovatus, rounded at apex, broad, feebly

concave, sparsely covered with blue pubescence at apex and median, forming a inconspicuous small spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each black elytron sparsely covered with short and recumbent, inconspicuous dark hairs, ornamented with five blue pubescence spots as follows: one at the middle of elytron at basal fourth, one at the middle of sublateral at basdal third, one at the middle of elytron, one at the middle of sublateral between apical fourth and third, and one which obliquely tranverse at apex; each elytron also decorated with a blue pubescence dot at sublateral, near lateral carina at the middle of basal fourth; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark reddish-brown, densely clothed with white pubescence, sparser on metasternum and centres part of abdominal segments, so that leaving dark reddish-brown portions on those areas; the external mucro at the apex of moderately length in male.



(a)

(b)

(c)

Figure 4.50: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp6.

48. *Glenea* sp.7 (SFC)

Materials examined: 4 specimens (4 ♀).

(FRC Coll.) – Sarawak, Baram, Lubang Napir, 21.X.1985, Lippa and Rahman (♀); Sarawk, Belaga, Danum, 18.VIII.2001, SFD Ento. Team (♀); Sarawak, Belaga, Danum, 17-19.VIII.2001, SFD Ento Team (♀); Sarawak, Kapit, Ulu Putai, 8.V. 2001, SFD Ento Team (♀).

Diagnosis: Body above uniformly dark brown, ornamented with white pubescence spots on pronotum and elytra, and with inconspicuous, narrow longitudinal white pubescence vitta on pronotum; body beneath uniformly dark, sparsely covered with inconspicuous recumbent white hairs; legs uniformly reddish brown; antennae entirely dark.

(♀) Length: 11.2 mm, width: 3.4 mm.

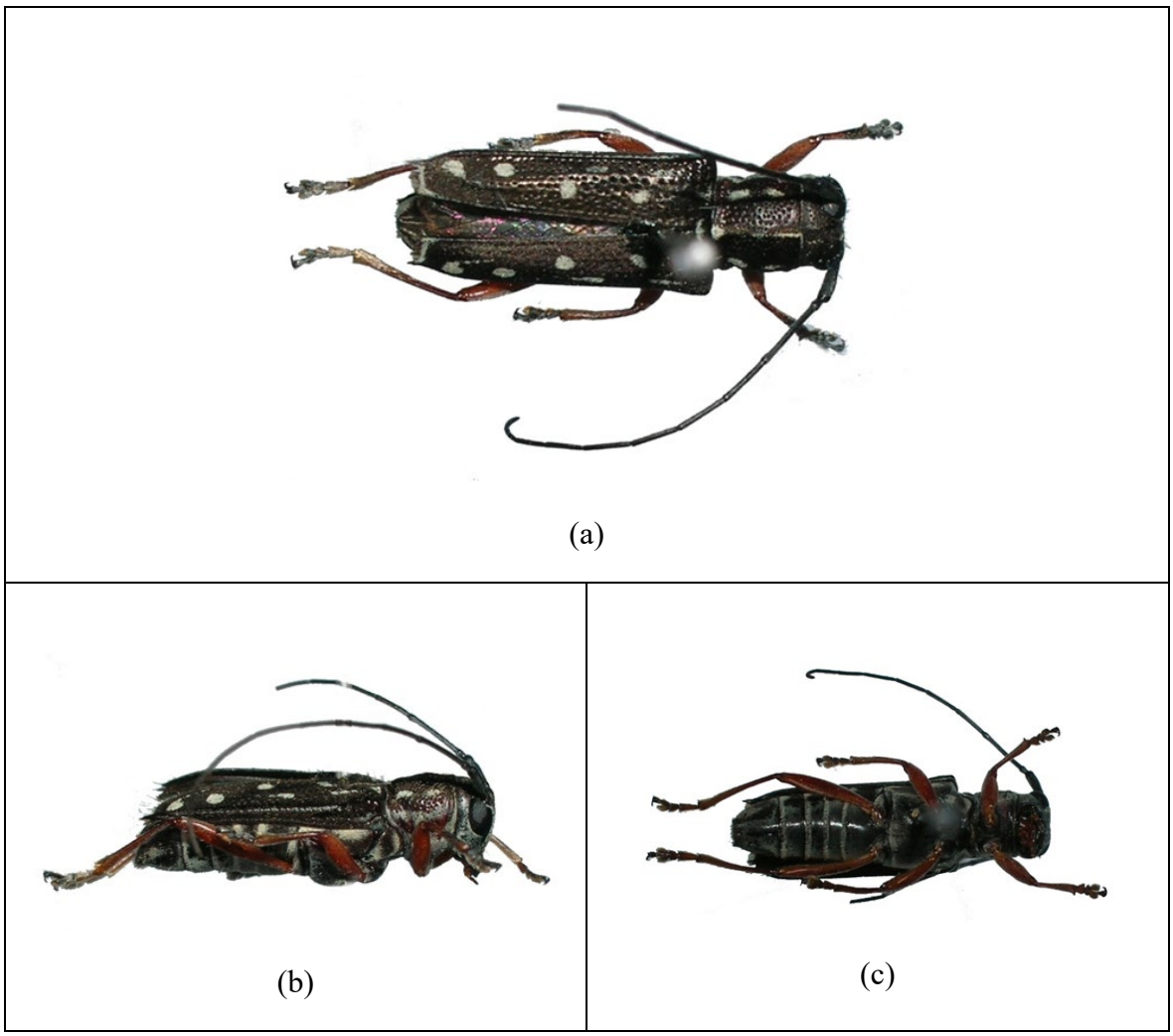
Description: Head with the front as long as wide, equal in width with the prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, sparsely clothed with white recumbent hairs on gena, around the eyes and margin of frons, sparsely clothed with short, inconspicuous, recumbent, white and brown hairs intermixed on median of frons, occiput sparsely clothed with dark brown recumbent hairs, and ornamented with two white pubescence dots on occiput divided by longitudinal furrow; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and weakly narrow at apex, sides feebly, arcuately rounded anteriorly, strongly constricted behind

middle; surface finely, densely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum sparsely clothed with inconspicuous recumbent dark brown hairs, ornamented with three longitudinal white pubescence vittae, one which narrow along median, a pair which broader laterally, and decorated with four white pubescence spots, two on each side dorso-laterally. Scutellum trapezoidal, feebly carinate along median, densely clothed with dark brown pubescence, except at the apex, where the pubescence is whitish.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each black elytron densely covered with dark brown recumbent hairs, and ornamented with white pubescence as follows: four spots, one between basal fourth and third at middle, one at the middle of disc, one at sublateral between apical fourth and third, and one at sublateral near apex; three dots, one at middle of base of elytron, one which elongated at middle of sublateral of basal fourth, and one which broader and elongated at middle of sublateral of basal third; one narrow transverse band at apices; and one narrow longitudinal vitta along upper punctures row of deflexed side extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, sparsely clothed with white pubescence on metasternum and centres and apical sides of abdominal segments, leaving black portions on interior of metepisternal and basal sides of abdominal segments.



(a)

(b)

(c)

Figure 4.51: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp7.

49. *Glenea* sp.8 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Limbang, Limbang Trading Camp A, 16.X.1985, Haidir Nusi (♂).

Diagnosis: Body above uniformly dark brown, ornamented with whitish blue pubescence spots on sides of pronotum and elytra, a narrow longitudinal whitish blue pubescence vitta on pronotum and a narrow longitudinal pale yellow pubescence along sutural margin; body beneath uniformly dark, sparsely covered with white pubescence; femora, tibiae and tarsl of hind legs reddish brown, tibiae and tarsal of front and middle legs dark, sparsely clothed with recumbent whitish blue hairs, mixed with moderately long, erect pale yellow hairs, denser toward apices; posterior half of antennal scape, and posterior of first and second antennal segments sparsely clothed with short and recumbent whitish blue hairs, the following joints uniformly dark.

(♂) Length: 11.2 mm, width: 3 mm.

Description: Head with the front as long as wide, equal in width with the prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with whitish blue pubescence on gena, along margin of frons and upper part of the eyes, sparsely covered with short, inconspicuous and recumbent dark hairs on median of frons and occiput, nearly hairless; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides vaguely, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, densely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum sparsely clothed with inconspicuous recumbent dark brown hairs, ornamented with a narrow longitudinal whitish blue pubescence vitta along median, and a pair of whitish blue pubescence spots at middle of lateral. Scutellum trapezoidal, broad, feebly concave, densely clothed with pale yellow pubescence, except of at the sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each black elytron densely covered with short and recumbent dark brown hairs, ornamented with whitish blue pubescence as follows: four spots, one at middle of elytron at basal fourth, one which smaller at sublateral of basal third, one which broadest at sublateral between apical fourth and third, and one near apex; two dots, one at sublateral of basal fourth at middle, and one at middle of disc; each elytron also decorated with a narrow longitudinal inconspicuous pale yellow pubescencee vitta along sutural margin extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark, rather densely clothed with white pubescence on metepisternal and apical sides of abdominal segments, sparser on other areas, leaving dark

brown portions on interior of metepisternal, metasternum, centres and basal sides of abdominal segments; the external mucro at the apex of moderately length in male.

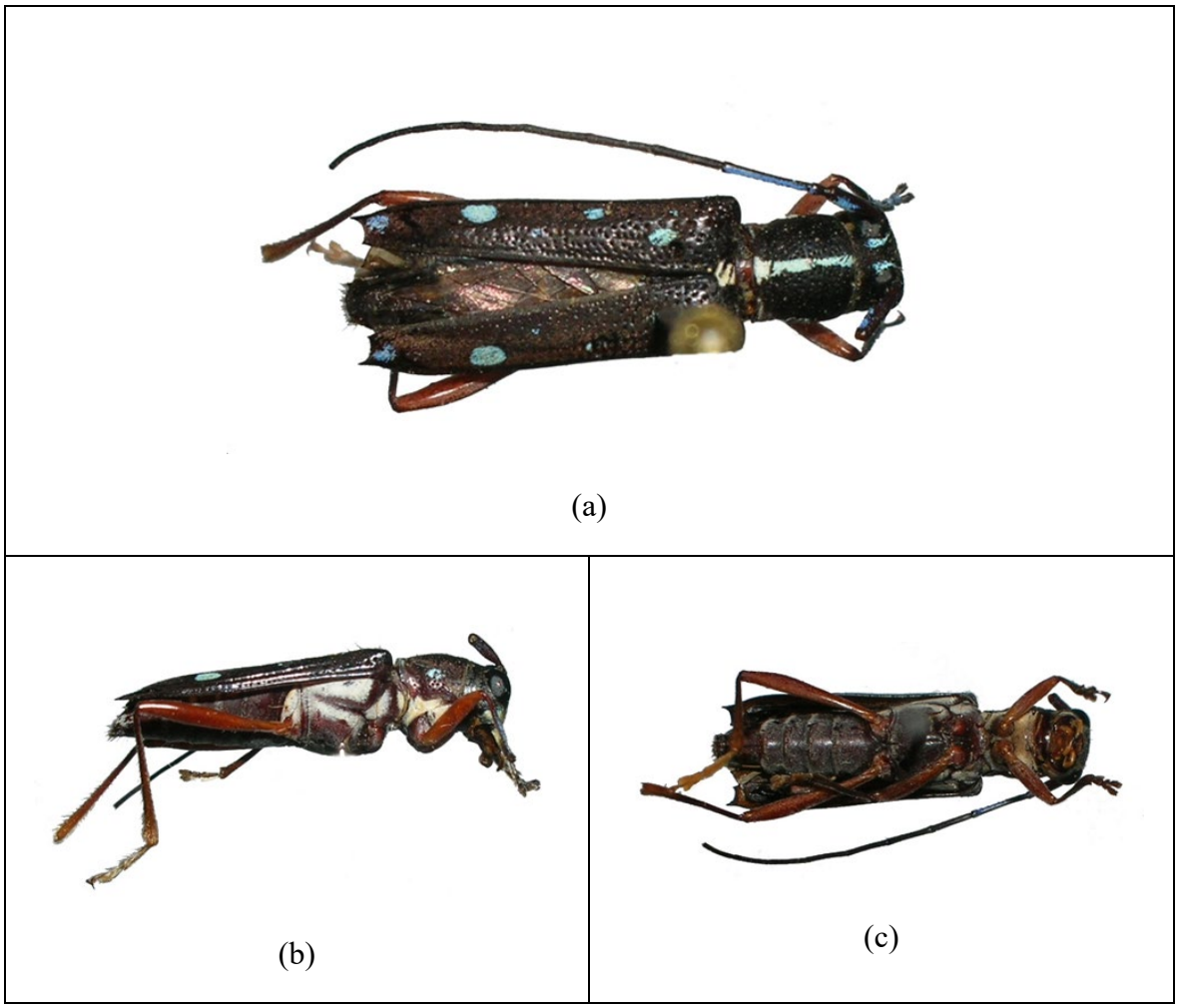


Figure 4.52: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp8.

50. *Glenea* sp.9 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Tebakang, Sg. Tubih, 29.VI.1983, Lippa and Haidir (♂).

Diagnosis: Body above uniformly dark brown, ornamented with whitish blue pubescence spots on elytra, three longitudinal whitish and pale yellow pubescence vittae on pronotum and a narrow longitudinal pale yellow pubescence vitta along sutural margin; body beneath uniformly dark brown, sparsely clothed with white pubescence; femora, tibiae and tarsl of hind legs reddish brown, tibiae and tarsal of front and middle legs dark, sparsely clothed with recumbent whitish blue hairs, mixed with moderately long, erect pale yellow hairs, denser toward apices; posterior half of antennal scape, and posterior of first and second antennal segments sparsely clothed with short and recumbent whitish blue hairs, the following joints uniformly dark.

(♂) Length: 9 mm, width: 2.4 mm.

Description: Head with the front as long as wide, slightly broader than the prothorax, vertex broad, weakly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, densely punctuated, rather densely clothed with whitish blue pubescence on gena, along margin of frons and upper part of the eyes, sparsely covered with short, inconspicuous and recumbent dark hairs on median of frons and occiput, nearly hairless; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and narrow from behind to middle, sides vaguely, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, sparsely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum sparsely clothed with inconspicuous short and recumbent dark brown hairs, ornamented with three longitudinal whitish blue pubescence vittae, one which narrow along median, and a pair which broader laterally. Scutellum trapezoidal, broad, nearly flat, densely clothed with pale yellow pubescence, except of at the basal sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each black elytron densely covered with short and recumbent dark brown hairs, ornamented with whitish blue pubescence as follows: five spots, one at middle of elytron at basal fourth, one which smaller at sublateral of basal fourth at middle, next to the previous, one which oblong at sublateral of basal third, one which oval and broadest at sublateral between apical fourth and third, and one near apex; one dot at middle of disc; each elytron also decorated with a narrow longitudinal inconspicuous pale yellow pubescence vitta along sutural margin extending from base to apex, and with a inconspicuous, sparsely yellow pubescence spot at middle of base; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark reddish brown, rather densely clothed with white pubescence on metepisternal and apical of first to fourth abdominal segments, sparsely on metesternum, basal and centres, and fifth abdominal segments, leaving dark reddish-brown portions on ventro-lateral basally of abdominal segments; the external mucro at the apex of moderately length in male.

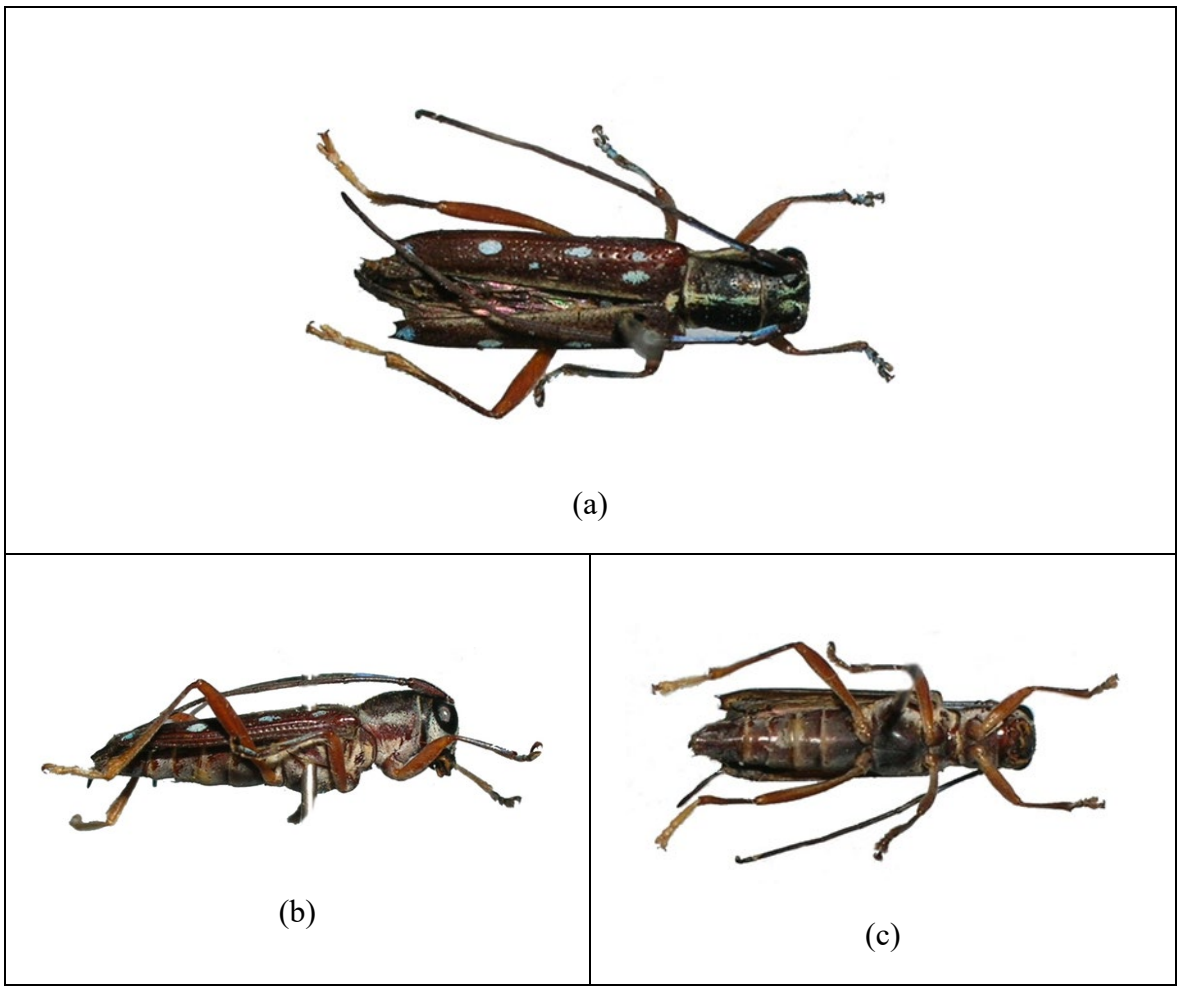


Figure 4.53: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp9.

51. *Glenea* sp.10 (SFC)

Materials examined: 1 specimen (♀).

(FRC Coll.) – Sarawak, Belaga, Bukit Semalong, 17.IV.1985, Lippa Akeng (♀).

Diagnosis: Body above uniformly dark brown, ornamented with white pubescence spots, dots, and longitudinal vittae; body beneath rather densely clothed with white pubescence; legs uniformly reddish-brown, sparsely clothed with short and recumbent white hairs, mixed with moderately long and erect white hairs, denser toward apices; antennae uniformly dark brown.

(♀) Length: 14 mm, width: 4.5 mm.

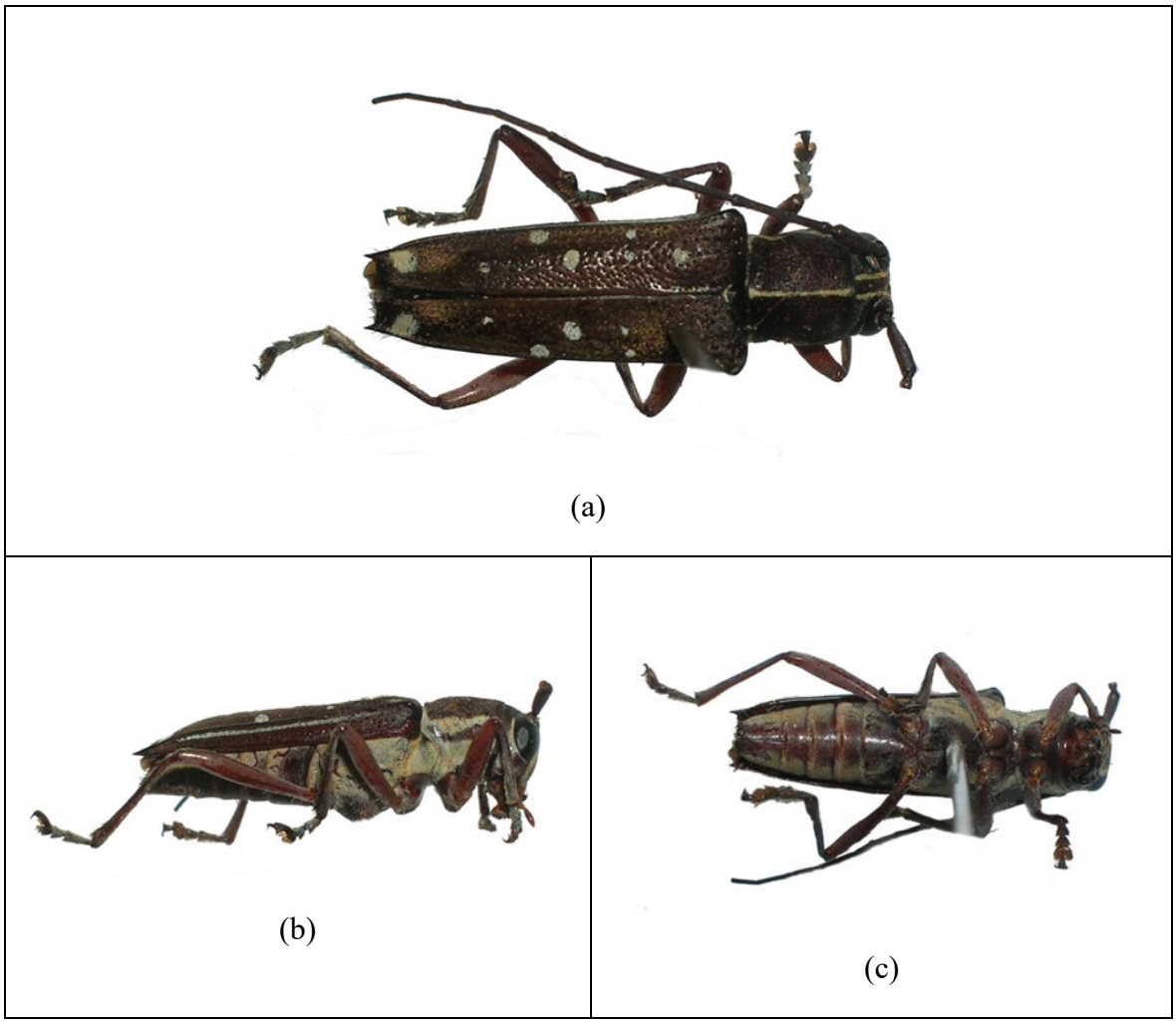
Description: Head with the front as long as wide, slightly smaller than the prothorax, vertex narrow, feebly concave, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with white pubescence on gena posteriorly, around the eyes and along margin of frons extending to occiput which forming two narrow longitudinal white pubescence vittae that divided at middle by longitudinal furrow, sparsely covered with short, inconspicuous and recumbent dark brown hairs on median of frons, occiput and anterior part of gena; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and weakly narrow at apex, sides vaguely, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, densely punctuated, vaguely punctuated at the sides, the punctures

nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, ornamented with three longitudinal white pubescence vittae, one which narrow along median, and a pair which broader laterally. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, densely clothed with short and dark brown pubescence, except of at the apex, where the pubescence is whitish.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, ornamented with white pubescence as follows: four spots, one at middle of elytron at basal fourth, one at middle of disc, one at sublateral of apical third before middle, and one which broadest near apex; four dots, one which elongated at sublateral near base, one before middle of basal third, one at sublateral of basal third before middle, and one between apical fourth and third at middle; each elytron also decorated with a narrow longitudinal vitta along upper punctures row of deflexed sides extending from base to apex, and with a inconspicuous, sparsely yellow pubescence spot at middle of base; the pubescence nearly hiding the punctures in good specimens.

Body beneath uniformly dark brown, rather densely clothed with white pubescence on metepisternal and sides of abdominal segments, sparsely on metasternum and centres of abdominal segments.



(a)

(b)

(c)

Figure 4.54: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp10.

52. *Glenea* sp.11 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Belaga, Bukit Semalong, 16.IV.1985, Manis Lintang (♂).

Diagnosis: Body above uniformly dark brown, ornamented with whitish blue pubescence spots on elytra and sides of pronotum, and a narrow longitudinal pale yellow pubescence vitta along sutural margin; body beneath dark reddish-brown, sparsely clothed with tawny yellow and white pubescence; femora, tibiae and tarsal of hind legs reddish-brown, tibiae and tarsal aof front and middle legs dark, sparsely clothed with recumbent whitish blue hairs, mixed with moderately long and erect pale yellow hairs, denser toward apices, hind tarsal sparsely clothed with recumbent and erect pale yellow hairs; posterior half of antennal scape, and posterior of first and second antennal segments sparsely clothed with short and recumbent whitish blue hairs, the following joints uniformly dark.

(♂) Length: 14.5 mm, width: 3.7 mm.

Description: Head with the front as long as wide, slightly broader than the prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely punctuated, rather densely clothed with whitish blue pubescence on lower part of gena, along margin of frons and upper part of the eyes, sparsely covered with short, inconspicuous and recumbent dark brown hairs on median of frons, upper part of gena, and on occiput, nearly hairless; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax distinctly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides vaguely, arcuately rounded anteriorly, strongly constricted behind middle; surface finely, densely punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum sparsely clothed with inconspicuous short and recumbent dark brown hairs, ornamented with a narrow longitudinal whitish blue pubescence vitta along median, and a pair of whitish blue pubescence spots at middle of lateral. Scutellum trapezoidal, broad, feebly concave, densely clothed with tawny yellow pubescence, except at the sides and basal, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with short and recumbent dark brown hairs, ornamented with whitish blue pubescence as follows: four spots, one at middle of elytron at basal fourth, one at sublateral of basal third before middle, one which oval and broadest at sublateral between apical fourth and third, and one near apex; two dots, one at middle of base, and one at middle of apical third, but tending to submedial; each elytron also decorated with a narrow longitudinal inconspicuous pale yellow pubescence vitta along sutural margin extending from basal thirh to near apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark reddish-brown, sparsely clothed with white pubescence on apical and centres of abdominal segments and metasternum, rather densely clothed with tawny

yellow pubescence on metepisternal, leaving dark reddis-brown portions on interior of metepisternal and basal sides of abdominal segments; the external mucro at the apex of moderately length in male.

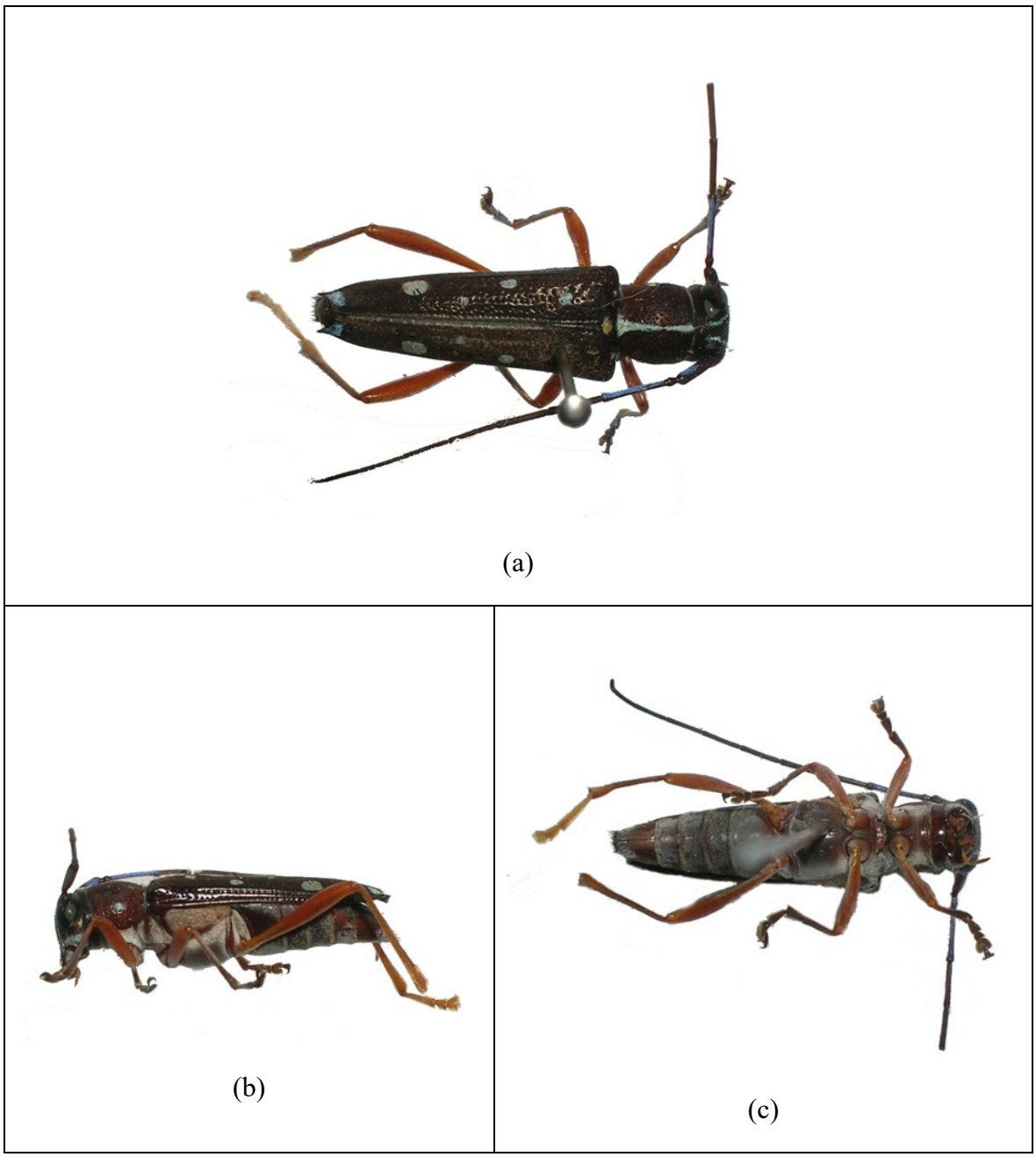


Figure 4.55: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp11.

53. *Glenea* sp.12 (SFC)

Materials examined: 1 specimen (♂).

(FRC Coll.) – Sarawak, Belaga, Danum, 21.VIII.2001, SFD Ento. Team (♂).

Diagnosis: Elytra uniformly dark reddish-brown, ornamented with white pubescence dots, pronotum dark bluish metallic; body beneath dark bluish metallic, rather densely clothed with white pubescence; femora third quaterly ochraceous, apical of femora, tibiae and tarsal dark bluish metallic, sparsely clothed with white recumbent hairs, mixed with moderately long and erect pale yellow hairs, denser toward apices; antennal scape, first and second segments dark bluish metallic, the following joints uniformly dark.

(♂) Length: 13.5 mm, width: 3.5 mm.

Description: Head with the front longer than wide, slightly broader than the prothorax, vertex narrow, feebly concave and sparsely clothed with white pubescence, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface coarsely, sparsely irregularly punctuated, densely clothed with pale yellow pubescence on gena and along margin of frons, median of frons sparsely clothed with short and erect dark hairs, nearly hairless, occiput densely clothed with inconspicuous, short, erect and recumbent dark brown hairs; the eyes and mandible black, maxillary and labial palpal ochraceous; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted behind middle; surface coarsely, densely irregularly punctuated, vaguely punctuated at the sides, the

punctures nearly concealed by the pubescence, pronotum clearly dark bluish metallic, rather densely clothed with short, erect and inconspicuous brown hairs, and ornamented with white pubescence spots and dots as follows: four spots, two on each side laterally, one near base and one which bigger near base; two dots on median, one near base and one near apex. Scutellum transverse lateovovatus, rounded at apex, broad, feebly concave, densely clothed with black pubescence, except of at the apex, where the pubescence is whitish.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, rather densely, irregularly punctuated basally, the punctures becoming finer, sparser and obsolete toward apices, each elytron densely covered with short and recumbent brown hairs, and ornamented with four white pubescence dots, one which ill-defined just behind middle of basal fourth basal fourth, one which slightly elongated at sublateral between basal fourt and third, one which biggest at the middle of disc, and one at sublateral of apical fourth, apices of elytron also decorated with a narrow transversely white pubescence band; the pubescence nearly hiding the punctures in good specimens.

Body beneath dark bluish metallic, densely covered with white pubescence on basal and apical of metepisternal, and the sides of abdominal segments, leaving dark bluish metallic portions on metasternum, centres of metepisternal and centres of abdominal segments; the external mucro at the apex of moderately length in male.

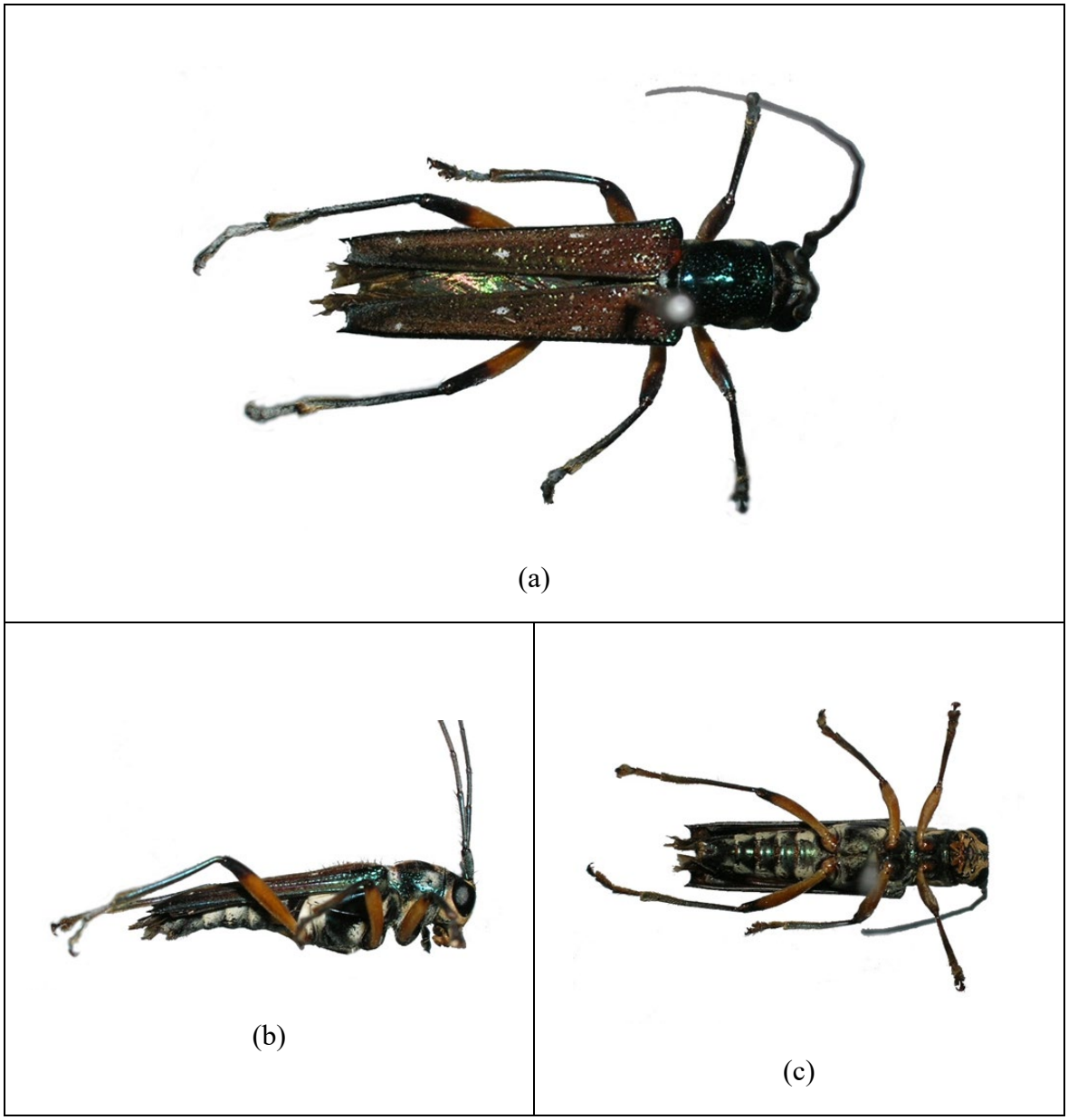


Figure 4.56: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp12.

54. *Glenea* sp.13 (SFC)

Materials examined: 2 specimens (1 ♀, 1 ♂).

(FRC Coll.) – Sarawak, Niah, 28.III.1984, SFD Ento. Team (♀); Sarawak, Niah, 28.III.1984, SFD Ento. Team (♂).

Diagnosis: Body above uniformly dark brown, decorated with tawny yellow pubescence spots on elytra and longitudinal pubescence vittae on pronotum; body beneath dark densely clothed with pale yellow pubescence; legs uniformly reddish-brown, darker in male; antennae uniformly brown, darker in male.

(♀) Length: 12 mm, width: 3.7 mm.

(♂) Length: 12.7 mm, width: 3.7 mm.

Description: Head with the frons longer than wide, slightly broader than the prothorax, vertex broad and flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with pale yellow pubescence on gena and along margin of frons, occiput decorated with two narrow longitudinal tawny yellow pubescence vittae along median extending from vertex, divided by a fine longitudinal furrow, median of frons and other area of occiput densely clothed with short and recumbent brown hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, slightly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted

behind middle; surface finely, densely irregularly punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and ornamented with a narrow longitudinal tawny yellow pubescence vitta along median. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, densely clothed with tawny yellow pubescence, except at the basal sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with short and recumbent dark brown hairs, and ornamented with four tawny pubescence spots as follows: first of which oblong at sublateral behind base at basal fourth, second at the middle of elytron at basal fourth, third of which bigger at sublateral just behind middle of disc, and fourth near apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with pale yellow pubescence, sparser on metasternum and centres of abdominal segments, and leaving dark reddish-brown portions on abdominal segments ventro-laterally; the external mucro at the apex of moderately length in male.

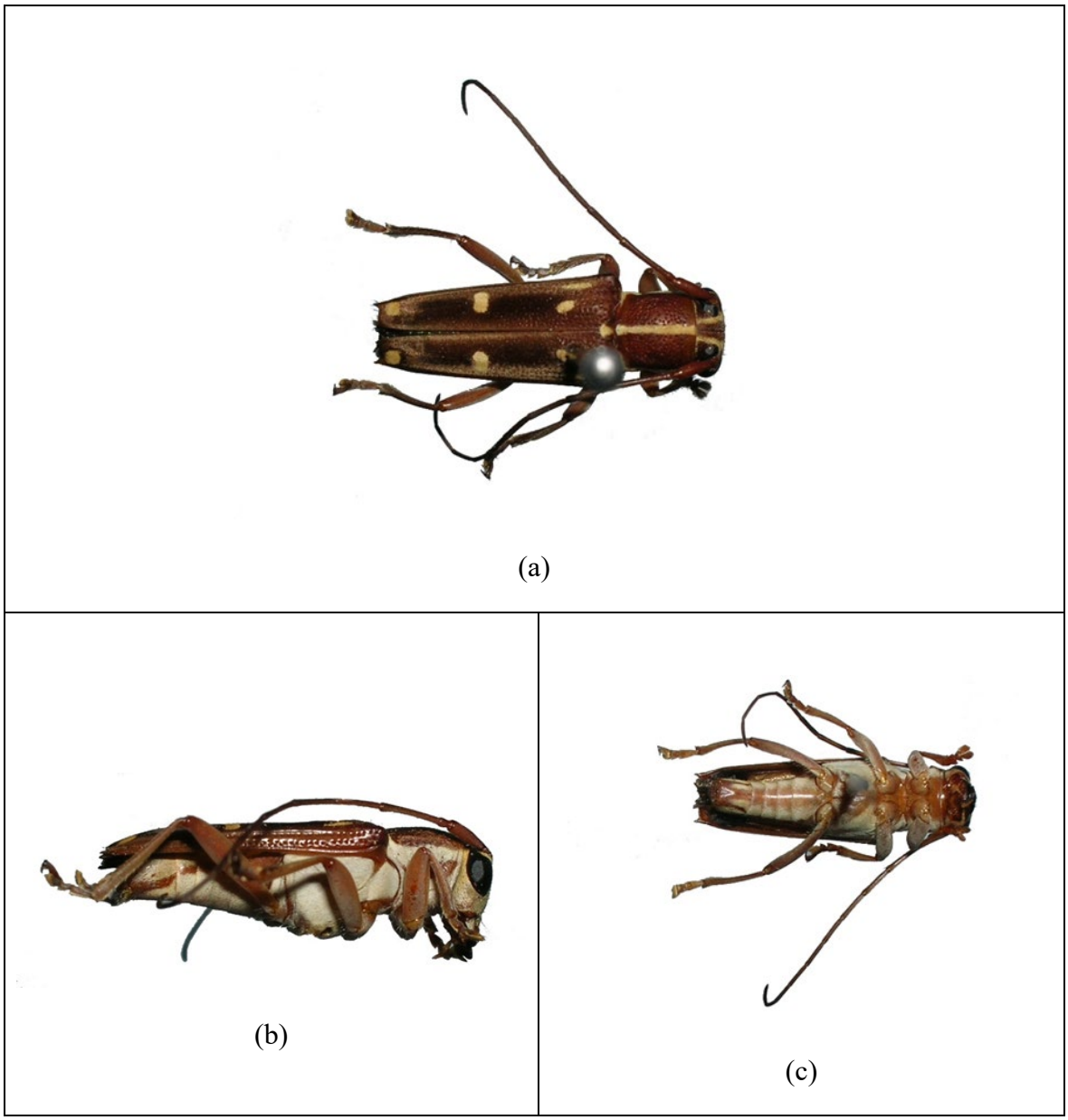


Figure 4.57: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp13.

55. *Glenea* sp.14 (SFC)

Materials examined: 1 specimen (♀).

(FRC Coll.) – Sarawak, Samunsam Wildlife Sanctuary, 22.IX.1988, Mahmud Merdek (♀).

Diagnosis: Body above uniformly dark brown, decorated with tawny yellow pubescence spots on elytra and longitudinal pubescence vittae on pronotum and deflexed sides of elytra; body beneath densely clothed with white pubescence; legs uniformly dark reddish-brown; antennae uniformly dark brown.

(♀) Length: 12 mm, width: 3.7 mm.

Description: Head with the front as long as wide, slightly broader than the prothorax, vertex broad and flat, occiput weakly convex at middle of base, frons rectangular, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with pale and tawny yellow pubescence around the eyes and margin of frons, sparsely clothed with short and inconspicuous pale yellow hairs on median part of frons, occiput decorated with two narrow longitudinal tawny yellow pubescence vittae along median extending from vertex, divided by a fine longitudinal furrow, other area of occiput densely clothed with short and recumbent brown hairs; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, scarcely constricted behind middle; surface finely, densely irregularly punctuated, vaguely punctuated at the

sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and ornamented with a narrow longitudinal tawny yellow pubescence vitta along median. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, densely clothed with tawny yellow pubescence, except at the basal sides, where the pubescence is dark brown.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with short and recumbent dark brown hairs, and ornamented with four tawny pubescence spots as follows: first of which oblong along sublateral of basal fourth extending just behind base, second which also oblong and tapering posteriorly along median of basal fourth extending from base to middle, third of which biggest slightly transverse but not touching sutural and lateral margin just behind middle of disc, and fourth near apex; each elytron also decorated with two narrow longitudinal tawny yellow pubescence vittae, one which ill-defined along sutural margin, and one at the deflexed sided along upper punctures row; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with white pubescence, sparser on metasternum and centres of abdominal segments, and leaving dark brown portions on basal sides of first abdominal segments.

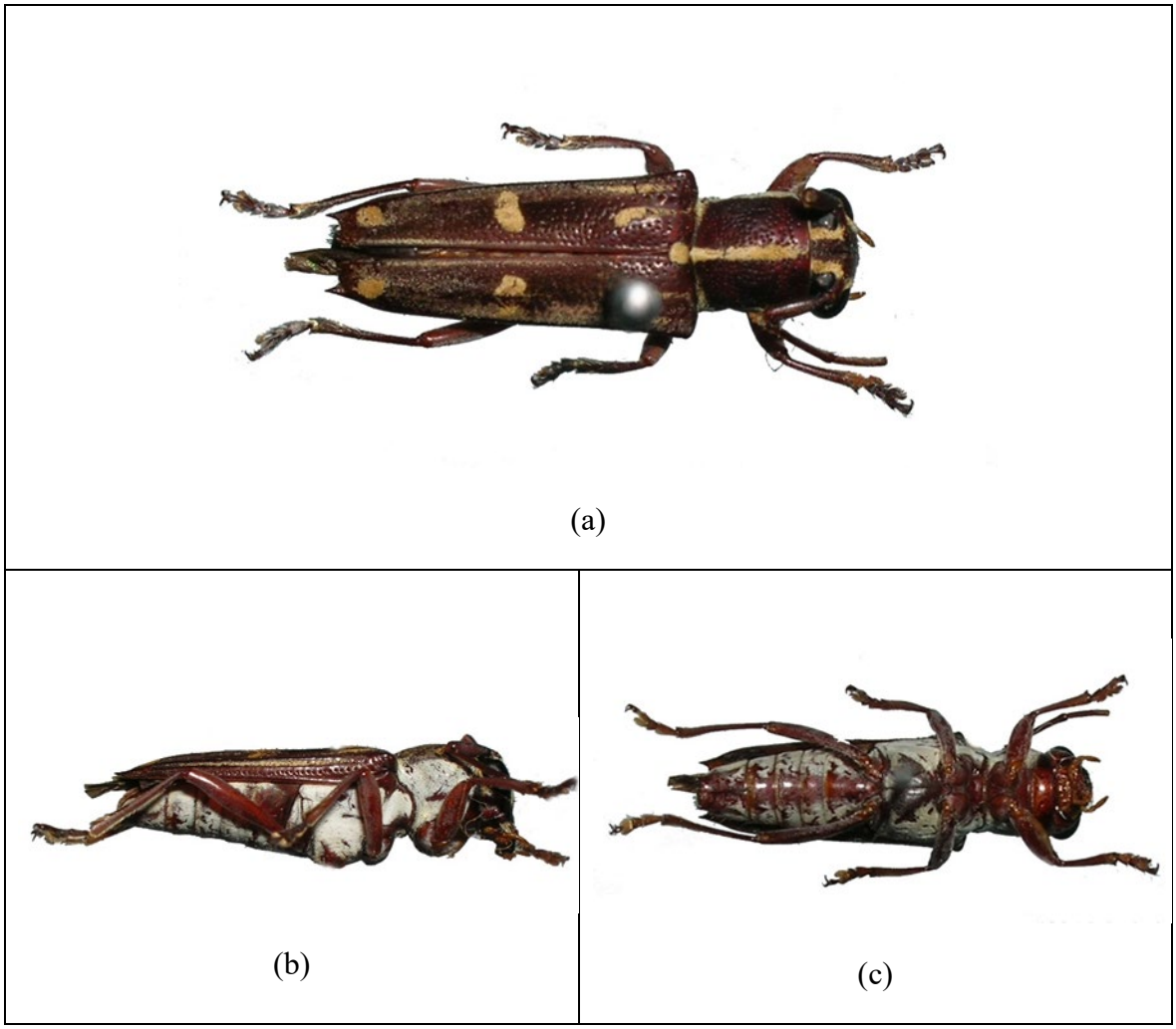


Figure 4.58: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp14.

56. *Glenea* sp.15 (FRC)

Materials examined: 2 specimens (2 ♂).

(FRC Coll.) – Sarawak, Belaga, Bukit Semalong, 14.IV.1985, Lippa Akeng (♂); Sarawk, Belaga, Bukit Semalong, 17.IV.1985, Manis Lintang (♂).

Diagnosis: Head and pronotum black, elytra uniformly dark brown, decorated with longitudinal tawny yellow pubescence vittae; body beneath densely clothed with pale yellow pubescence; femora reddish-brown, tibiae and tarsal dark brown, sparsely clothed with short and recumbent pale yellow hairs, sparsely mixed with erect and moderately long pale yellow hairs, denser toward apices; antennae uniformly dark brown.

(♂) Length: 11-12 mm, width: 3.1-3.4 mm.

Description: Head with the front longer than wide, equal in width with prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, slightly oblong, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with pale and tawny yellow pubescence on gena posteriorly and margin of frons, sparsely clothed with inconspicuous, short and inconspicuous dark brown hairs on gena anteriorly, median part of frons and occiput, and ornamented with two narrow longitudinal pale yellow pubescence vittae along median of occiput divided by a fine longitudinal furrow at the middle; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, about as long as the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted

behind middle; surface finely, densely irregularly punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and ornamented with three longitudinal pale yellow pubescence vittae, one which narrow along median, and a pair which broader and whiter laterally. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, rather sparsely clothed with pale yellow pubescence along the rounded apex, other area sparsely clothed with recumbent dark brown hairs.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely covered with short and recumbent dark brown hairs, and ornamented with two slightly narrow longitudinal tawny yellow pubescence vittae, one along sutural margin extending from base to apices, crossing along apical margin and touching lateral margin, and one along sublateral extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath black, densely covered with pale yellow pubescence on metepisternal, rather sparsely on metasternum and centres of abdominal segments, and leaving black portions on basal sides of abdominal segments and interior of metepisternal; the external mucro at the apex of moderately length in male.

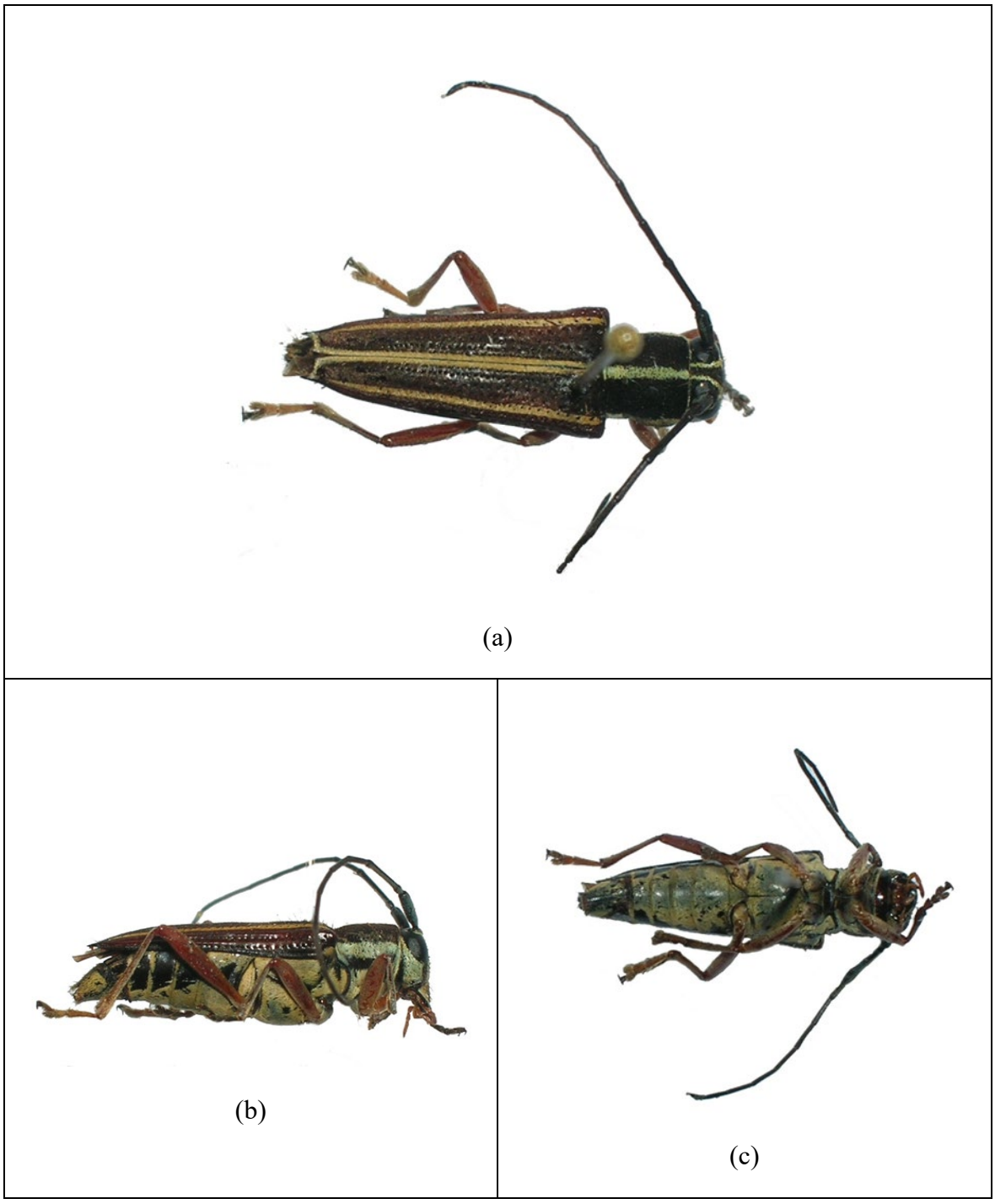


Figure 4.59: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp15.

57. *Glenea* sp.16 (FRC)

Materials examined: 2 specimens (2 ♂).

(FRC Coll.) – Sarawak, Belaga, Bukit Semalong, 13.IV.1985, Lippa Akeng (♂); Sarawk, Belaga, Bukit Semalong, 24.IV.1985, SFD Ento. Team (♂).

Diagnosis: Body above uniformly dark brown, ornamented with rather broad and narrow longitudinal tawny yellow pubescence vittae; body beneath densely clothed with pale yellow pubescence; femora dark reddish-brown, tibiae and tarsal dark brown, sparsely clothed with pale yellow pubescence, sparsely mixed with erect and moderately long pale yellow hairs, denser toward apices; antennae uniformly dark.

(♂) Length: 10 mm, width: 2.7 mm.

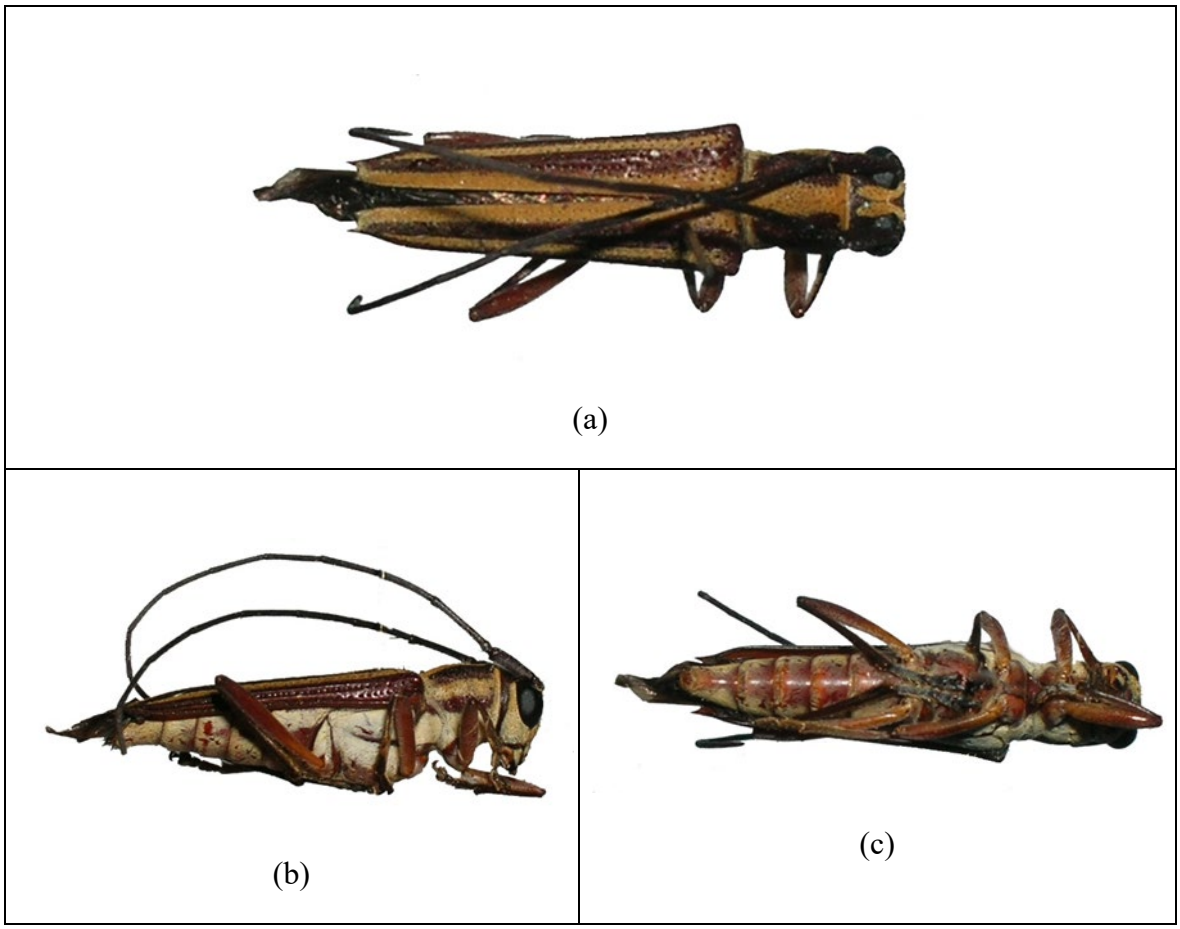
Description: Head with the front slightly longer than wide, slightly broader than prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, slightly oblong, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with pale and tawny yellow pubescence on gena, around eyes and margin of frons, median part of frons and occiput densely clothed with recumbent and short black hairs, and ornamented on median of occiput with two broad longitudinal tawny yellow pubescence vittae divided by a fine longitudinal furrow at the middle, but the vittae not touching the base of occiput; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted

behind middle; surface finely, densely irregularly punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and ornamented with three longitudinal tawny yellow pubescence vittae, a pair which broad along lateral, and one which broader along median, these vittae connected by two narrow transverse tawny yellow pubescence bands at base and apex. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, rather densely clothed with tawny yellow pubescence entirely, forming a spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, and ornamented with two rather broad longitudinal tawny yellow pubescence vittae, one which broad but narrowed apically along sutural margin extending from base to apex, and this pubescence covered apices, and one which narrower along sublateral extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with pale yellow pubescence, sparsely clothed on metasternum and centres of abdominal segments, and leaving dark portions on basal ventro-laterally of first to fourth abdominal segments and interior of metepisternal; the external mucro at the apex of moderately length in male.



(a)

(b)

(c)

Figure 4.60: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp16.

58. *Glenea* sp.17 (FRC)

Materials examined: 2 specimens (2 ♂).

(FRC Coll.) – Sarawak, Niah, 24.II.1979, A.A. Hamid (♂); Sarawak, Simanggang, Jongkong, 2.VII.1980, Mercer and Suhaili (♂).

Diagnosis: Body above uniformly dark brown, ornamented with rather broad and narrow longitudinal tawny yellow pubescence vittae; body beneath densely clothed with pale yellow pubescence; femora uniformly dark reddish-brown, tibiae and tarsal of front and middle legs dark, hind tarsal reddish-brown, sparsely clothed with pale yellow pubescence, sparsely mixed with erect and moderately long pale yellow hairs, denser toward apices; antennae uniformly dark.

(♂) Length: 12 mm, width: 3.3 mm.

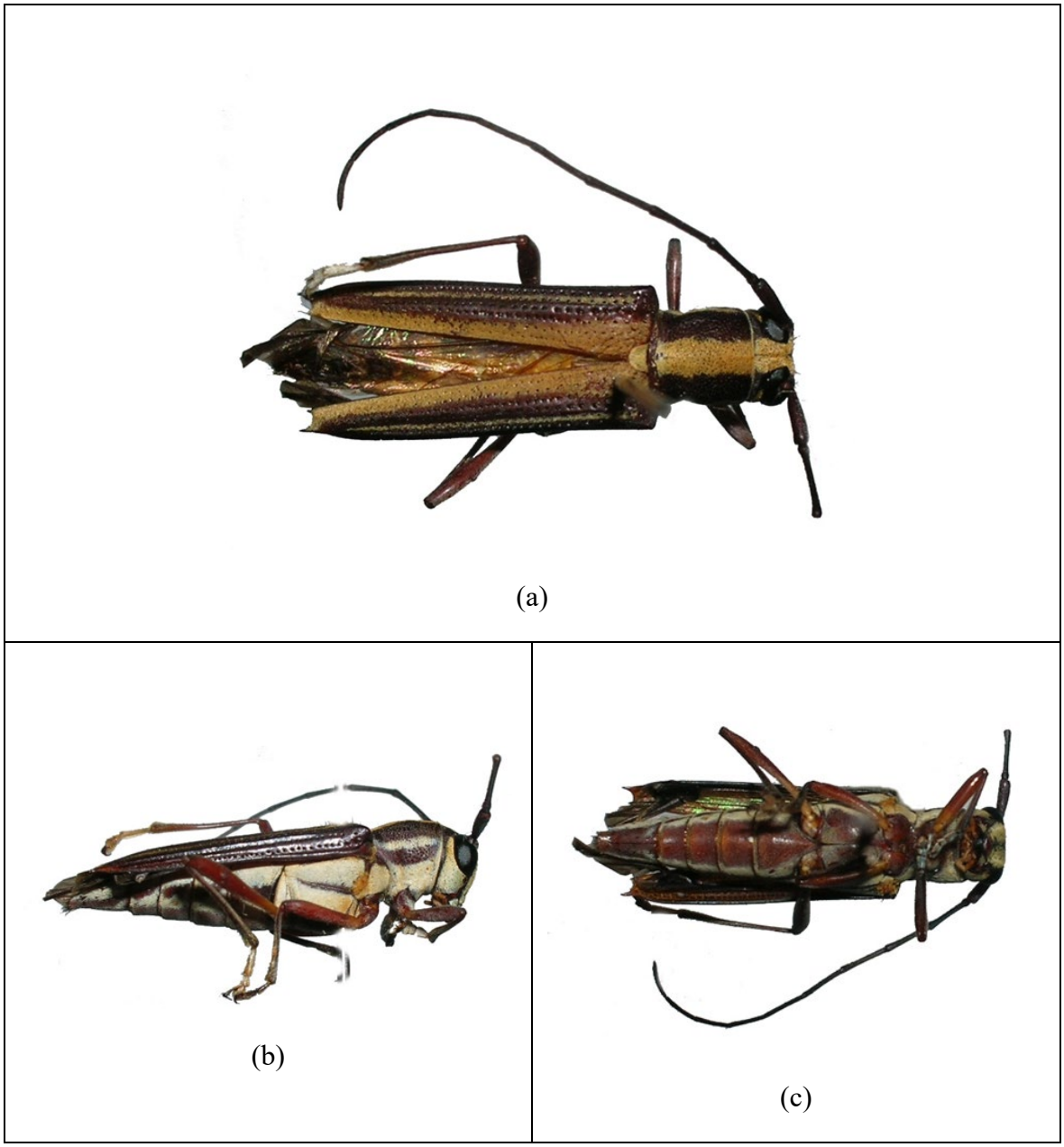
Description: Head with the front slightly longer than wide, slightly broader than prothorax, vertex broad, feebly flattened, occiput weakly convex at middle of base, frons rectangular, slightly oblong, with a fine longitudinal furrow extending from epistoma to occiput; surface finely, sparsely irregularly punctuated, densely clothed with pale and tawny yellow pubescence on gena, around eyes and margin of frons, median part of frons and occiput densely clothed with recumbent and short black hairs, and ornamented on median of occiput with a slightly large tawny yellow pubescence spots elongated from vertex to occiput occiput; the eyes and mandible black, maxillary and labial palpal reddish-brown; gena fairly shorter than the inferior eyelobe; antennae slender, fairly longer than the body.

Prothorax slightly longer than wide, almost parallel-sided at apical half and narrowed from behind to middle, sides feebly, arcuately rounded anteriorly, strongly constricted

behind middle; surface finely, densely irregularly punctuated, vaguely punctuated at the sides, the punctures nearly concealed by the pubescence, pronotum densely clothed with short and recumbent dark brown hairs, and ornamented with three longitudinal pubescence vittae, a pair which narrow and pale yellow along lateral, and one which broad and tawny yellow along median, these vittae connected by two narrow transverse tawny yellow pubescence bands at base and apex. Scutellum transverse late ovovatus, rounded at apex, broad, feebly concave, rather densely clothed with tawny and pale yellow pubescence entirely, forming a spot.

Elytra broader than prothorax at base, nearly one and half time as long as the basal width, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of fine punctures, almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically, each elytron densely clothed with short and recumbent dark brown hairs, and ornamented with two rather broad longitudinal tawny yellow pubescence vittae, one which broad but narrowed apically along sutural margin extending from base to apex, and this pubescence covered apices, and one which narrower along sublateral extending from base to apex; the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with pale yellow pubescence, leaving dark reddish-brown portions on interior of metepisternal, metasternum, ventro-lateral and centres of abdominal segments; the external mucro at the apex of moderately length in male.



(a)

(b)

(c)

Figure 4.61: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp17.

59. *Glenea* sp18 (nr. *elegans* Olivier, 1795)

Materials examined: 1 ♀.

(FRST Museum Coll.) – Sarawak, Bario, Kelabit Highland, 14.IV.1995, Lim Chan Kun (♀).

Diagnosis: Above uniformly dark bluish metallic, densely covered with short, erect, velvety black pubescence and ornamented with white pubescence spots and stripes; body beneath dark bluish metallic, covered with white pubescence, front and middle legs, femora and tibiae of hind legs dark bluish metallic, meanwhile tarsal of hind legs reddish brown; antennae uniformly dark bluish metallic, scape and first segment sparsely clothed short, recumbent white hairs.

(♀) Length: 24 mm, width: 5.5 mm.

Prothorax slightly longer than wide, margin wider at the base, narrowed anteriorly, sides scarcely, arcuately rounded anteriorly; surface sparsely, coarsely, irregularly punctuated, vaguely punctuated at sides, the punctures nearly concealed by the pubescence, densely clothed with short, erect, velvety black hairs, ornamented with three, slightly narrow, longitudinal white pubescence vittae, one on the median, and two dorso-laterally. Scutellum triangular, slightly rounded at apex, nearly flat, but concave anteriorly, dark bluish metallic scutellum densely covered with white pubescence, formed a white spot.

Elytra broader than prothorax, slightly narrowed basally, strongly carinate and deflexed at the sides, deflexed sides with two longitudinal rows of coarse punctures, almost straightly narrowed posteriorly to the point of short distance before apices, then fairly narrowed to obliquely truncate apices with a short spine at the sutural margin and a longer

spine at the outer angle; surface coarsely, sparsely, irregularly punctuated basally, the punctures becoming finer and sparser apically; each dark bluish metallic elytron densely clothed with short, erect, velvety black hairs, ornamented with two, short, narrow longitudinal white pubescence vittae, one along median of basal fourth, and one which longer along sublateral of basal fourth, a narrow , longitudinal white pubescence vitta on sutural margin extending from middle of basal fourth to middle of disc, one obliquely transverse white pubescence spot at middle of disc, and also decorated with five white pubescence spots as follows: one between basal fourth and third medially, one at sublateral of basal third just in front of middle, one which oblong along sublateral of apical third, one at middle of submedial of apical third, and one nearly transverse near apex at apical fourth; each elytron also decorated with four smaller, white pubescence spots at apical third, one at middle, and three arranged parallel submedially, the pubescence nearly hiding the punctures in good specimens.

Body beneath densely covered with white pubescence, leaving dark bluish metallic portions on metasternum, basal and centres of abdominal sternites.

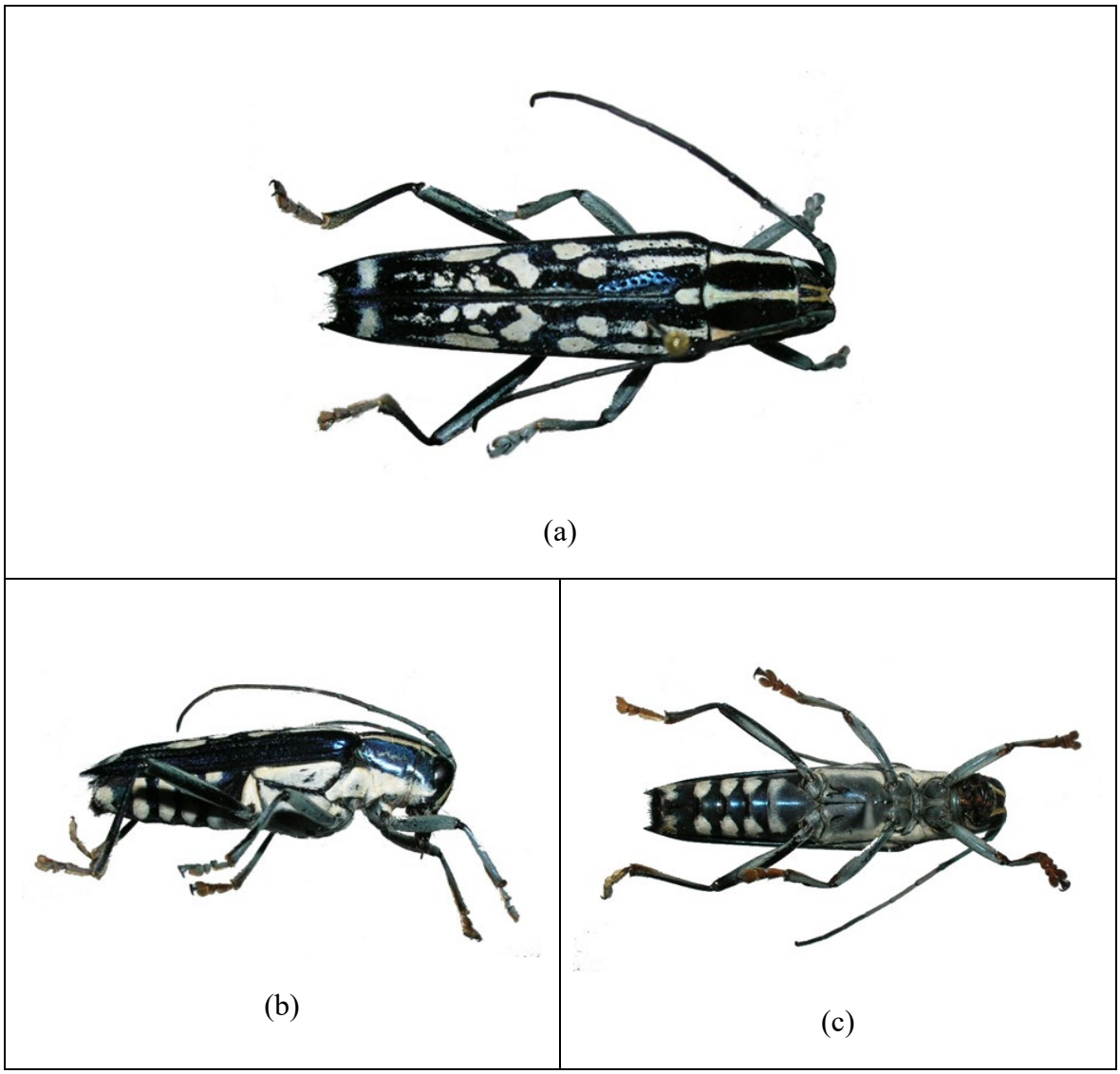


Figure 4.62: a) Dorsal view, b) Lateral view, c) Ventral view of species *Glenea* sp18.

4.3.8 Dichotomous key to the species of genus *Glenea* Newman of Sarawak.

1.	Elytra strongly carinate and deflexed at the sides…….....2
	Elytra with lateral carinae incomplete and moderately deflexed at the sides. Body above and beneath densely clothed with short yellow pubescence, decorated with two broad transverse short black pubescence bands near base and apex around pronotum. Each elytron decorated with two black pubescence blotches and one black pubescence spot (Figure 4.39)……..……..……*citrina*
2.	Margin wider at base of prothorax……3
	Margin not wider at base of prothorax…….……..…6
3.	Head with a narrow and smooth longitudinal carina extending from epistoma to vertex, and a fine longitudinal furrow extending from vertex to occiput……..…….4
	Head with a fine longitudinal furrow extending from epistoma to occiput, and ornamented with two white pubescence spots dorso-ventrally. Prothorax decorated with five longitudinal white pubescence vittae. Each elytron ornamented with three white pubescence spots and three longitudinal white pubescence vittae (Figure 4.41)……*juno*
4.	Head and pronotum with three longitudinal pubescence vittae……5
	Head with four and pronotum with five longitudinal white pubescence vittae. Each elytron decorated with white pubescence as follows: five spots, one

	transverse band, two longitudinal vittae, and one dot (Figure 4.37)……..…….....*trivittata*
5.	Each elytron ornamented with two longitudinal white pubescence vitttae, five white pubescence spots, and a transverse white pubescence band (Figure 4.40)……..…….……..…*elegans*
	Each elytron ornamented with three longitudinal white pubescence vittae, five white pubescence spots, and a transverse white pubescence band (Figure 4.62)…….. sp. 18
6.	Elytra not ornamented……7
	Elytra ornamented……..8
7.	Pronotum ornamented with a narrow longitudinal yellow pubescence vitta along median, and two narrow longitudinal yellow pubescence vittae on occiput (Figure 4.10)…….……...*camelina*
	Pronotum densely clothed with short orange-coloured pubescence, head with a slightly broad longitudinal orange-coloured pubescence vittae along median of occiput (Figure 4.33)…..……..……....*rufifrons*
8.	Pronotum not ornamented with blotches, spots, dots, transverse bands or longitudinal stripes…….9
	Pronotum ornamented with blotches, spots, dots, transverse bands or longitudinal stripes……..….12
9.	Scutellum ornamented with pubescence spots or dots……..….10

	Scutellum not ornamented with pubescence spots or dots…….11
10.	Prothorax densely clothed with sulphurous pubescence at the sides and beneath, leaving dark brown late obtriangular portion on pronotum, each elytron ornamented with three sulphurous pubescence blotches, and the deflexed sides decorated with a sulphurous pubescence dot at basal fourth (Figure 4.31)……...*pulchella*
11.	Head, pronotum, and posterior half of elytra uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a yellow pubescence spot on occiput in female, no spot in male, and yellow pubescence transverse band and spot on elytra body beneath uniformly dark, sparsely clothed with short greyish pubescence (Figure 4.24)……..……..……...…..*laudata*
	Head, pronotum, and posterior half of elytra uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a yellow pubescence spot on occiput in female, no spot in male, and yellow pubescence transverse band and spot on elytra; body beneath dark reddish-brown, covered with white or pale yellow pubescence (Figure 4.14)……..……*dimidiata dimidiata*
	Each elytron ornamented with a blotch, a spot, an obliquely transverse band, and two inconspicuous white pubescence dots (Figure 4.46)…….…sp. 2
12.	Scutellum not ornamented……...…….13
	Scutellum ornamented with bright coloured pubescence spot or dot……...22

13.	Head not ornamented with bright coloured pubescence spots, dots, or stripes……14
	Head ornamented with bright coloured pubescence spots, dots, or stripes…….....19
14.	Prothorax decorated with pubescence collar……15
	Prothorax no pubescence collar……...……17
15.	Each elytron decorated with a pubescence blotch…….16
	Each elytron decorated with three narrow longitudinal pale yellow pubescence vittae (Figure 4.11)……..…….….*collaris*
16	Each elytron decorated with a large median patch of ochraceous yellow pubescence and an ochraceous yellow pubescence spot at the apex (Figure 4.25)……..…..…*manto*
	Each elytron decorated with white pubescence as follows: a blotch behind middle of elytron, a dot at sublateral before middle of apical fourth, a spot near apex, and a longitudinal vitta at the deflexed sides (Figure 4.20)……..*funerula funerula*
17.	Elytra ornamented with transverse band……...18
	Elytra no transverse band, each elytron ornamented with a yellow pubescence spot near apex, and five yellow pubescence dots (Figure 4.19)…..*fatalis*
18.	Each elytron ornamented with three narrow and inconspicuous longitudinal white pubescence vittae, and obliquely incomplete and inconspicuous white

	transverse pubescence band; pronotum ornamented with a white pubescence dot at base on median (Figure 4.22)…….*iresene*
	Each elytron ornamented with four whitish blue pubescence spots, and a slightly obliquely transverse whitish blue pubescence band or crescent-shaped just behind the middle of disc. Prothorax clothed with short orange-coloured pubescence, and ornamented with two black pubescence spots (Figure 4.43)……...……*regina*
19.	Head with less than four pubescence stripes…….20
	Head with four pubescence stripes……21
20.	Head and pronotum ornamented with a slightly broad longitudinal yellow pubescence vitta, posterior half of elytron uniformly dark, covered with short black pubescence, anterior half of elytra uniformly brown, ornamented with a yellow pubescence spot and transverse band on elytra; body beneath covered with white or pale yellow pubescence (Figure 4.15)……...…*dimidiata semigrisea*
	Head ornamented with two narrow longitudinal white pubescence vittae; prothorax ornamented with five longitudinal white pubescence vittae; elytra reddish-brown except dark on posterior half of apical fourth, which decorated with a narrow obliquely transverse white pubescence band near apex (Figure 4.44)**……..……...***angerona angerona*
21.	Prothorax ornamented with five narrow orange-coloured longitudinal pubescence vittae; each elytron decorated with seven orange-coloured

	pubescence dots, a slightly transverse orange-coloured pubescence band near apex, and an inconspicuous longitudinal orange-coloured pubescence vitta along median of basal fourth extending from base to middle of basal fourth (Figure 4.6)……..…...*aspasia*
	Prothorax ornamented with four broad longitudinal white bluish pubescence vittae; each elytron decorated with five longitudinal white bluish pubescence vittae, which two vittae along the deflexed sides, and a white bluish spot at middle of basal third (Figure 4.47)……..…….…...…sp. 3
22.	Pronotum no pubescence blotch……23
	Pronotum ornamented with tallow pubescence blotch along median; each elytron ornamented with two narrow longitudinal yellow pubescence vittae, one which ill-defined along sutural margin, and one along sublateral near lateral carina extending just behind middle of disc to half of apical fourth, and two yellow pubescence spots, one at middle of disc, and one which bigger near apex (Figure 4.23)……..……..…..…….……*latevittata*
23	Elytra ornamented with a pair of pubescence blotch……..…...24
	Elytra no pubescence blotch……...…...26
24	Each elytron ornamented with two pubescence spots……...25
	Each elytron ornamented with a testaceous yellow pubescence spot at apex; pronotum with a testaceous yellow pubescence dot at median of base (Figure 4.17)……..……...…*disa*

25	Pronotum decorated with a pale yellow pubescence spot at middle of base, and two longitudinal vitae laterally; each elytron ornamented with a blotch, two spots, and three longitudinal pubescence vittae (Figure 4.49)…….sp. 5
	Body above uniformly bluish white, ornamented with velvety black pubescence as follows: three spots on head, two dots on pronotum, a longitudinal vitta along median of pronotum, a blotch with obliquely transverse bluish white pubescence band on each elytron, and two spots on each elytron (Figure 4.42)……..……...….. *celia*
26	Elytra ornamented with transverse pubescence band……....27
	Elytra no transverse pubescence band……...……33
27.	Elytra ornamented with one transverse pubescence band……..28
	Elytra ornamented with two pale yellow transverse pubescence band, two longitudinal pale yellow pubescence vittae, and one pale yellow pubescence spot at the deflexed sides; pronotum decorated with three pale yellow pubescence vittae (Figure 4.48)……..…..……..... sp. 4
28.	Head ornamented with stripes on occiput……..29
	Head no stripe, only with two white pubescence dots; pronotum ornamented with three longitudinal white pubescence vittae, and four white pubescence spots; each elytron ornamented with four white pubescence spots, three white pubescence dots, one narrow transverse white pubescence band at apex, and one longitudinal white pubescence vitta at the deflexed sides (Figure 4.51)…….……..sp.7

29.	Head ornamented with four stripes on occiput……..30
	Head ornamented with less than four stripes on occiput……32
30	Pronotum ornamented with five longitudinal pubescence vittae…….……31
	Pronotum ornamented with three longitudinal white pubescence vittae; head ornamented with four white stripes; each elytron ornamented with white pubescence as follows: two longitudinal vittae, one transverse band near apex, and two dots (Figure 4.28)……..……..……*melia*
31.	Each elytron ornamented with three longitudinal yellow pubescence vittae, and a narrow transverse yellow pubescence band at middle; apical of second antennal segment densely clothed with short white pubescence vitta (Figure 4.18)……..……..…*extensa*
	Each elytron ornamented with three longitudinal yellow pubescence vittae, and a narrow transverse yellow pubescence band at middle; antennae entirely dark brown (Figure 4.35)…….……*sejuncta*
32.	Head ornamented with two ochraceous yellow stripes on occiput; pronotum ornamented with a narrow longitudinal ochraceous yellow pubescence vittae along median; each elytron ornamented with ochraceous yellow pubescence as follows: one transverse band at middle of disc, one spot at apex, and four longitudinal vittae (Figure 4.30)…….*ochraceovittata ochraceovittata*
	Head and pronotum ornamented with a slightly broad longitudinal yellow pubescence vitta; posterior half of elytra uniformly dark, covered with short

	black pubescence, anterior half of elytra uniformly brown, ornamented with a yellow pubescence spot and transverse band on elytra; body beneath uniformly dark, sparsely clothed with short greyish pubescence (Figure 4.16)……..…….……*dimidiata* var.
33.	Elytra no longitudinal pubescence vitta……..……..34
	Elytra ornamented with longitudinal pubescence vittae……...….41
34.	Head ornamented……..35
	Head not ornamented…….....38
35.	Pronotum striped……...36
	Pronotum ornamented with six pale yellow or white pubescence spots; each elytron ornamented with four inconspicuous white pubescence dots (Figure 4.9)……..……..…*calypso*
36.	Pronotum ornamented with three longitudinal pubescence vittae…….……37
	Pronotum ornamented with a narrow longitudinal yellow pubescence vitta along median; each elytron ornamented with four yellow pubescence spots (Figure 4.57)……...…..sp. 13
37.	Head ornamented with two longitudinal white pubescence vittae on occiput; each elytron ornamented with five white pubescence spots, and two white pubescence dots (Figure 4.32)…….……*pustulata pustulata*

	Head ornamented with four longitudinal tawny yellow pubescence vittae on occiput; each elytron ornamented with five tawny yellow pubescence spots, one on the base of deflexed sides, and decorated with an inconspicuous, narrow, elongated and small tawny yellow pubescence dot at middle of sublateral between basal fourth and third (Figure 4.45)…..……..……sp. 1
38.	Pronotum with a longitudinal pubescence vitta…….39
	Pronotum ornamented with four white pubescence spots laterally, and two white pubescence dots; each elytron ornamented with four white pubescence dots (Figure 4.56)…….……..sp. 12
39.	Each elytron ornamented with five pubescence spots……...40
	Each elytron ornamented with four whitish blue pubescence spots, and two whitish blue pubescence dots (Figure 4.26)…..…...……*matangensis*
40.	Each elytron ornamented with a whitish blue pubescence dot (Figure 4.50)……sp. 6
	Each elytron no pubescence dot (Figure 4.36)…….……*subsimilis thetis*
41.	Elytra no pubescence spot……..……...42
	Elytra ornamented with pubescence spots…….46
42.	Head ornamented with longitudinal pubescence vittae….....43
	Head ornamented with a tawny yellow pubescence spot on median of occiput; pronotum ornamented with three longitudinal yellow pubescence vittae; each

	elytron ornamented with two rather broad longitudinal tawny yellow pubescence vittae (Figure 4.61)…….sp.17
43.	Pronotum ornamented with three longitudinal pubescence vittae……..…44
	Pronotum ornamented with a broad longitudinal testaceous yellow pubescence vitta along median; each elytron ornamented with a broad longitudinal testaceous yellow pubescence vittae along sutural margin, and decorated with three ill-defined whitish blue elongated pobescence dots (Figure 4.4)…….……...……..…*algebraica*
44.	Each elytron ornamented with two longitudinal pubescence vittae…….....45
	Each elytron ornamented with three yellow pubescence vittae, one which pale yellow along the deflexed sides (Figure 4.5)….……*analytica*
45.	Pronotum ornamented with three longitudinal tawny yellow pubescence vittae, a pair which broad along lateral, and one which broader along median, these vittae connected by two narrow transverse tawny yellow pubescence band at base and apex (Figure 4.60)…..…… sp. 16
	Three longitudinal pubescence vittae on pronotum separated (Figure 4.59)……... sp. 15
46.	Head not ornamented with pubescence spot or stripe……47
	Head ornamented with pubescence spot or stripe……..49
47.	Pronotum decorated with pubescence spot and vitta…….48

	Pronotum decorated with three longitudinal whitish blue pubescence vittae; each elytron also decorated with five whitish blue pubescence spots, one whitish blue pubescence dot, and a narrow longitudinal pale yellow pubescence vitta along sutural margin (Figure 4.53)……..…..… sp. 9
48.	Each elytron ornamented with whitish blue pubescence as follows: four spots, one at median of elytron at basal fourth, one which smaller at sublateral of basal third, one which broadest at sublateral between apical fourth and third, and one near apex; two dots, one at sublateral at basal fourth at middle, and one at middle if disc; each elytron also decorated with a narrow longitudinal inconspicuous pale yellow pubescence vitta along sutural margin extending from base to apex (Figure 4.52).……..…sp. 8
	Each elytron ornamented with whitish blue pubescence as follows: four spots, one at median of elytron at basal fourth, one at sublateral of basal third before middle, one which oval and broadest at sublateral between apical fourth and third, and one near apex; two dots, one at middle of base, and one at middle of apical third, but tending to submedial; each elytron also decorated with a narrow and inconspicuous longitudinal pale yellow pubescence vittae along sutural margin (Figure 4.55)……..…sp. 11
49.	Head ornamented with longitudinal pubescence vittae…….....50
	Head ornamented with a whitish blue pubescence spot on vertex; pronotum ornamented with a narrow whitish blue pubescence vitta along median, and two narrow blue pubescence collars at base and apex; each elytron ornamented with three narrow longitudinal whitish blue pubescence vittae,

	two whitish blue pubescence spots, and three whitish blue pubescence dots (Figure 4.12)……..……...*coris*
50.	Pronotum ornamented with three longitudinal pubescence vittae…….51
	Pronotum ornamented with a narrow longitudinal tawny yellow pubescence vittae along median; head decorated with two narrow longitudinal tawny yellow pubescence vittae on occiput; each elytron ornamented with four tawny yellow pubescence spots, and two narrow longitudinal tawny yellow pubescence vittae: one which ill-defined along sutural margin, and one at the deflexed sides along upper punctures row (Figure 4.58)……..… sp. 14
51.	Head ornamented with two longitudinal pubescence vittae……..52
	Head ornamented with four longitudinal pubescence vittae; each elytron ornamented with three narrow longitudinal tawny yellow pubescence vittae, and a tawny yellow pubescence spot at middle of disc (Figure 4.34)…..…… ……*saperdoides saperdoides*
52.	Each elytron ornamented with six pubescence spots…….53
	Each elytron ornamented with less than six pubescence spots……..54
53.	Each elytron ornamented with six white pubescence spots as follows: one at middle of basal fourth, one between basal fourth and third at middle, one which smallest and elongated at sublateral of basal third, one at submedial just behind middle of elytron, one at sublateral between apical fourth and third, and one near apex; the upper punctures row of deflexed sides decorated

	with a narrow longitudinal white pubescence vitta extending from base to apex (Figure 4.27)……..……*medea*
	Each elytron ornamented with six bluish white pubescence spots, one at base of the deflexed sides; the upper punctures row of the deflexed sides decorated with a narrow and inconspicuous longitudinal bluish white pubescence vitta (Figure 4.8)……..…*blandina*
54.	Each elytron ornamented with more than one pubescence spot….……55
	Each elytron ornamented with two narrow longitudinal yellow pubescence vittae, one along sutural margin, and one which broader along sublateral next to lateral carina extending from base to a more or less distinct apical spot; also decorated with two yellow pubescence dots, one which inconspicuous and elongated at median of basal fourth, one which ill-defined at middle of disc, and a yellow pubescence spot at apex (Figure 4.13)……..…*despecta*
55.	Each elytron ornamented with more than two pubescence spots……...56
	Each elytron ornamented with two pubescence spots……...57
56.	Each elytron ornamented with three yellow pubescence spots, one which biggest at apex, one which elongated on median of basal fourth, and one at middle of disc; and also decorated with two narrow longitudinal yellow pubescence vittae, one along sutural margin, and one along sublateral (Figure 4.7)……...*bellona albomaculata*
	Each elytron ornamented with four white pubescence spots, four white pubescence dots, and a narrow longitudinal white pubescence vitta along

	upper punctures row of the deflexed sides extending from base to apex (Figure 4.54)…….……sp. 10
57.	Each elytron ornamented with more than one longitudinal pubescence vitta……...58
	Half of elytron anteriorly ornamented with an inconspicuous longitudinal deflexed white pubescence vitta along lower punctures row of the deflexed sides; each elytron ornamented with two white pubescence spots and three white pubescence dots (Figure 4.29)……...……..…*myrsine*
58.	Each elytron ornamented with four whitish pubescence vittae and two whitish pubescence spots as follows: a narrow vitta along sutural margin extending from base to apical margin, a narrow and short slightly bend toward submedial vitta along median of basal fourth to near middle of basal third, a narrow vitta along subblateral extending from base to a more or less distinct apical spot, a narrow along deflexed sides extending from base to near apex, a spot at middle of disc, and a median spot at apical fourth (Figure 4.21)……..…. *interrupta*
	Each elytron ornamented with three longitudinal testaceous yellow pubescence vittae, one along sutural margin, one along lateral margin, which connected at apex of elytron with testaceous yellow pubescence, and one along median of basal fourth, which slightly bending toward submedial; middle of elytron decorated with a slightly transverse testaceous yellow pubescence spots; and base of deflexed sides decorated with pale yellow pubescence spot (Figure 4.38).…… *numerifera*

CHAPTER 5

SPECIES MORPHOLOGICAL EVALUATION BASED ON BINARY OPERATIONAL TAXONOMIC UNIT (DENDOGRAM RECONSTRUCTION USING SPECIES MORPHOLOGICAL CHARACTERISTICS DISTANCES ANALYSIS) OF GENUS *GLENEA*

5.1 Introduction

The inferred lines of ancestry of a set of organisms, including a reconstruction of the common ancestor and the degree of divergence (anagenesis) of the individual branches, are represented by a phylogeny or evolutionary tree. It is also referred to as the science of the changes in form that phyla or organic lineages undergo over the course of their distinct existence (Wiley, 1981). We are all evolutionary cousins and branches on the same tree of life, which links all life on earth. The formal name for the branch of biology that investigates patterns of links between organisms and reconstructs evolutionary history is phylogenetic systematics.

The evolutionary relationships between a collection of creatures or groups of organisms, known as taxa, are represented by a phylogeny. The nodes of the tree represent the common ancestors of those descendants, while the tips of the tree represent groups of descendant taxa (typically species). Sister groups are two descendants that diverged from the same node.

Many phylogenies also contain an outgroup, or a taxon unrelated to the study group. The interest group's members are all more intimately tied to one another than to the outgroup. As a result, the outgroup emerges from the tree's root. An out group can help us understand

where the primary group of organisms lies on the larger tree of life. Also, it is helpful when building evolutionary trees.

More information about the representation will be revealed depending on the context in which the term is used (e.g., whether the branch lengths of the tree represent nothing at all, genetic differences, or time; whether the phylogeny represents an actual record of that history or a reconstructed hypothesis about that history); etc. The term "cladogram," according to some scientists, emphasises that the diagram depicts a theory regarding the genuine evolutionary history of a group, whereas "phylogenies" depict the actual evolutionary history. While in a "phylogeny," the branch lengths represent the degree of character change, "cladogram" implies that the lengths of the branches in the diagram are arbitrary (Podani, 2017).

Clades are shown by evolutionary trees. A clade is a collection of organisms that comprises both its ancestor and all its offspring. Cladistics study involves examining an organism's characteristics to determine the evolutionary branching pattern of a group's phylogeny.

To clarify the evolutionary relationships of fossil taxa and their connections to modern taxa, the most compelling reason to continue collecting morphological data for a very long time (Maddison, 1996; Hillis and Wiens, 2000; Jenner, 2004). Taxa from fossils must be included in the reconstructed Tree of Life. Many extinct groups were diversified, ecologically significant, and considerably different from their nearest living relatives. Of all the species that have ever evolved, the majority are now extinct (>99% according to some estimates; Novacek and Wheeler, 1992). Most fossil taxa's relationships can only currently and going forward be discovered through phylogenetic analysis of morphological data

(despite impressive molecular studies of very recent fossil taxa). This idea can be applied to valuable, nearly rotten museum specimens that are decades old, but some of the species are hard to obtain from the wild because of habitat devastation.

The scenario is one in which molecular information is used to establish the relationships of every living species. Although though such a future appears probable (especially if rates of genome sequencing and species extinction continue to rise), we are obviously still far from it. Given this, there are several compelling reasons to keep using morphological data to build phylogenies. Secondly, it may be challenging to incorporate many existing taxa in molecular research due to their rarity. For instance, many reptile and amphibian species are only known from a small number of specimens, are maintained (i.e., formalin fixation) in a way that makes acquiring molecular data very challenging, and may never be collected again (i.e., because of limited distributions, habitat destruction, and other factors). With current technology, morphological phylogenetic analysis is the only method we can possibly learn anything about the relationships between these species. In other taxa as well, such as insects and plants (Wilson, 1992; Donoghue and Alverson, 2000), a similar situation may happen, and many species continue to be known from a single specimen that was collected decades ago. But it's possible that these issues don't exist to the same extent in other groups of organisms, and it's possible that soon technological limitations on the collection of useful DNA sequence data from other preserved specimen types may be overcome.

Phylogenies based on morphology are a "reality check" for molecular findings (e.g., Doyle, 1992; Hillis and Wiens, 2000; Jenner, 2004). Many variables could lead molecular studies to reconstruct erroneous and statistically well-supported clades. Some of these variables include long-branch attraction, differences in gene and species trees (e.g., Doyle,

1992; Maddison, 1997), and less significant issues such as contamination and incorrect specimen identification. We can avoid being misled by comparing rigorous morphology-based phylogenies to molecular data.

Longhorn beetles of the genus *Glenea* are found in the subfamily Lamiinae of the family Cerambycidae. *Glenea* is a common species in tropical rain forests, growing close to trees and bushes like many other genera in the Cerambycidae family (Abang, 2003). Numerous species are important economically, both as pests in forestry and in agriculture. Trees and occasionally woody shrubs as well as a few herbaceous plants serve as the host plants. Certain species tend to prefer to attack healthy trees, while others seem to prefer to attack dead or dying trees, choosing either dry or damp wood (Mercer, 1982). This chapter's major goal is to describe the genus *Glenea*'s cladistics connection or phenetics, which is primarily based on external physical traits.

5.2 Materials and methods

The 59 species of longhorn beetles that all fall within the genus *Glenea* was examined for cladistics analysis to discover the relationships among species. External morphological characters of each species examined to determine the character states (Appendix 4) and build the following data table to record the observations (Appendix 5). Since they were inherited from a common ancestor, significant homology features were chosen.

A total of 154 characters of antennae, head, thorax (pro, meso and meta), scutellum, elytra, legs, and abdomen were being binary coded with presence / absence coding with 1 if presence and 0 if absence (Appendix 4). All specimens were examined at least two times. RS PRO 150mm Digital Calliper was used to measure length and width of the specimens.

Species were identified based on the dichotomous key as illustrated in Chapter 4. An operational taxonomic unit (OTU) based on external morphological characteristics (Appendix 5) in the excel format was used as the base data input for phylogenetics reconstruction analysis in R. These binary matrixes of OTU were cropped by excluding the morphological characteristics raw, and then this file was saved in as coma separated value (CSV) format in Microsoft Excel. The coma separated value (CSV) format is readable by R, and one of the ways of data inputs to R. Only build-in packages called “base” in R software was used.

5.3 Results

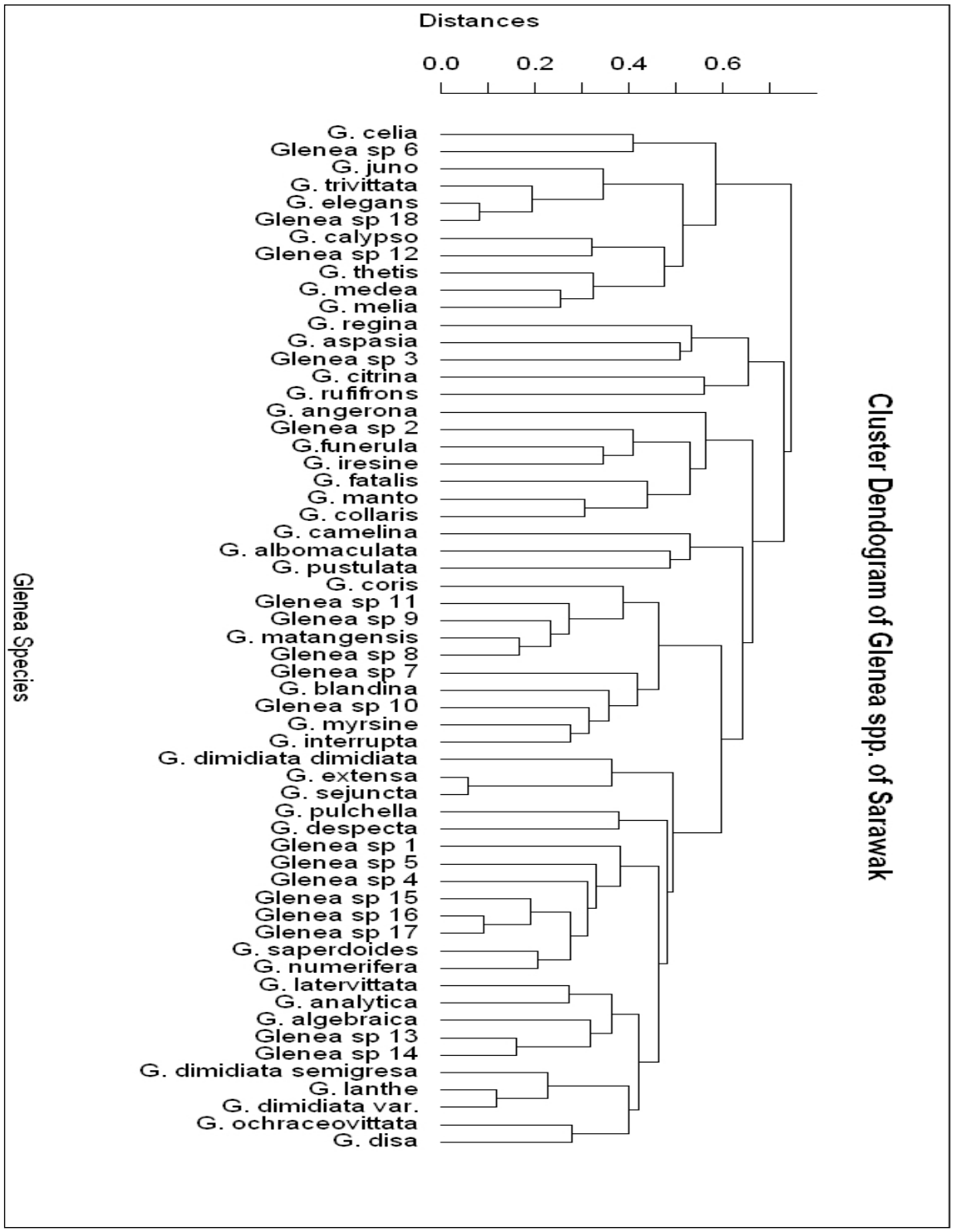


Figure 5.1: The Cluster Dendogram of *Glenea* spp. of Sarawak.

Figure 5.1 is the results of distances analyses of external morpho characteristics among *Glenea* species using R statistical program. Based on the results, *Glenea* species of Sarawak are divided into six major clade comprising varied numbers of species with the smallest clade containing three species, and the biggest clade containing 23 species.

The *Glenea celia*, *G*. sp.6, *G. juno*, *G. trivittata, G. elegans, G*. sp.18, *G. calypso*, *G*. sp. 12, *G. thetis, G. medea*, and *G. melia* fall into first major clade. In this first major clade, they divided into four small clades, with the *G. celia* and *G*. sp. 6 are, sister group in one first small clade with the phylogenetics distances is 0.409 (Appendix 6). In the second small clade, *G. juno* and *G. trivittata* are the outgroup to the sister groups *G. elegans* and *G*. sp. 18. The phylogenetics distances between *G. elegans* and *G*. sp. 18 is quite close with a distance 0.079 (Appendix 6), meanwhile the longest distance of this small clade is 0.343, that is between *G. juno* and *G. trivittata* (Appendix 6). The third small clade is between sister groups *G. calypso* and *G*. sp. 12 with the morphophylogenetics distance is 0.321 (Appendix 6: Continue 4). The *G. thetis* is the outgroup to the sister groups *G. medea* and *G. melia*. The distances between them are 0.254 (Appendix 6).

The second major clade containing only five species, that are *Glenea regina, G. aspasia, G*. sp. 3, *G. citrina*, and *G. rufifrons*. This clade comprising two sister groups *G. aspasia* and *G*. sp. 3; and *G. citrina* and *G. rufifrons*, with their morphophylogenetics distances are 0.507 and 0.559 (Appendix 6), meanwhile *G. regina* is the outgroup.

The third major clade consisting of seven species, *Glenea angerona, G*. sp. 2, *G. funerula, G. iresine, G. fatalis, G. manto* and *G. collaris*. There are three subclades in this major clade, with *G. angerona* is in the outgroup clade. The *G*. sp. 2 is an outgroup to sister groups *G. funerula* and *G. iresine* in second small clade. The distances of *G. funerula* and *G. iresine* is 0.344 (Appendix 6). In the third small clade, *G. fatalis* is the outgroup of sister groups *G. manto* and *G. collaris*, with the morphophylogenetics distances of this sister group is 0.305 (Appendix 6).

The fourth major clade is the smallest clade in this reconstructed phylogeny with only three members, they are *Glenea camelina* as an outgroup to sister groups *G. albomaculata* and *G. pustulata*. The external morphophylogenetics distances between this sister groups are 0.529 (Appendix 6).

There are ten species in two subclades in the fifth major clade. These two small clades are homologous in nature, which mean the similarity between characters that is due to their share ancestry. The first small clade consisting of *Glenea coris, G*. sp. 11, *G*. sp. 9, *G. matangensis* and *G*. sp. 8. Only G. *matangensis* and G. sp. 8 is sister groups, meanwhile the others are outgroups. The morphocharacteristics distances between *G. matangensis* and *G*. sp. 8 is 0.164 (Appendix 6). The second small clade consisting of *G*. sp. 7, *G. blandina*, *G*. sp. 10, *G. myrsine* and *G. interrupta*. The *G*. sp 7, *G. blandina* and *G*. sp.10 are the outgroups

of sister groups *G. myrsine* and *G. interrupta*, with the morphocharacteristics distances between them is 0.275 (Appendix 6).

The sixth major clade is the biggest clade in this dendogram comprising 23 species. These 23 species grouped into 5 small clades. First small clade containing 3 species, that are *Glenea dimidiata dimidiata* as the outgroup to sister groups *G. extensa* and *G. sejuncta*, with their morphocharacteristics distances is 0.056 (Appendix 6). The *G. pulchela* and *G. despecta* are sister groups in second small clade with morphocharacteristics distances is 0.378 (Appendix 6). The third small clade comprising eight species with two pairs of sister groups, *G*. sp. 16 and *G*. sp. 17; and *G. saperdoides* and *G. numerifera*, while the rest are outgroups of these pairs, they are *G*. sp. 1, *G*. sp. 4, *G*. sp. 5 and *G*. sp. 15. The fourth small clade also containing two pairs of sister groups, they are *G. latevittata* and *G. analytica*; and *G*. sp. 13 and *G*. sp. 14, with their morphocharacteristics distances 0.271 (Appendix 6) and 0.159 (Appendix 6) respectively, meanwhile the *G. algebraica* is the outgroup to *G*. sp. 13 and *G*. sp. 14 in their small clade. The fifth small clade also containing five species, *G. dimidiata semigresea, G. laudata, G. dimidiata var., G. ochraceovittata* and *G. disa*. The *G. dimidiata semigresea* is the outgroup of sister groups *G. laudata* and *G. dimidiata* var., with this sister group distances are 0.117 (Appendix 6). The G. *ochraceovittata* is sister group to *G. disa* with their distances is 0.277 (Appendix 6). The details of external morpho characteristics distances among each species can be seen in Appendix 6.

5.4 Discussion

Research on the phenetics reconstruction of the genus *Glenea* in Sarawak, such as morphological or molecular study, is lacking. The results of the current study clarify the morphometrics of the *Glenea* genus in Sarawak. With the increased usage of genes and genomes for species identification, information on changing molecular traits might shed light on a particular phylogenetic tree (Rokas et al., 2003). Despite the numerous unquestionable benefits of molecular data, it is crucial to keep gathering more morphological data for phenetics analysis and to keep developing the techniques for morphology-based investigations.

According to conservative estimates, 1.5 million species have been described, while 5 to 10 million additional species are still undiscovered (Wilson, 1992; May 2000). With a few notable exceptions, morphological information is typically used to identify, classify, and describe new species. Although morphological data-based species delimitation is often based on diagnostic traits rather than phylogenetic analysis, tree-based methods can be used and arguably should be used instead (Baum and Donoghue, 1995; Wiens and Penkrot, 2002). The most effective way for defining species boundaries based on morphological data is still up for debate, and these various approaches can result in wildly divergent species boundaries for the same morphological data (Wiens and Penkrot, 2002). Given the evident drawbacks of utilising overall morphological similarity to categorise species, phylogenetic analysis of morphological data is essential for putting new species under a higher taxon in the context of morphology-based taxonomy (Wiley, 1981).

More study on specific ecological and biological need of this genus can be explored in the future to find out why certain species are grouped tighter and together. So far, very

difficult to explain why these patterns happened due to lack of study on this genus. A multivariate analysis can be done when other covariates collected to show the connection through the morphometrics analysis. This classification patterns occurs where some species are close to each other were assumed associated with their feeding mechanisms that allows them to be a pest on live trees. While some species shares similar structure suggesting these species can play an important role as decomposer or foraging on death trees.

CHAPTER 6

DISTRIBUTION AND MULTIPLE SPECIES OCCUPANCY MODEL (MSOM) OF GENUS *GLENEA* IN SARAWAK

6.1 Introduction

Several ecologists have long been fixated on community level metrics; nevertheless, by obsessing over the small print, they fail to perceive the wider picture. Ecologists can be divided into two groups: those interested in modelling biological communities and those interested in modelling species occupancy (Kery and Royle, 2015).

Although concerns with poor detection or likelihood in detection still exist, modelling biological communities is directly related to species richness, diversity indices, similarity or beta diversity, and habitat linkages. When a species is numerous, missed individuals cause populations to be underestimated; when a species is rare, lost individuals cause misleading absences. Imperfect detection has predictable effects. Uncorrected counts of observed species, which are frequently employed in diversity estimates, completely neglect detection, and known methods used to account for missed species do not distinguish between occurrence and detection (Iknayan et al. 2014).

Species occupancy modelling tracks temporal trend, habitat linkages, and distribution using population metrics like occupancy. This group conducts repeat surveys at the same location for several sites to calculate the chance of detection (p), given the presence of the species. The calculated probability (p) is then used to calculate the probability that a site is inhabited, or psi (). They collected binary data, with 1 indicating the presence of a

species and 0 indicating its absence. Typically, binary data acquisition yields poor information, hence this group always has insufficient data (Iknayan et al. 2014).

These two groups can include their models into multi-level (hierarchical) models because the data are gathered from the same population dynamics. To account for false absences while modelling the occurrence of a single species, hierarchical occupancy models have lately emerged as a standard technique (MacKenzie et al. 2006). These models can distinguish between and clarify two important processes (Royle and Dorazio 2008): (i) the ecological or state process of interest (for example, site occupancy); and (ii) the observation process that always goes along with field sampling and taints the identification of the state process. These hierarchical "detection-based" mode that incorporate the underlying detection process separately from the ecological measure of interest, have recently been used to estimate diversity metrics in surveys including several species. In addition to taking into account different detection methods, they can also estimate the number of species that are never found during surveys (Dorazio and Royle 2005). Recently, Kery and Royle (2015), introduce a new model called “The Dorazio/Royle (DR) Community Occupancy Model with Data Augmentation (DA)”. This model is known today as Multiple Species Occupancy Model (MSOM). The point estimates and credible intervals of parameters of interest can be acquired from full Bayesian posteriors of MSOM.

In line with the most recent metacommunity theory, Hamer et al. (2021) discovered that occupancy rose with wetland extent and connectedness. Also, they discovered that there was a favourable association between predatory *Gambusia* and emergent vegetation and a strong negative link between occupancy and the presence of predatory *Gambusia*. The presence of canopy cover significantly boosted occupancy for multiple species of tree frogs,

according to Multi Species Occupancy Modelling, demonstrating the significance of terrestrial habitat for the formation of amphibian communities. The model also showed how occupancy patterns at the metacommunity scale might be related to amphibian responses to environmental variables at the species level.

A dynamic multi-species occupancy model was employed by Maphisa et al. (2019) to analyse the seasonal occupancy dynamics and habitat preferences of 12 common grassland bird species. Throughout the 2011–2012 mating season, the model was used to estimate monthly occupancy, colonisation, and persistence in relation to grass height and grass cover. They discovered that for most of these species, occupancy rose at the start of the growing season as grass height climbed and fell as grass cover increased. When grass height and cover increased, so did persistence and colonisation. The reactions of the 12 species to grass height and cover, however, differed greatly.

The goals of this chapter are to obtain occupancy and detection parameters for each species, estimate local species richness at each site, create species richness maps based on habitat covariates (Species Distribution Map), assess site and species similarity using Jaccard and Sorensen indices, and create a species accumulation curve.

6.2 Methodology

6.2.1 Data and data preparations

The counts data or the number of individual species was gathered from museum specimens and this genus was found from 61 locations in Sarawak as explained in Chapter 3. Firstly, raw data from separate files for sites, species, and counts in excel format were imported and various data objects needed for analysis were constructed. The list of objects in R were created (Appendix 6.1), so that analysis can be done later.

The commented R codes in Appendix 6.1 show the script how to import from separate raw data files for sites, species, and counts in Coma Separated Value format in Excel.

Multiple Species Occupancy Model only can be run if the data are from replicated detection/non-detection data, but in this case, the *Glenea* counts data only came from one replicate or one visit to each site. As such, replicated counts was simulated based on single occasion. However, additional 4 replicates created according to Poisson distribution where the counts are based on lambda of existing single count at every site for each species. The object C is 3-dimension array (rows for sites, columns for replicates, and every page for each species). This object C of data counts in 3-D will be used in Community N-mixture model. For MSOM, count data C need to be collapsed into detection/non-detection array that called object Y.

Two covariates were simulated namely, forest cover in percentage and duration of survey in hour. However, focus is on duration of survey since data for land cover can be downloaded from DIVA-GIS (2020).

Another object to create is Ysum, a 2-D matrix of site x species with number of times the species was detected at each site.

One crucial step in data preparations is produce maps of Sarawak showing the sample sites and plotting it's on elevation or land cover map, as well as extracting elevation and land cover values for each surveyed site. All of GIS here was done using R.

Packages such as "raster", "maptools", "rgdal", "sp" and "rgeos" were used for mapping in R. Then a file containing coordinates for surveyed sites was read in. The existing coordinate system was set, to treat it as coordinates. Therefore, in this case existing lat-long coordinates were converted to RECTIFIED SKEW ORTHOMORPHIC PROJECTION (RSO) by setting European Petroleum Survey Group (EPSG) to 29873 for World Geodetic System (WGS) 84, RSO Timbalai 84, an easting-northing system. The Sarawak shapefile also read-in into R.

The R codes in Appedix 6.1 are the commands to read raster file in VRT format or Geospatial Data Abstraction Library (GDAL) virtual format. This file is Digital elevation model (DEM) for Malaysia and was acquired from DIVA-GIS (2020). However, this DEM for Malaysia is not in the same Coordinate Reference System (CRS) with Sarawak map. Therefore, DEM following CRS of Sarawak-Timbalai 48 / RSO Borneo was cropped based on geographic subset of DEM of Malaysia as specified by Sarawak.

The same process was done to get land cover of Sarawak from raster of land cover of Malaysia as in R commands in Appendix 6.1.

The land cover for Sarawak above categorized into 22 categories (Appendix 6.2) based on Global Land Cover Global Class 2000 according to Land Cover Classification

System (LCCS) terminology. Nevertheless, for this MSOM analysis, these 22 categories realigned into 2 categories only, forested, and non-forested. Data frame of land cover and elevation were created as in Appedix 6.1.

R codes in Appendix 6.1 are commands to extract values or covariates of elevation and land cover category at sampling points that are needed for analysis from elevation and land cover maps. R codes in Appendix 6.1 show the commands to produce maps as in Figure 6.2.

6.2.2 The Model

The Single-Species, Single-Season Occupancy Model (MacKenzie 2002) is extended by the Multi Species Occupancy Modelling (MSOM), which compiles and examines the history of detections and non-detections (denoted by 1s and 0s, respectively) of all species encountered during replicated surveys at a set of sites (Dorazio and Royle 2005). The hierarchical model has three layers, one for each species (i), site (j), and replicate (k).

Augmentation process:

The first level represents the true occurrence states (w) within the community of all partially observed and never observed species.

$w_i \sim$ Bernoulli (Ω) - superpopulation process (data augmentation)

The parameter omega (Ω) governs the data augmentation variable w (Appendix 6.3). Data augmentation is used in MSOMs to estimate the number of species present in a community (or metacommunity) but not detected at any site. The detection histories of *Sobs* observed species are augmented by M all-zero detection histories that represent species with

unknown identities. The number of all-zero augmented detection histories, *M*, should be arbitrarily large without being computationally unwieldy (Royle and Dorazio 2012). An indicator variable, *w*, is modelled such that $w = 1$ for species that were either observed (total = *Sobs*) or unobserved but available for sampling. The total number of unobserved species, *x*, for which $w = 1$, is equivalent to the asymptote of a species-accumulation curve (Kery and Royle 2009). Consequently, gamma diversity is represented by $Sobs + x$ (where $0 \leq x \leq M$), which estimates the total number of species in a sample of sites. This can be directly calculated by multiplying the posterior estimate of Ω by the known quantities $Sobs + M$.

Biological process:

The second level is the ecological process governing occurrences (z) of partially observed species given that the superpopulation w_k. Now, given that the superpopulation w_k, occurrences ($z_{i,k}$) at every sites for every species distributed according to Bernoulli distribution which governs by superpopulation (w_k) for every species and occupancy ($\psi_{i,k}$) at every sites for every species.

$z_{i,k} \mid w_k \sim \text{Bernoulli}\ (w_k * \psi_{i,k})$ - ecological process

$\text{logit}(\psi_{i,k}) = \text{lpsi}_k + \text{betalpsi1}_k * \text{ele}_i + \text{betalpsi2}_k * \text{ele2}_i + \text{betalpsi3}_k * \text{forest}_i$

Here, occupancy at every site for every species was modelled depend on elevation, quadratic elevation and 2 categories of land cover, forested and non-forested. The reason of have quadratic elevation here because it is not making sense to have occupancy depend on elevation linearly forever, and for most of the species there will be optimum numbers of species at certain elevation.

Observation process:

The third level explains the detection history (Y) from the replicated surveys. Detection history $Y_{i,j,k}$ is detection (1s) non-detection (0s) at every sites for every replicates and for every species. Now, given that the latent occurrences ($z_{i,k}$), detection history ($Y_{i,j,k}$) distributed according to Bernoulli distribution which governs by latent occurrences ($z_{i,k}$) for every sites on every species and probability of detection ($p_{i,j,k}$) at every sites for every replicates and for every species.

$Y_{i,j,k} \mid z_{i,k} \sim$ Bernoulli ($z_{i,k} * p_{i,j,k}$) - observation process

$\text{logit}(p_{i,j,k}) = lp_k + \text{betalp1}_k * \text{DUR}_{i,j}$

Here, probability of detection ($p_{i,j,k}$) at every sites for every replicates and for every species was modelled depend on duration of survey at every sites in every replicates. In this observation process it is does not make sense to model probability of detection depend on elevation and 2 categories of land cover, forested and non-forested because probability of detection is about how good the observers detect the species in wild, elevation, forested and non-forested area not influencing the observer's detectability (Appendix 6.3).

In a single-species paradigm, the second and third layers are always present. Within the same system of linked, hierarchical models, the MSOM expands these levels over all observed species. Via the addition of the first level, it also addresses the community of just partially observed and never observed species. The occupancy and detection probability parameters in a single-species model are, respectively, (percent of sites occupied) and p (probability of detection) (Kery and Royle 2015).

Priors:

Priors for omega:

The parameter omega (Ω) is distributed according to beta distribution that parameterized by alpha, $\alpha = 1.5$ and beta, $\beta = 3$.

Priors for species-specific effect in occupancy and detection:

The intercept, $lpsi_k$, is the probability of occupancy on the logit scale for every species with all the predictors equal to zero. Since the covariates to form the predictors were standardised, that is equivalent to a site with non-forested area and elevation 238.9 m. This intercept, $lpsi_k$ distributed according to Normal distribution controlled by mean *mu.lpsi* with *tau.lpsi*. JAGS uses "precision" as a parameter in specifying a Normal distribution instead of variance, so *tau.lpsi* here is a "precision", and its equal to 1/Variance or $1/SD^2$.

All the coefficient for elevation ($betapsi1_k$), coefficient for quadratic elevation ($betapsi2_k$), and coefficient for land cover ($betapsi3_k$) for every species including the augmented species distributed according to Normal distribution with mean (*mu.betapsi1, mu.betapsi2, mu.betapsi3*) and precision (*tau.betalpsi1, tau.betapsi2, tau.betapsi3*) respectively.

Another intercept, lp_k, is the probability of detection on the logit scale for every species including the augmented species at mean duration of survey (31.4 hours), since this predictor was standardized. This intercept, lp_k distributed according to Normal distribution controlled by mean *mu.lp* with *tau.lp*. Only one coefficient for this detection, $betalp1_k$, and it also distributed according to Normal distribution controlled by mean *mu.betalp1* with *tau.betalp1* (Appendix 6.3).

The next step (Appendix 6.3), priors of mean and standard deviation for intercepts and coefficients for both occupancy and detection models were specified. It is difficult to imagine a suitable prior on the logit scale, but it is easily defining a uniform prior for the probability and then convert to the logit scale. For occupancy model, prior for probability of occupancy on averaged covariates, *mu.psi* distributed uniformly according to Beta distribution of Beta (1,1), so mean of intercept, *mu.lpsi* determined by logit(*mu.psi*), and prior for standard deviation of intercept, *sd.lpsi* on Normal distribution is Uniform distribution (0,10). Since the analysis are working on the logit scale and the predictors have been standardized to have SD = 1, the choice of prior is Uniform (-5,5) for all mean of coefficients (*mu.betapsi1, mu.betapsi2, mu.betapsi3*) because it will be very surprised if the coefficients were outside the range ±5. The priors for standard deviation for coefficients (*sd.betapsi1, sd.betapsi2, sd.betapsi3*) are Uniform (0,10), Uniform (0,5) and Uniform (0, 10) respectively. These supposed to be big enough and not show up as a constraint in the posterior.

For detection model (Appendix 6.3), prior for probability of detection on average covariates, *mu.p* distributed uniformly according to Beta distribution of Beta (1,1), so mean of intercept *mu.lp* determined by logit(*mu.p*), and prior for standard deviation of intercept, *sd.lp* on Normal distribution is Uniform distribution (0,5). Prior for mean of coefficient, *mu.betalp1* on Normal distribution is Uniform(-5,5), and prior for standard deviation of coefficient, *sd.betalp1* on Normal distribution is Uniform distribution (0,3).

Some derived numbers can be easily obtained from the model, including the number of sites inhabited by each species, the number of species that occur at each site, and the total number of species in the metacommunity (Appendix 6.3). The total number of species in the

metacommunity may be determined by looking at the membership of the metacommunity w_k for all species, including augmented species. The first two numbers can be determined using latent occurrence $z_{i,k}$ for all sites and species in the ecological model.

The ability to draw conclusions at all three levels of the sampling process metacommunity, community, and individual species is greatly enhanced by multispecies occupancy models. Nevertheless, there's more. The estimation of the latent variable *z*, gathered in this presence/absence matrix *Z*, is one of the most intriguing but possibly unappreciated features of hierarchical models like this one. The estimation of alpha diversity has already been done using this matrix (local species richness Nsite). It can also be used to compare species based on the locations where they co-occur and to compare sites based on the species that occur there (species turnover or beta diversity). Many different measurements have been suggested for beta diversity (Whittaker et al., 2001). One of these is the Jaccard index (*J*), which compares two sites based on the species that are present there (Dorazio et al., 2011). *J* is the percentage of species shared between those species that appear either at *r* or *s* for two sites *r* and *s*.

$$Jr,s = \frac{\sum ZrZs}{\sum Zr + \sum Zs - \sum ZrZs},$$

where species are summed over. This similarity index's values range from 0 to 1, with 0 and 1 representing no shared species and all species present at both sites, respectively (Kery and Royle, 2015).

6.2.3 JAGS Code:

The full model in JAGS (Just Another Gibbs Sampler) codes will be passed to separate Open-Source Software JAGS version 4.3.0 based on R command in software R (Appendix 6.3), then JAGS 4.3.0 return the output into R.

6.2.4 R code for preparations and running the model.

Specific packages such as “jagsUI”, “wiqid” and “mcmcOutput” are required to run and display the results (Appendix 6.3). The total number of observed species is 59, but due to probability of detection is not 1, there will be a few species were missed, so the number of augmented species arbitrarily chosen as 100. The covariates need to be included in the data to be passed to JAGS. All the covariates were standardized, so standard deviation equal 1 and mean equal 0. Then, all data set for JAGS will be bundled, summarized, and listed in 1 object.

The model will then be run using the instructions in Appendix 6.3. Number of iterations to run in the JAGS adaptive phase, n.adapt = 1000, number of burn-in iterations to discard, n.burnin = 0, total number of iterations per chain (including burn-in), n.iter = 200000, thinning rate, n.thin = 100, and parallel set to equal TRUE are the parameters that must be used. Deviance information criteria (DIC) is set to false for complex models like MSOM because it is not relevant in this situation. The process of fine-tuning or adjusting the proposal distribution to maximise MCMC sampling is referred to as adaptation. By subsampling the MCMC chain after a predetermined period of iterations, thinning is a technique for minimizing autocorrelation in the MCMC sample. This optimized the computer's operating process since when parallel is equal to TRUE, MCMC chains will operate concurrently across several CPU cores (Plummer, 2017).

The MCMC output will be saved after a long run (Appendix 6.3). MCMC ran in parallel for about 10 hours.

6.3 Results

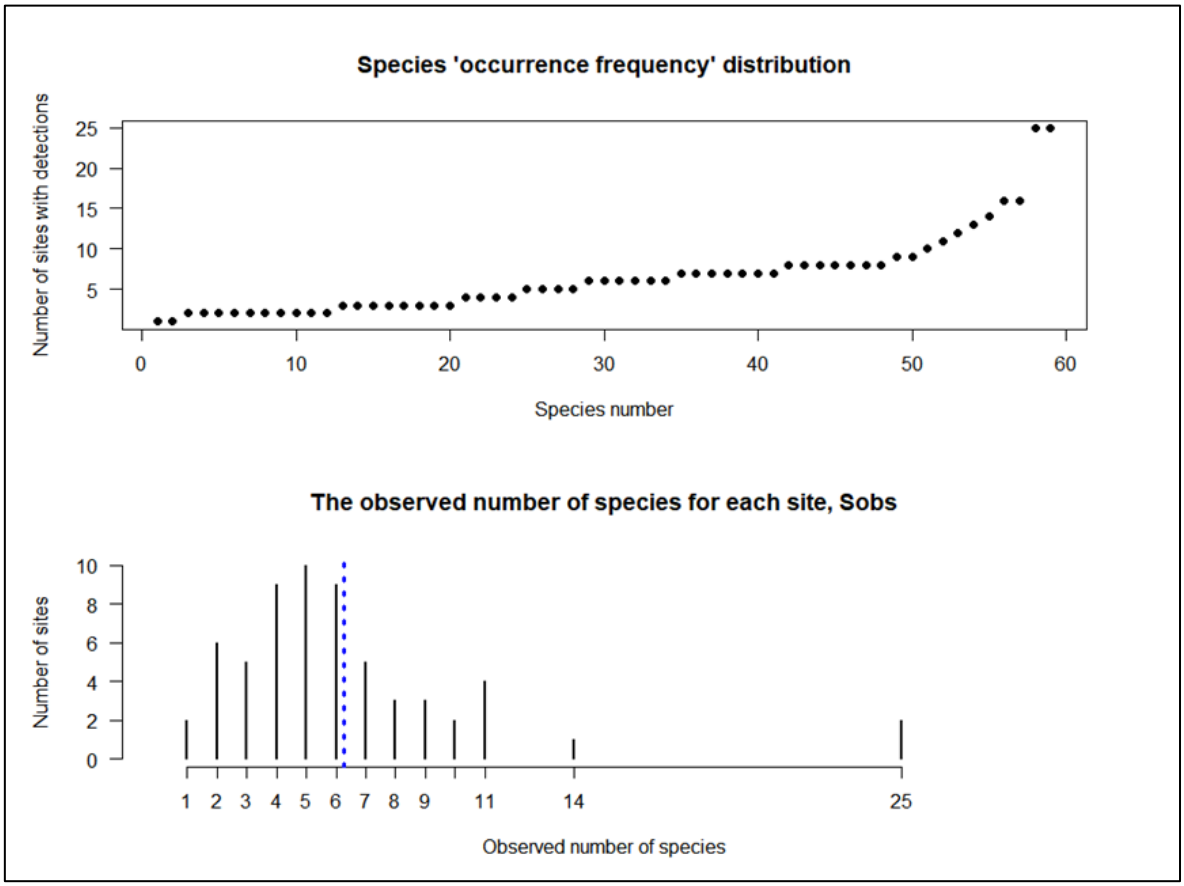


Figure 6.1: Distribution of "occurrence frequency" of species (top), and the number of species observed for each site (bottom).

The two plots (Figure 6.1) here are distribution of species "occurrence frequency" which provide details on number of sites with detections for each species and another plot is the observed number of species for each site.

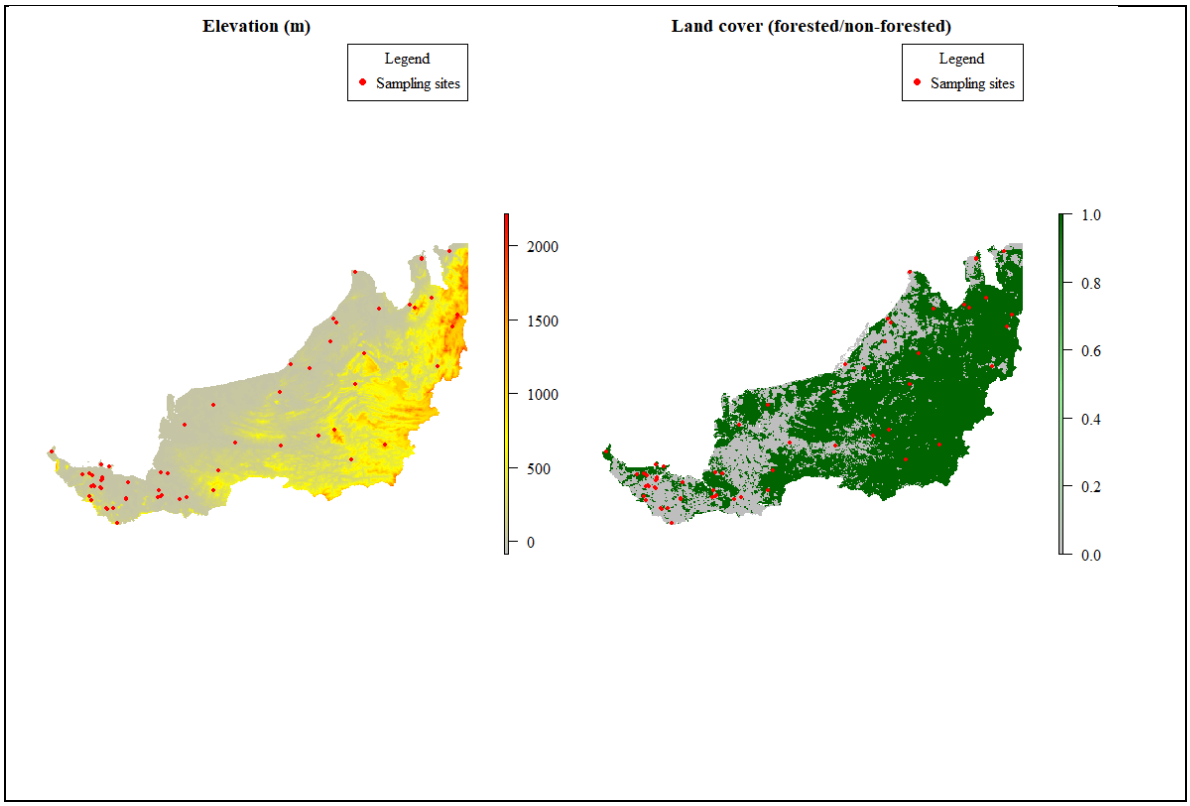


Figure 6.2: Elevation and Land Cover of Sarawak.

The maps for elevation (above sea level in meters) and land cover category (forested and non-forested) at the sampling points are shown in Figure 6.2 above. Most of high elevation and highly forested areas are in interior of Sarawak. However, mostly sampling points are at lower elevation areas.

The summary of Markov Chain Monte Carlo output from this multi species occupancy modelling with covariates was obtained after about 10 hours to run 10 chains, each with 2000 draws, and adaptation was sufficient. There are 20 parameters with 10410 nodes monitored (Appendix 6.4).

The result of 8 parameters were selected to show the mean, standard deviation, median, lower 95% credible interval, upper 95% credible interval, Rhat and Monte Carlo

Error as a percentage (Appendix 6.5). All Rhat were about 1, this indicated that all 10 chains in iteration were converged, this mean estimated parameters were fine. Monte Carlo errors for all parameters not more than 5% were indicated enough effective sample size or sufficient draws from posterior distribution.

Another way to see if the model was right and estimated parameters were right too by looking at diagnostic plots (Appendix 6.6). The diagnostic plots of 8 selected parameters were all fine. The posterior distributions for the coefficients are well clear of the limits that imposed by priors.

The results of Markov Chains are all in mathematical values, some in logit scale, some in probability, some in real values, so the best way understand the results is to generate some plots. Since this model enables inferences at all three hierarchical levels; metacommunity, local community, and individual species, therefore examples of each will be given. The plots here divided into 4 parts: Part A (Main community-level parameters and Species accumulation curves), Part B (Species-level parameters and Species Distribution Modelling (SDM) maps), Part C (Similarity measures based on the z matrix - similarity among sites and species), and Part D (Inferences based on posterior predictive distributions (PPDs)).

6.3.1 Main community-level parameters and species accumulation curves

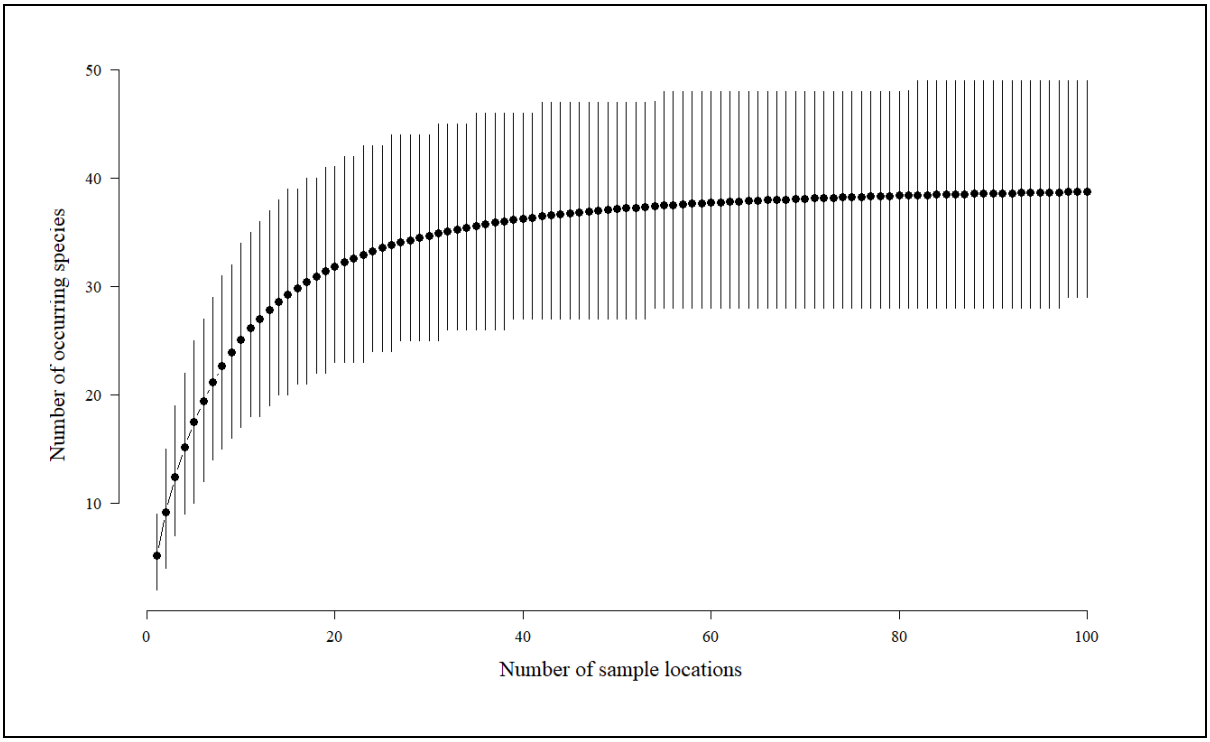


Figure 6.3: Species accumulation curves of *Glenea* species.

Figure 6.3 shows the species accumulation curves of *Glenea* species in Sarawak. Solid dots at the middle are mean number of occurring species at each number of sampling locations, meanwhile the segmented lines are lower and upper 95% Credible Interval of number of occurring species corresponding to number of sample locations.

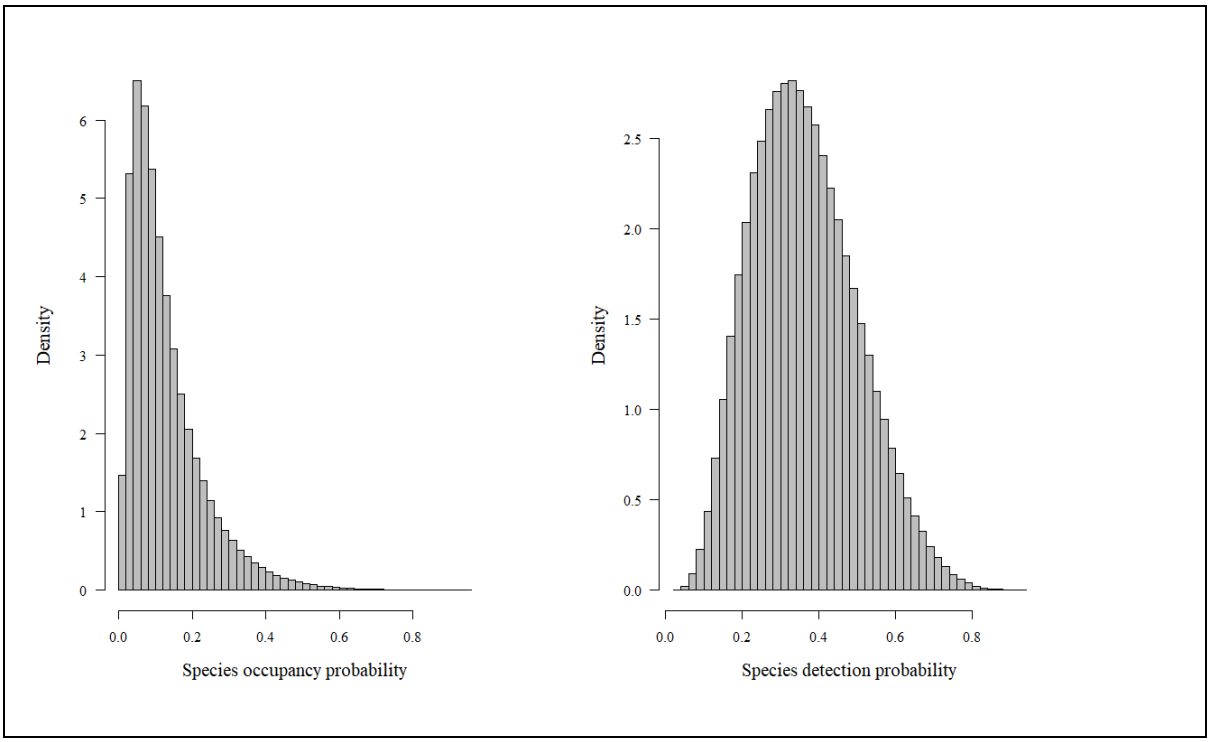


Figure 6.4: Community distribution of average occupancy and detection probability among *Glenea* species based on estimates of the species intercept model parameters (*mu.lpsi, sd.lpsi, mu.lp, sd.lp*).

The metacommunity was described using the hyperparameters in terms of the species mean, between-species variability of occupancy and detection parameters, or the average response of the community to covariates. According to Figure 6.4, there isn't much inter-species variation in occupancy or detection probability, but a small number of species are ubiquitous, although the majority have a large distribution and are often more difficult to find. During the mean survey circumstances (duration), the average species occupancy probability was 0.10, while the average species detection probability was 0.35.

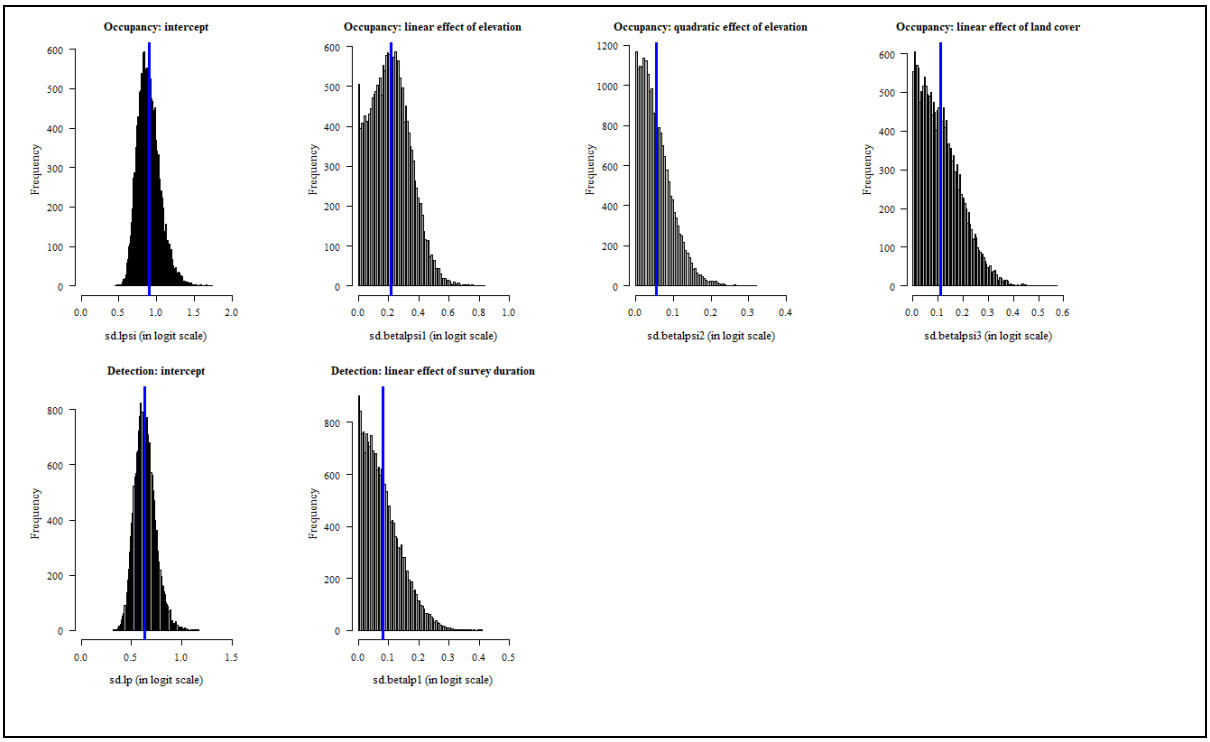


Figure 6.5: Effect of covariates on occupancy and detection in logit scale.

The community average reaction to modelled variables is the subject of the figure above (Figure 6.5), where the mean community responses of occupancy probability to elevation and forest cover were anticipated, as well as species detection probability to survey time. Each covariate's impact is visible because the plots are on logit scale here. On average, land cover and elevation had a favourable impact on occupancy, and survey duration had a marginally favourable impact on detection.

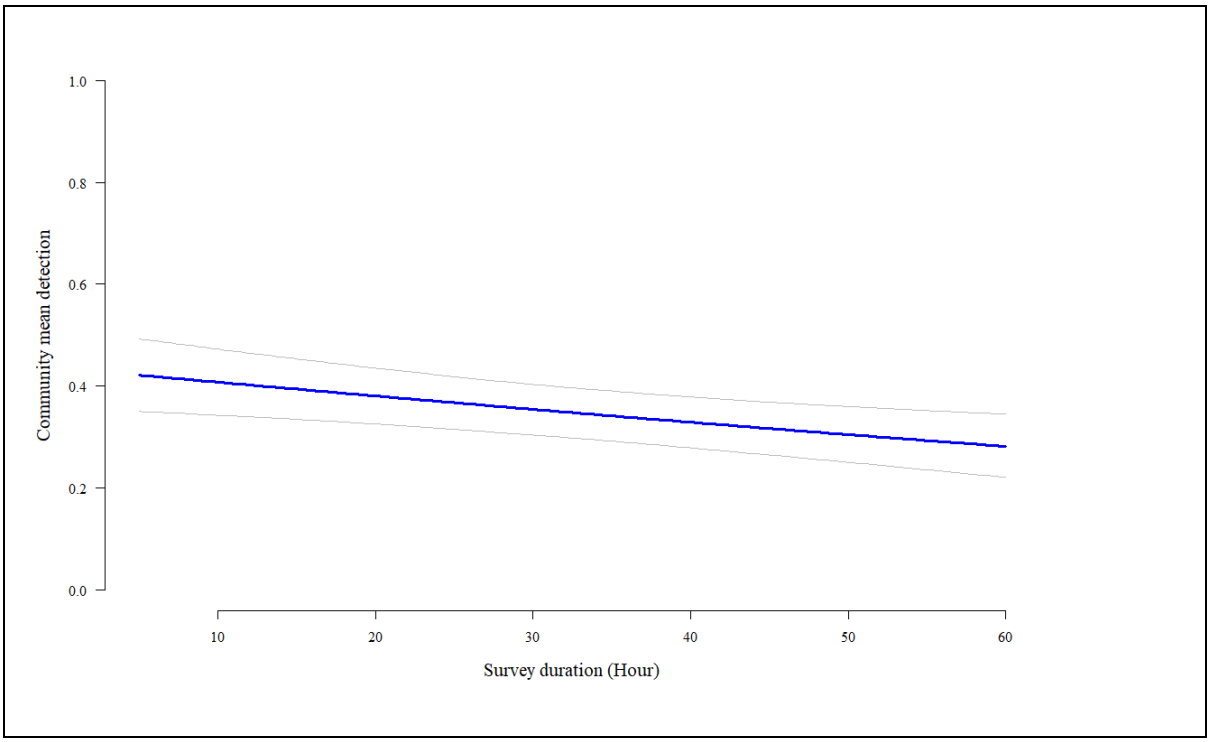


Figure 6.6: Community mean detection over survey duration.

The increasing in survey duration seem to not influent the probability of detection, in fact probability of detection went down slightly with more effort (Figure 6.6). This situation can be happened with taxonomy specimen collection because researcher will be stopped searching when found 'enough' *Glenea* specimens. So, probability of detection will be higher at the very beginning of sampling.

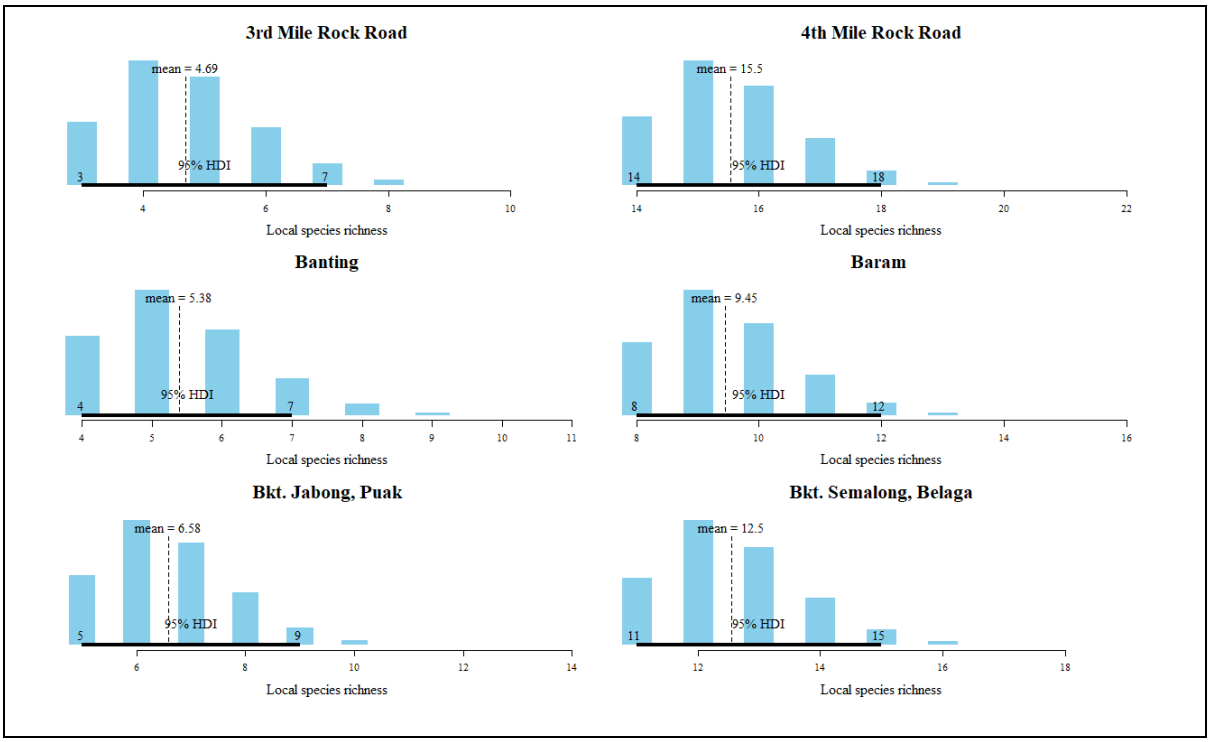


Figure 6.7: Estimated species richness of *Glenea* at first six sites.

Nsite, or the number of species that occur at each site, is one of the model's derived quantities. As a result, conclusions about the estimates of species richness at each site can be drawn at the community (i.e., site-specific) level. Examples of posterior distributions for the first six sample sites estimated local species richness (community size Nsite or alpha diversity) are shown in Figure 6.7. These maps show the mean and 95% highest density interval of the local species richness. The Appendix 6.7 contains the plots for the remaining sites. For most of the species that are estimated in the model, these estimates of the local species richness rely on elevation, land cover, and the length of the survey.

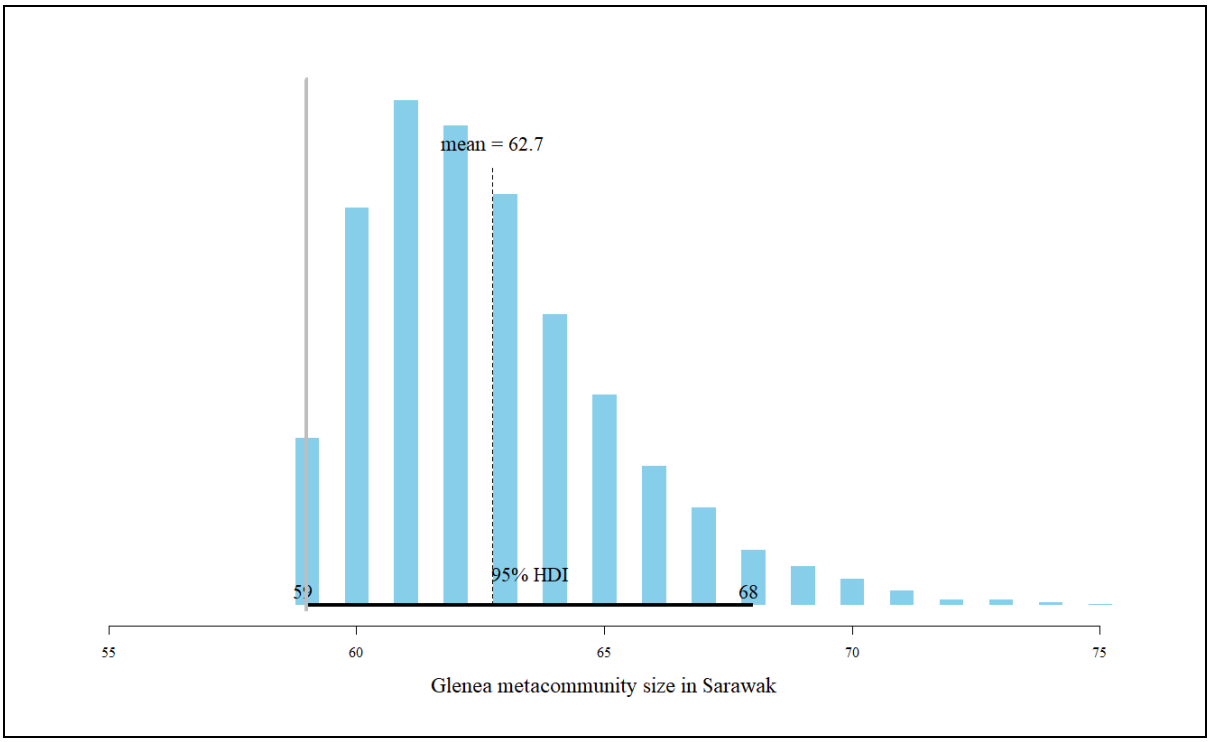


Figure 6.8: Estimated total species richness of *Glenea* in Sarawak.

The model can be used to estimate the total species richness of *Glenea* in Sarawak (Figure 6.8). The total number of species observed during the survey is 59, but since there is a decreased likelihood of detection, the actual number of species may be higher. Thus, the mean number of species is estimated to be 63, with the 95% Maximum Density Interval falling between 59 and 68 species.

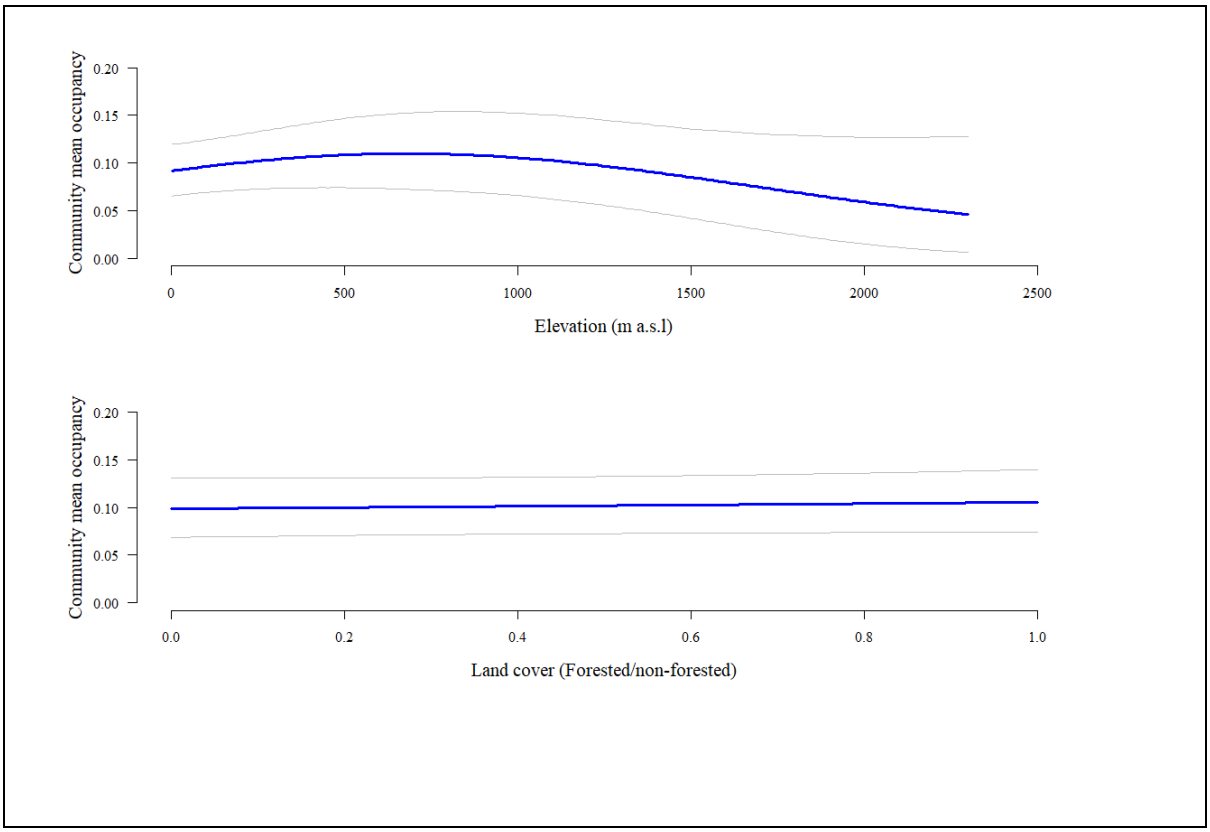


Figure 6.9: Community mean occupancy along the elevation profile and land cover.

The mean occupancy of the *Glenea* community is shown in Figure 6.9 across the entire range of elevation and habitat land cover (forested vs. non-forested). Based on posterior samples from the modelled quantity, these predictions have been made. The community's average occupancy probability in *Glenea* was highest about 800 metres above sea level and didn't really change in response to the presence of trees.

6.3.2 Species-level parameters and SDM maps

To investigate the influence of covariates on parameter estimations, inferences regarding specific species under the community occupancy model were provided.

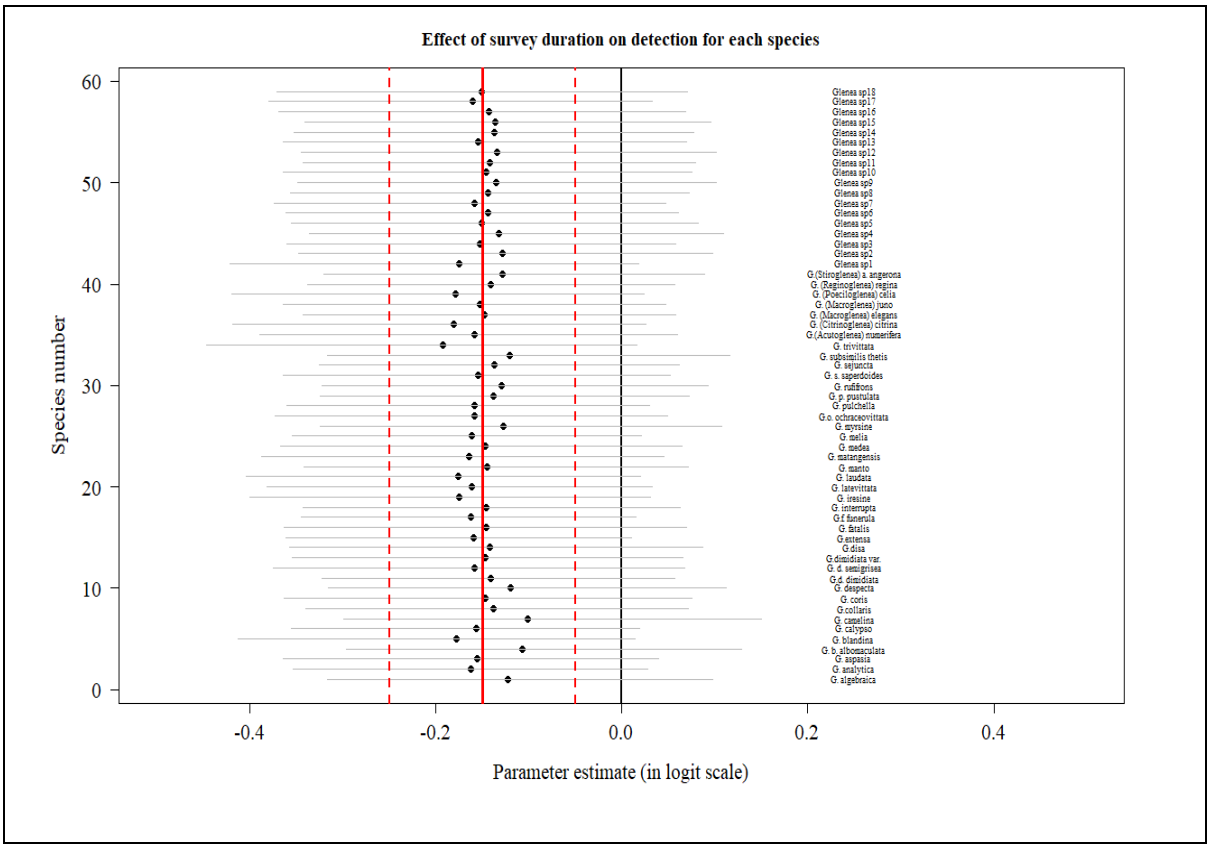


Figure 6.10: Effect of survey duration on detection for each *Glenea* species in logit scale. Red lines show posterior mean and 95% CRI of the community mean hyperparameter, and black dots and grey lines show the same thing for each individual species (for the 59 observed species).

The effect of survey time on detection for each *Glenea* species is shown in logit scale in Figure 6.10. The graphic compares the detection probability responses of the community and individual species to the length of the survey. Survey lengths have a negative impact on the likelihood of discovering all 59 species that have been spotted.

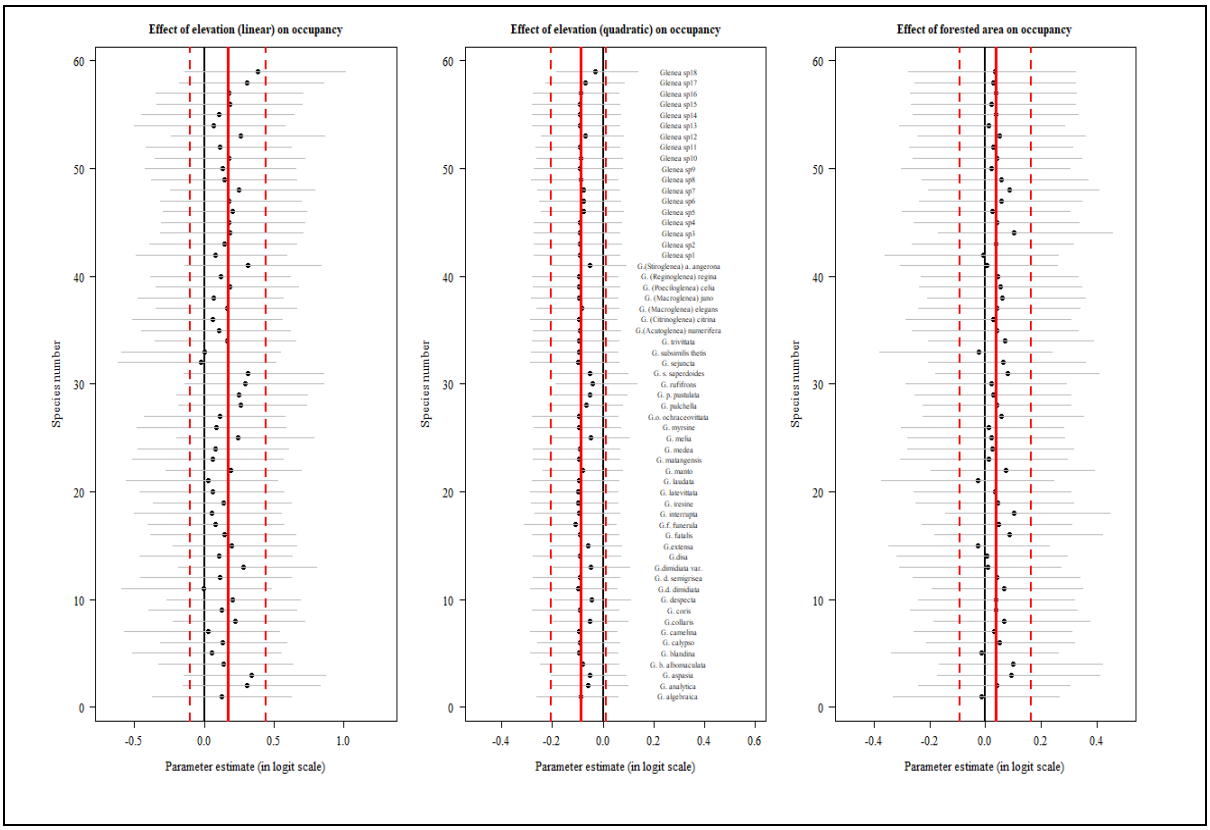


Figure 6.11: Effects of elevation (linear and quadratic) and of land cover on occupancy in logit scale. Red lines show posterior mean and 95% CRI of the community mean hyperparameter, and black dots and grey lines show the same thing for each individual species (for the 59 observed species).

The comparisons in Figure 6.11 between the community and individual species responses to site elevation (linear) for 59 observed species, the community, and individual species responses to site elevation (squared/quadratic) in the middle, and the comparisons between the community and individual species responses to forest cover on the left, are shown (on the right). According to the coefficient values, elevation has a positive effect on all species and communities, occupancy is higher in areas with forest cover, and the elevation effect has a hump (elevation squared is negative).

To plot the species-specific predictions of detection and occupancy as a function of the covariates for the 59 observed species, coefficient values must first be extracted from the model.

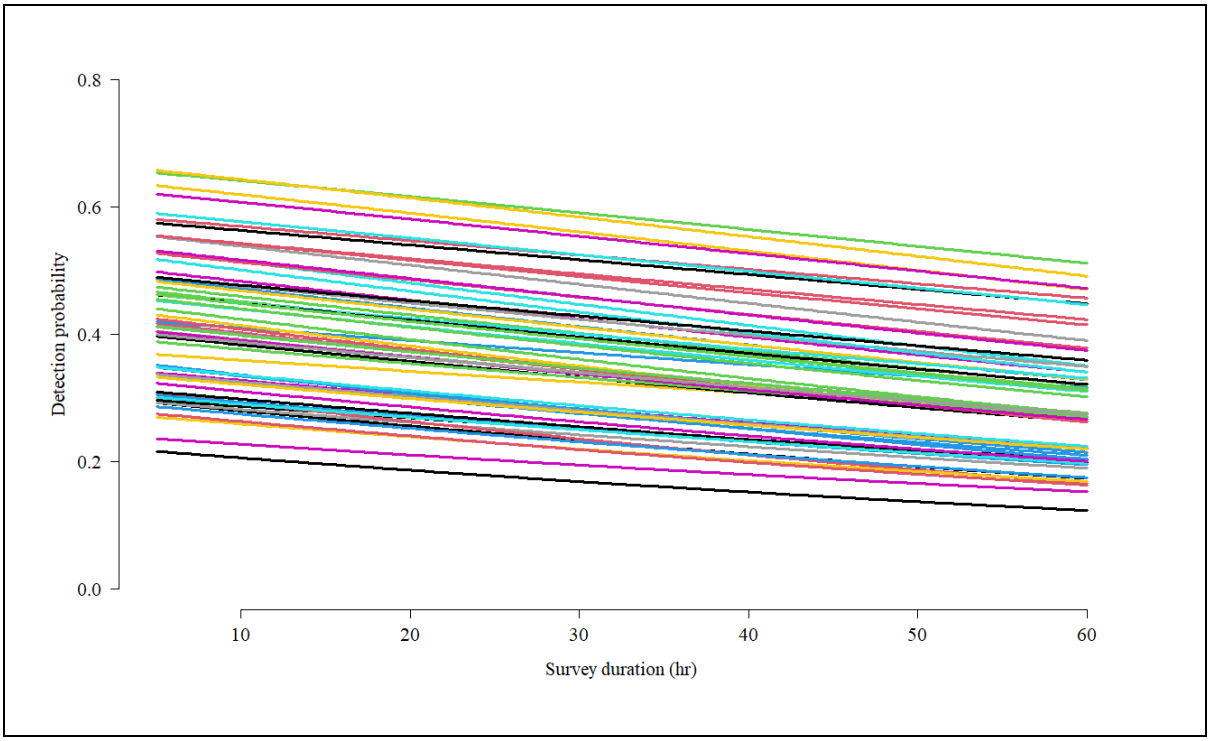


Figure 6.12: Prediction of detection probability for duration of survey in hour for each of the 59 observed species.

For each of the 59 observed species, species-specific predictions of detection probability as a function of survey length are shown in Figure 6.12. One of the 59 observed species is represented by each line. With increased survey duration, it was projected that the probability of detection for each species would decrease. This is most likely because specimen collecting for taxonomical reasons typically ends after "enough" samples have been collected.

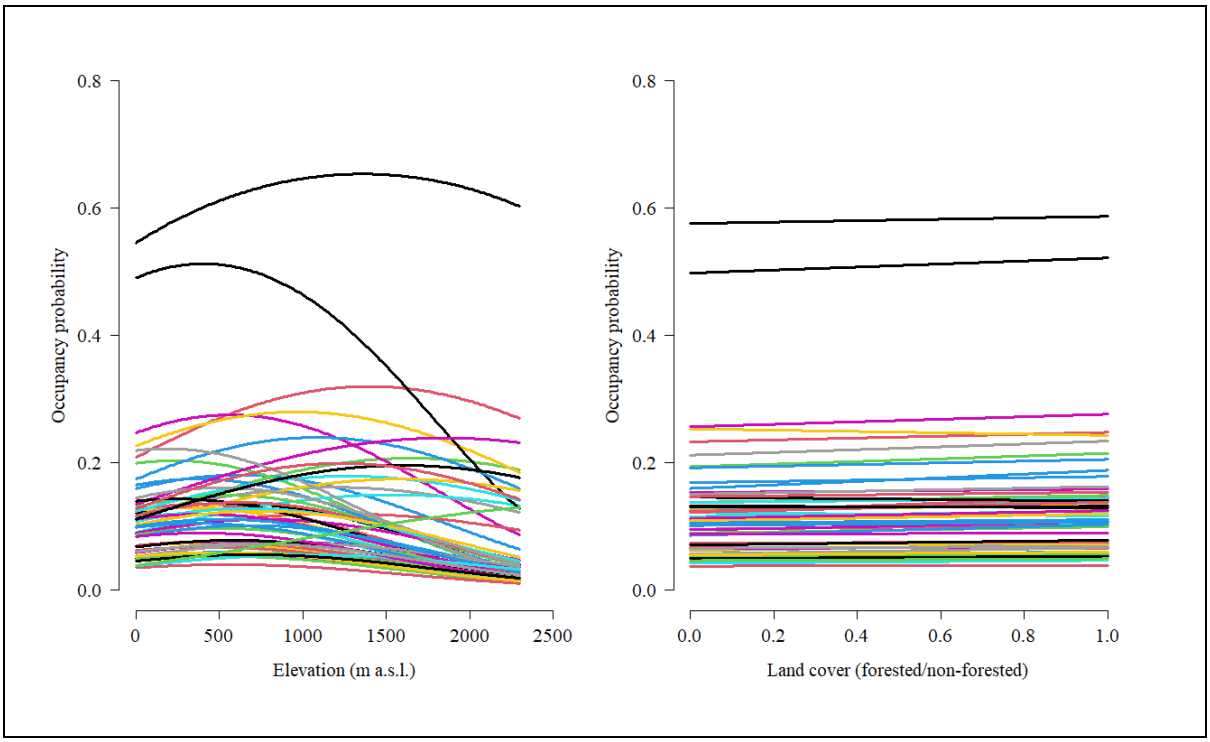


Figure 6.13: Prediction of occupancy probability for elevation and land cover (forested/non-forested) for each of the 59 observed species.

Under the community occupancy model, Figure 6.13 shows species-specific predictions of occupancy probability as a function of elevation and land cover (forested/non-forested). One of the 59 observed species is represented by each line. Most species have peak occupancy levels at specific elevations, and most species are projected to favour forested areas.

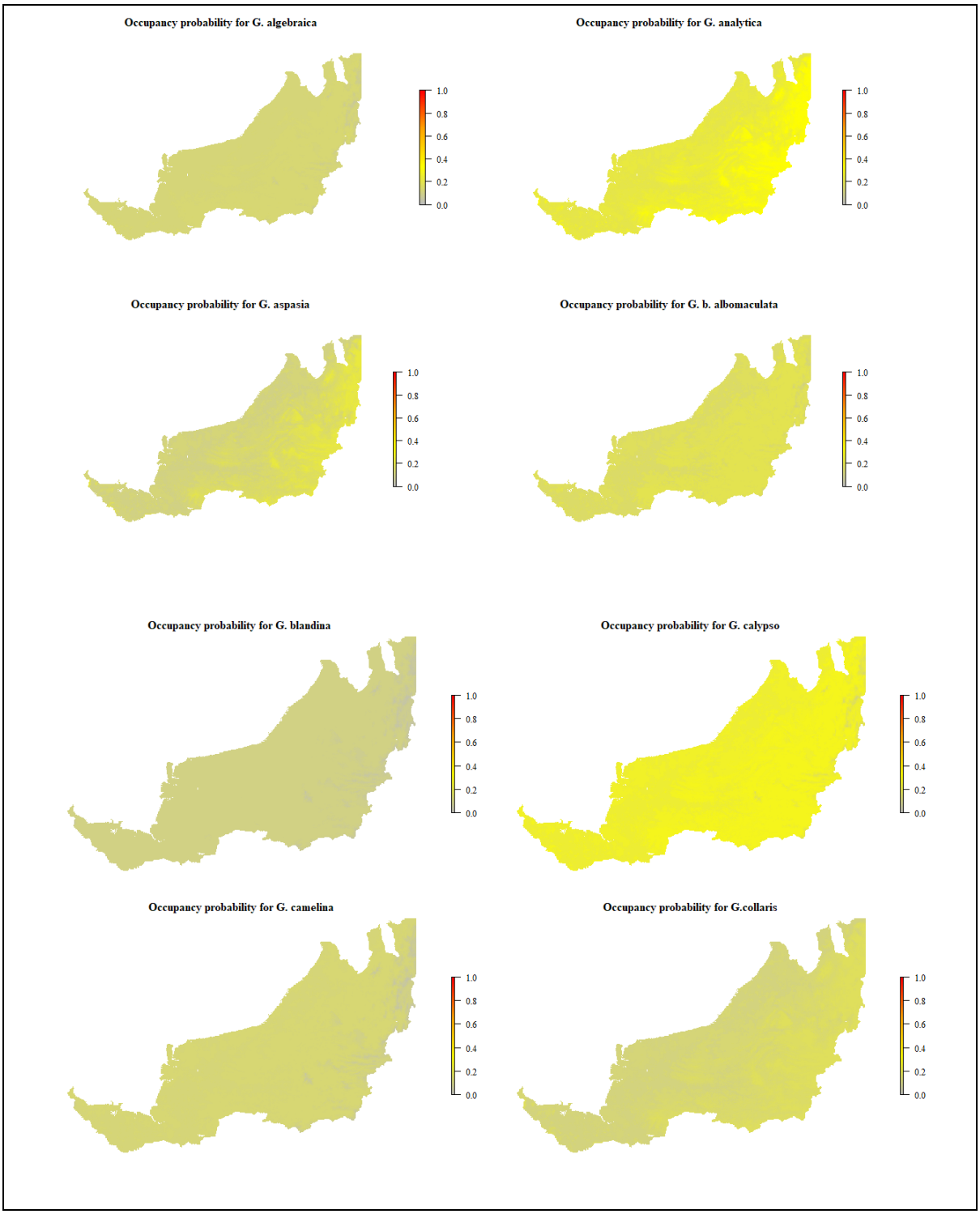


Figure 6.14: Multispecies Species Distribution Model (SDM) maps for first 8 observed species based on species-specific effects of occupancy on elevation and land cover.

Figure 6.14 above are example of Species Distribution Model (SDM) maps for first 8 observed species based on species-specific effects of occupancy on elevation and land cover. The occupancy SDM maps for other species are in Appendix 6.8. Based on these SDM maps the status of each species in term of occupancy is easily known.

6.3.3 Similarity measures based on the z matrix - similarity among sites and species.

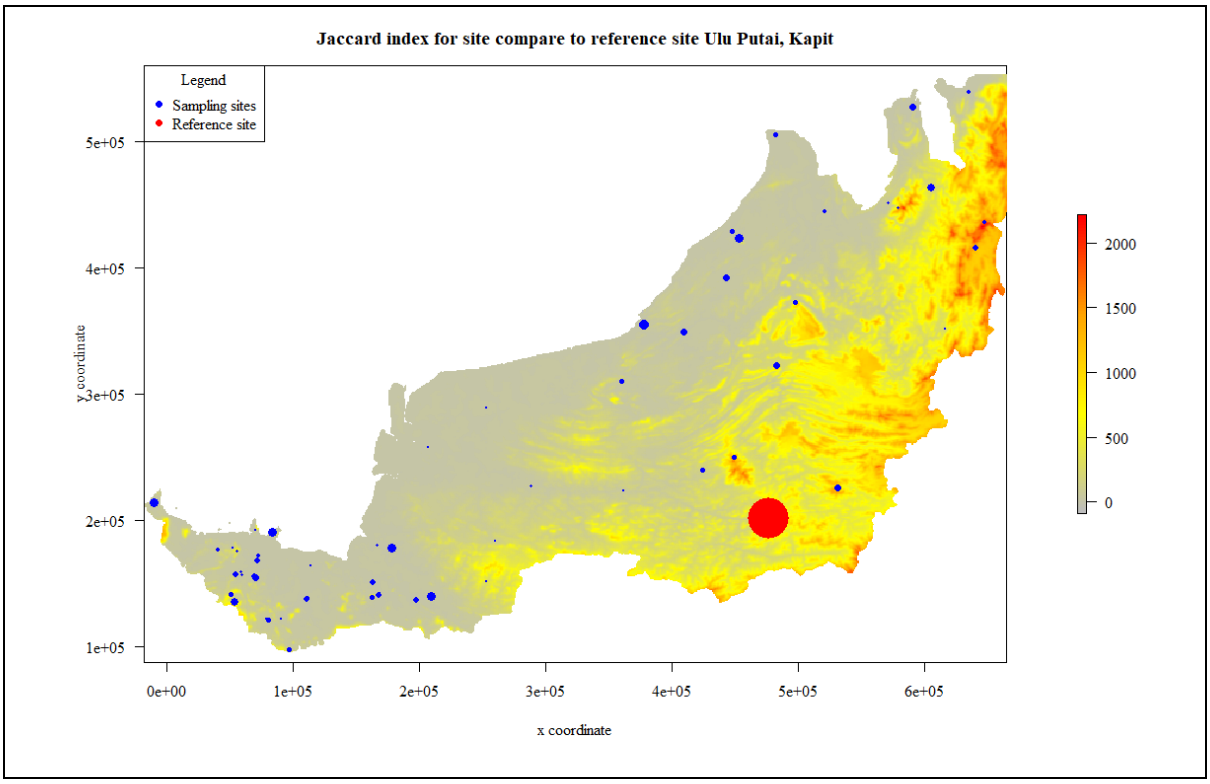


Figure 6.15: Site similarity in terms of shared species based on Jaccard index.

Figure 6.15 illustrates the Jaccard index-based similarity of sites in terms of shared species. This is a map of the Jaccard site indices' posterior means regarding Ulu Putai, Kapit (shown in red). The Jaccard index is inversely correlated with circle size, with a red circle equal to 1.

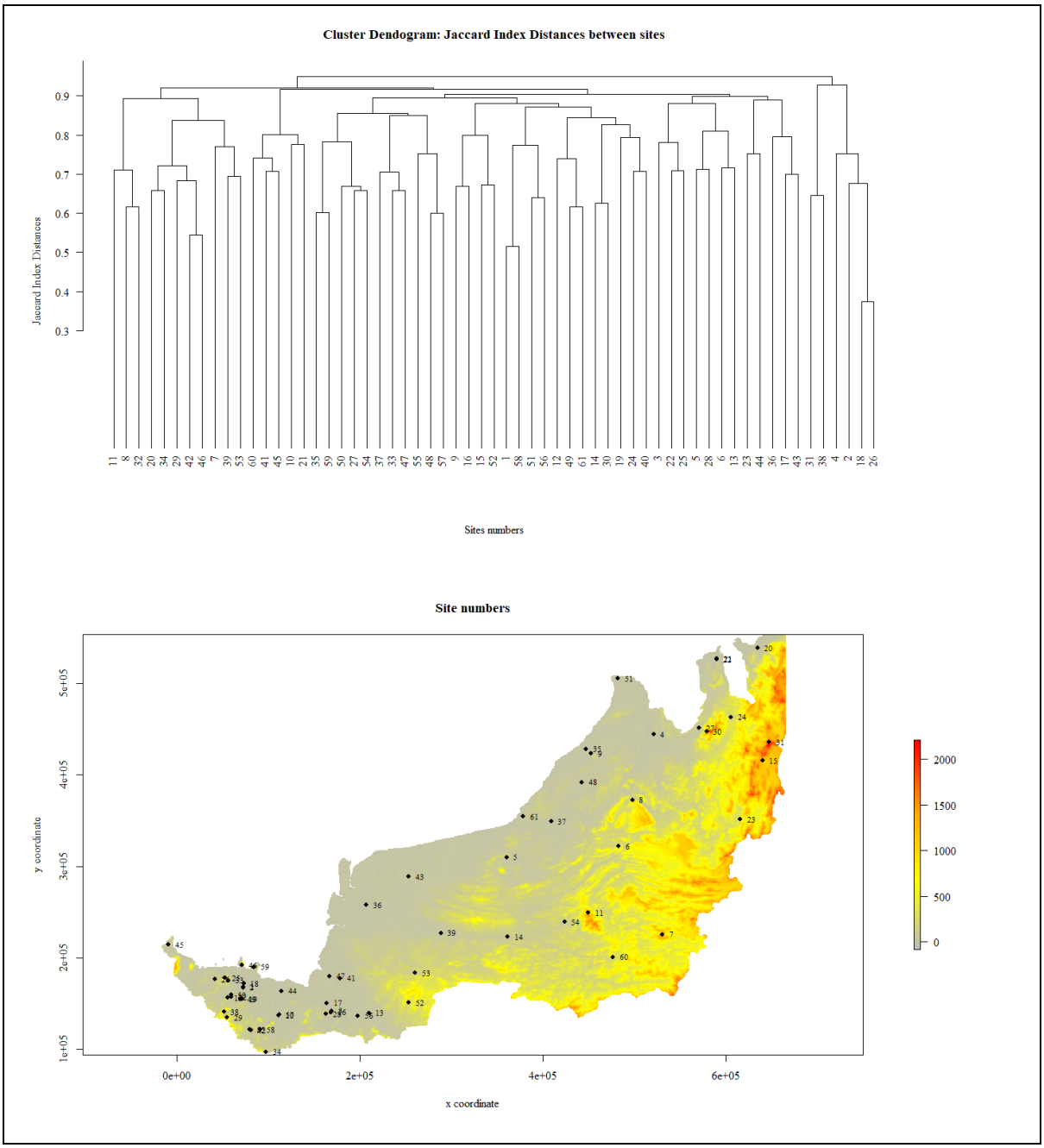


Figure 6.16: Jaccard index distances between sites in term of shared species.

Distances between sites in term of shared species based on Jaccard Index can be calculated too, and cluster in dendogram (Figure 6.16) as above.

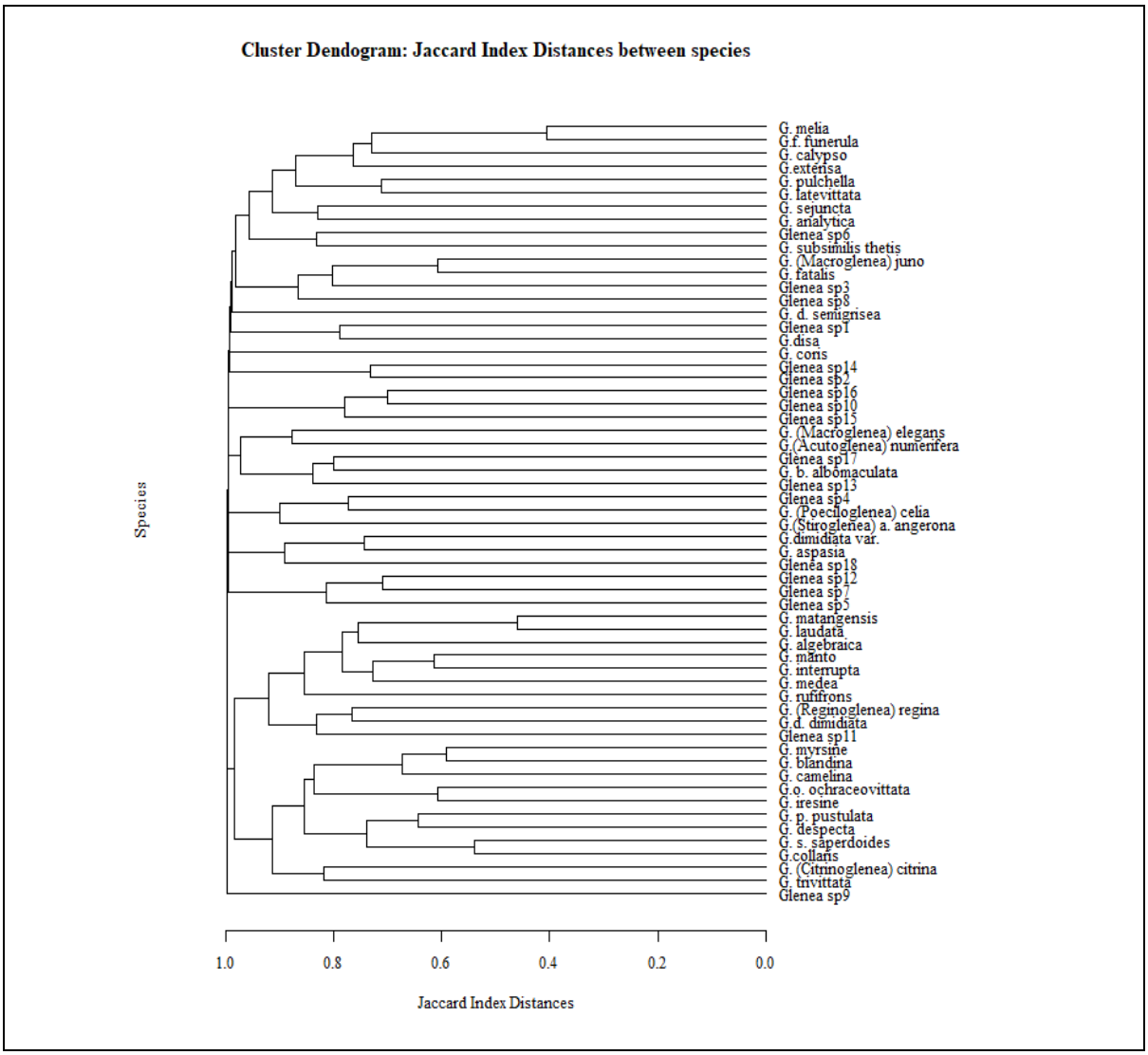


Figure 6.17: Species similarity in terms of occupancy based on Jaccard index.

Species similarity in terms of occupancy based on Jaccard index is shown in Figure 6.17 above.

6.3.4 Inferences based on posterior predictive distributions (PPDs)

The model's results were subsequently utilised to extrapolate in space. The posterior predicted distribution of the species richness in the local area was first mapped. Using the values of the covariates for a site, predictions in space were made using estimates of the

community regression parameters (*lpsi*[*k*], etc.) and the data augmentation variable (*w*). To create a species richness map, values of *w*, *lpsi*, *betalpsi1*, *betalpsi2*, and *betalpsi3* were generated for each species in the list of length *M* to provide a sample from the posterior distribution of presence/absence z_{ik} of species *k* at each site *I* in a broader area (as in Dorazio et al., 2011).

Finally, based on the elevation and forest cover values in the Sarawak landscape and the parameters connecting each species' occurrence with these variables from the model, the posterior mean of species richness at a 4-km2 scale was shown over the entire state of Sarawak.

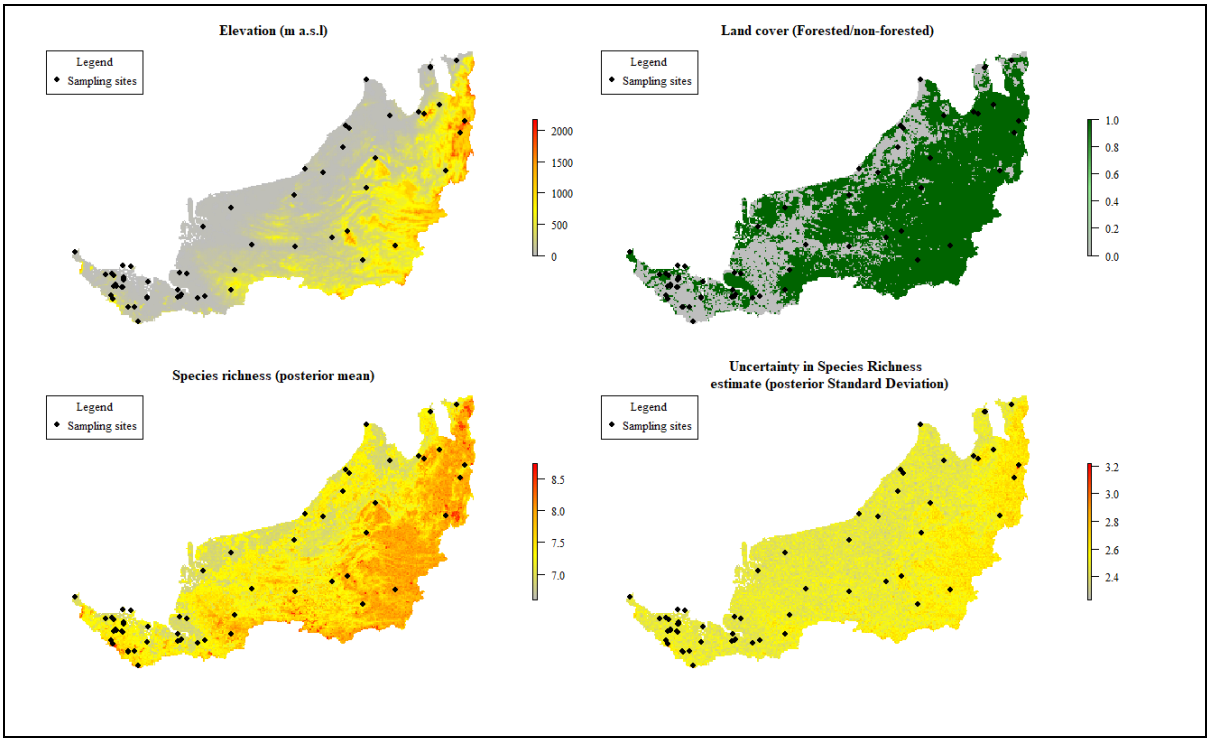


Figure 6.18: Posterior predictive distributions (PPDs) maps of species richness and its uncertainty due to elevation and forest cover for all 59 observed species in Sarawak.

The gradient in elevation and the presence of forests have a significant impact on the species richness map (Figure 6.18). The posterior standard deviation, or uncertainty in the estimated species richness, is shown on the map to the lower right. Instability is also influenced by elevation and forested area.

6.4 Discussion

Imperfect detection, comprising categories of recognised and undiscovered species, is a crucial element to consider providing estimates of diversity and species richness with a high degree of accuracy (Iknayan et. al. 2014). Without taking these factors into account, estimates of the species richness and diversity indexes are skewed and useless for managing wildlife. As a result, hierarchical multispecies models that consider both the detection process and the occurrence state offer a promising path ahead since they enable the separation of the biological and sampling processes, which results in a more process-driven estimate of diversity. The limitations and effectiveness of detection-based estimators of diversity, however, still need to be further examined. These estimators typically require multiple surveys at a site to estimate detectability, make assumptions about the closure of populations and the accuracy of species identification, and are relatively new (Royle and Link, 2006).

About half of the observed species were found to show a substantial reaction to forest cover at the individual species level, but there was no discernible effect of forest cover on species richness at the community level (Figure 6.4 versus Figure 6.11). The present metacommunity model, according to Hamer et al. (2021), can also explain and match species-habitat connections, as they discovered occupancy rose with wetland extent and connectedness.

Additional analyses have also been demonstrated, including the examination of estimates for specific species and the extrapolation of species richness to a region, such as the entirety of Sarawak, to produce a map of species richness that has been detection-corrected and accompanied by an uncertainty map (Figure 6.16).

As an example, Jaccard indices have been calculated to compare places in terms of the species that occur there as well as the locations of different species (Figure 6.13, Figure 6.14, and Figure 6.15).

This work demonstrates that multi-species occupancy models (MSOMs) offer a flexible way to address the primary objective of ecological entomology, which is to estimate patterns of species distribution, community composition, or species richness while addressing detectability difficulties. A similar outcome was shown by Mourguiart et al. (2021), who sampled Orthoptera communities at 81 mountain grassland sites in France using sighting, hearing, and sweep netting as three sampling strategies.

CHAPTER 7

MODELLING ABUNDANCE OF GENUS *GLENEA* USING COMMUNITY N-MIXTURE MODELS ON HABITAT AND SURVEY COVARIATES

7.1 Introduction

An essential part of the ecological study is estimating population abundance. When allowing for inaccurate detection, N-mixture models can be used to predict animal abundance using counts with both spatial and temporal replication (Royle, 2004). Other sampling techniques, such as capture-recapture, distance, removal, and multiple-observer sampling, are available for generating estimates of abundance; however, they may be expensive in terms of effort or expense, or they may not be feasible for all species and situations. An advantage of the N-mixture model is the comparably minimal cost and effort needed for data collecting, which does not need for individual identification.

The binomial mixture model is very appealing because it enables us to estimate abundance from relatively "cheap" data, such as simple counts without any additional information like individual identification or distance measurements. This abundance estimate can then be corrected for imperfect detection. Consequently, compared to capture-recapture techniques or distance sampling, this approach may have a wider range of applications. The model does, however, need replication in two dimensions, both time (during a period of closure) and geographically (at >10–20 sites) (at least two observations per site, though not necessarily at every site). Thus, it needs counts $y_{i,j}$ for the quantity of temporal replicates j and locations i.

Conceptually, such replicated counts arise from two distinct processes, one ecological and another observational. Accordingly, the simplest binomial mixture model for a single period of closure (season) can be written succinctly in just two lines:

$N_i \sim \text{Poisson}(\lambda)$ 1: Ecological process yields latent state

$y_i \mid N_j \sim \text{Binomial}(N_i, p)$ 2: Observation process yields observations

First, a Poisson distribution with mean λ is used to explain the spatial fluctuation of the local abundance at site i, Ni, for a group of sites. Second, a binomial distribution with sample size Ni and detection probability p describes the observed counts $y_{i,j}$ (given Ni) at site i and during repeat survey j. The Poisson-binomial mixture model is another name for this one.

The binomial distribution is the foundation of a wide range of capture-recapture models as a formal description of the coin-flip-like detection process of individuals, and the Poisson distribution is the standard distribution assumed for spatial or temporal variation in abundance (McCullagh and Nelder, 1989). (Williams et al., 2002). Due to the logistic regression that is added to the binomial mixture model to account for inaccurate detection, it can be referred to as a hierarchical Poisson regression. The adoption of distributions other than the Poisson for abundance or the binomial for detection, the addition of variables, and the relaxation of the independence of detection and of the closure condition are only a few of the significant modifications that are feasible. Then, we quickly draw each one.

At the beginning of this chapter, all community models have been "incidence-based," modelling the presence or absence of species or functions thereof, such as the number of detected species from detection or non-detection data. In this part, the DR community

occupancy model's structure is expanded to create an "abundance-based" community N-mixture model. It's interesting to note that this development's history has followed the same path as that of single-species models, where the Royle-Nichols (RN) model from 2003 (Section 6.13) paved the way from the straightforward Bernoulli-Bernoulli, or site occupancy, mixture model towards more general HMs with abundance modelled as a latent stated, i.e., the N-mixture models (Royle, 2004). To model species detection/non-detection, Yamaura et al. (2011) initially extended community occupancy models by adopting an RN formulation. Subsequently, Yamaura et al. (2012) used models to simulate counts and created the Dorazio/Royle/Yamaura (DRY) model, a comprehensive community N-mixture community model (Kery and Royle 2015).

Only a small number of studies, including those by Chandler et al. (2013), Barnagaud et al. (2014), Beesley et al. (2014), Dorazio et al. (2015), and Tobler et al. (2015), have been published on such abundance-based community models thus far But we anticipate that these will spread quickly.

The community occupancy model (Section 11.7.2) of the basic Community N-mixture model with DA is just a few simple steps away (Kery and Royle 2015). It explains the relationship between the species k at site *i*'s latent abundance Ni,k and the species k at site *i*'s count during replicate *j*'s observable response $y_{i,j,k}$ as follows.

1: Superpopulation process : $w_k \sim$ Bernoulli (Ω)

2: State process (abundance) : $N_{i,k} \mid w_k \sim$ Poisson (w_k,λ_k)

3: Observation process (detection) : $y_{i,j,k} \mid N_{i,k} \sim$ Binomial ($N_{i,k}$, $p_{i,j,k}$)

4: Models of species heterogeneity : $\log(\lambda_{i,k}) = beta0_k + beta1_k * elevation_i + \ldots\ldots$

$\text{logit}(p_{i,j,k}) = \text{alpha0}_k + \text{alpha1}_{k\,+}\, \text{date}_{i,j} + \ldots.$

with $\textit{beta0}_k \sim \text{Normal}\ (\mu_{\textit{beta0}}, s^2_{\textit{beta0}})$

$\text{beta1}_k \sim \text{Normal}\ (\mu\text{beta1}, s^2\text{beta1})$

$\text{alpha0}_k \sim \text{Normal}\ (\mu\text{alpha0}, s^2\text{alpha0})$

$\text{alpha1}_k \sim \text{Normal}\ (\mu\text{alpha1}, s^2\text{alpha1})$

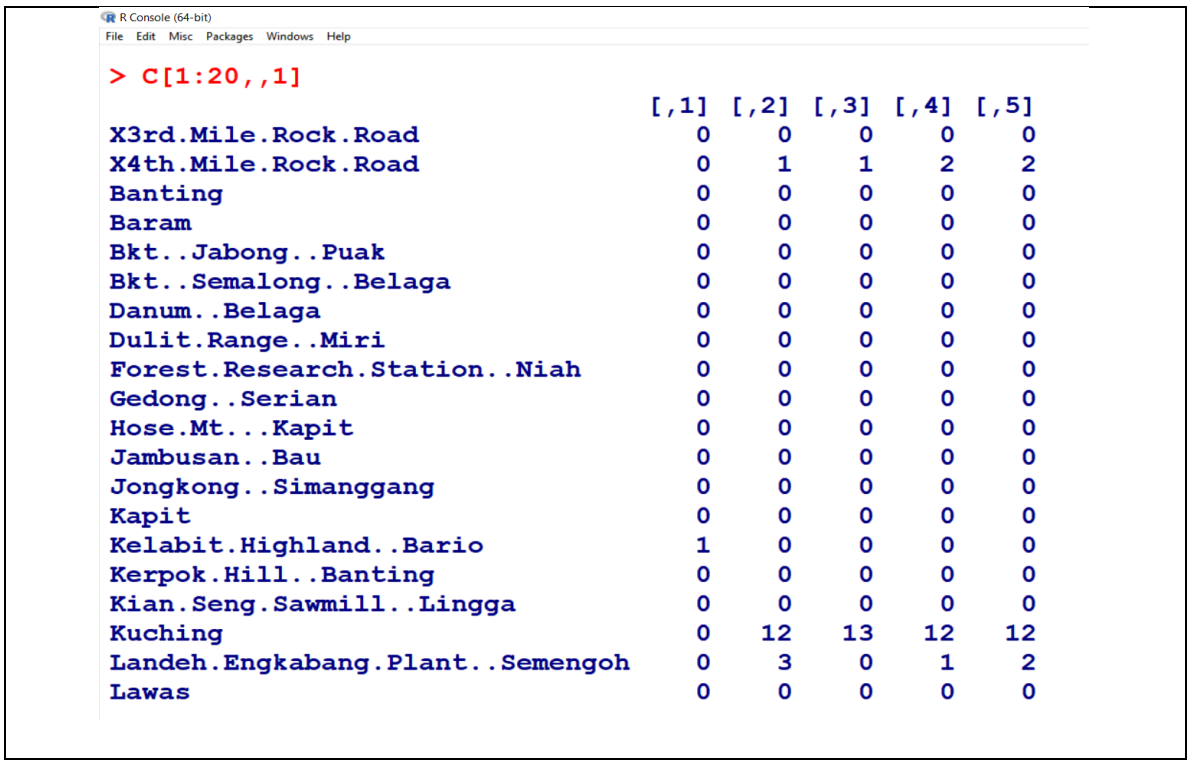
This is an N-mixture model for M species, where M may be either the total number of observed species or (as in the equations above) the number of species in the augmented data set.

7.2 Methodology

7.2.1 Data and data preparations:

The counts data and other information or objects that are needed for this Community N-mixture model was already organized in previous chapter and saved in "*Glenea*_data_full.RData" file. So, only required to be loaded into R, then start with organizing counts into a 3-D array that call Yc (Appendix 7.1). As previous chapter, specific packages "jagsUI", "wiqid" and "mcmcOutput" are required to run and display the results.

The box below shows the example of counts data for species *Glenea algebraica* in first 20 sites from 5 replicates survey. Just to remind, C is site x replicates x species array with counts, there are 61 sites x 5 replicates x 59 species.



The data was explored by plotting the distribution of observed counts before decided and organized appropriate model for that data. Exploring into the raw data is to get an idea of the variability of these counts, among sites, among replicates, among species.

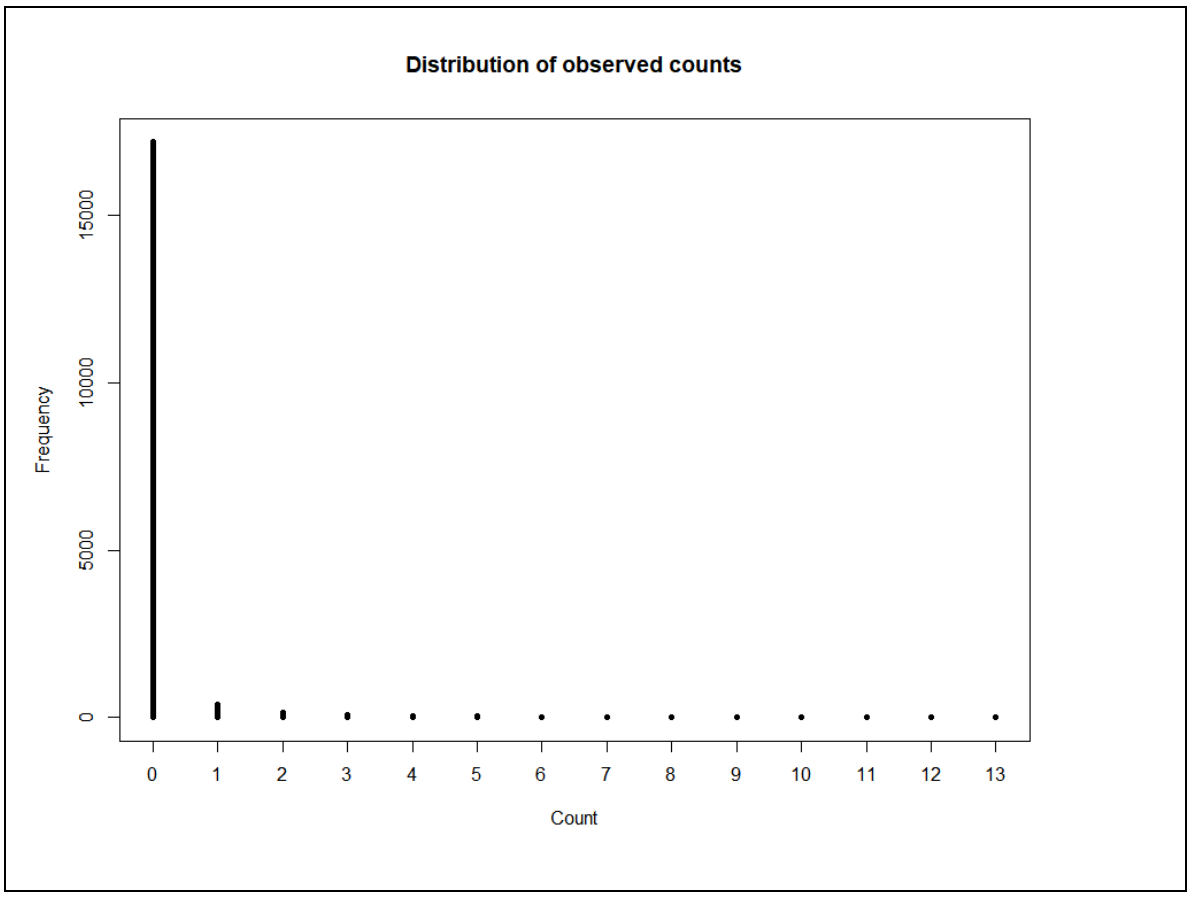


Figure 7.1: The distribution of observed counts.

Plot in Figure 7.1 above show extremely skewed distribution of observed counts with so many zero count, so model with Zero-inflation is the better model to consider.

7.2.2 The Model

Biological model:

The basic Dorazio Royle Yamaura Community N-mixture was extended to contain a zero-inflation component by considering the counts' data. Although the ZIP-DRY community model lacks the superpopulation process, it does have an additional hierarchical level that we can conceive of as the standard "suitability indication" (the data augmentation variable *w*). To make the model simpler and converge more quickly, there is no data augment here. It takes a lot longer to get this multispecies N-mixture model to converge than it does for the equivalent occupancy model, thus the term "quick" is relative. Therefore, there would be no issues in theory if DA and zero inflation were combined (Kery and Royle, 2015).

Suitability indicator, zero-inflation at every site for every species distributed according to Bernoulli distribution that governs by phi, (Φ) for every species. Given that (suitability; zero-inflation), at every site for every species, latent abundance variable N at every site for every species distributed according to Poisson distribution which governs by at every site for every species and lamda, λ for every species. Here, abundance at every site for every species was modelled depend on elevation, quadratic elevation and 2 categories of land cover, forested and non-forested. The reason of have quadratic elevation here because it is not making sense to have occupancy depend on elevation linearly forever, and for most of the species there will be optimum numbers of species at certain elevation. Sarawak land cover main data have 22 categories but does not make sense to modelled occupancy depend on all those categories because there were only 61 sites surveyed, so these 22 categories re-categorized into 2, forested and non-forested.

State process 1 (suitability; zero-inflation): $a_{i,k} \sim$ Bernoulli(Φ_k)

State process 2 (abundance) : $N_{i,k} \mid a_{i,k} \sim \text{Poisson}(a_{i,k}\lambda_k)$

$\text{Log}(\lambda_{i,k}) = \text{beta0}_k + \text{beta}_{k,1}*\text{ele}_i + \text{beta}_{k,2}*\text{ele2}_i + \text{beta}_{k,3}*\text{forest}_i$

The presence/absence matrix Z is computed as a derived quantity from the posterior samples of the latent abundance variable, *N* (refer to Appendix 7.1).

$z_{i,k} = \text{step}(N_{i,k} - 1)$

Observation model:

In the observation process (Appendix 7.1), the counts at every sites for every replicates and for every species, $Yc_{i,j,k}$ distributed according to Binomial distribution which control by probability detection ($p_{i,j,k}$) at every sites for every replicates and for every species, and latent abundance variable *N* at every sites for every species ($N_{i,k}$).

$Yc_{i,j,k} \sim \text{Binomial}\ (\ p_{i,j,k}\ ,\ N_{i,k}\ )$ - observation process

$\text{logit}(p_{i,j,k}) = \text{alpha0}_k + \text{alpha}_{k,1} * \text{DUR}_{i,j} + \text{alpha}_{k,2} * \text{BL}_{k,1}$

Here, probability of detection ($p_{i,j,k}$) at every sites for every replicates and for every species was modelled depend on duration of survey at every sites in every replicates and average body length (BL) of each species of *Glenea* . In this observation process it is does not make sense to model probability of detection depend on elevation and 2 categories of land cover, forested and non-forested because probability of detection is about how good the observers detect the species in wild, elevation, forested and non-forested area not influencing the observer's detectability.

Priors:

Priors for phi:

By using community priors for all species-specific parameters other than the zero-inflation parameter *phi,* Φ_k, the model was made fully hierarchical. The prior for the zero-inflation suitability indicator, phi_k, is a uniform distribution (0,1).

Priors for species-specific effect in detection and abundance:

In the model, suitably wide normal priors were adopted for all mean parameters, and uniform priors for all variance parameters.

The intercept, $alpha0_k$, is the probability of detection on the logit scale for every species at mean duration of survey (31.4 hours) and mean average body length (14.2mm), since this predictor was standardized. This intercept, $alpha0_k$, distributed according to Normal distribution controlled by mean *mu.alpha0* with *tau.alpha0*. Only two coefficients for this detection, $alpha_{k,1}$, and $alpha_{k,2}$, both distributed according to Normal distribution controlled by mean $mu.alpha_1$ with $tau.alpha_1$ and $mu.alpha_2$ with $tau.alpha_2$ respectively.

Another intercept, $beta0_k$, is abundance on the log scale for every species when all the predictors equal to zero. Since the covariates to form the predictors were standardized, that is equivalent to a site with non-forested area and elevation 238.9 m. This intercept, $beta0_k$ distributed according to Normal distribution controlled by mean *mu.beta0* with *tau.beta0*. JAGS uses "precision" as a parameter in specifying a Normal distribution instead of variance, so *tau.beta0* here is a "precision", and its equal to 1/Variance or $1/SD^2$.

All the coefficient for elevation ($beta_{k,1}$), coefficient for quadratic elevation ($beta_{k,2}$), and coefficient for land cover ($beta_{k,3}$) for every species distributed according to Normal distribution with mean ($mu.beta_1$, $mu.beta_2$, $mu.beta_3$) and precision ($tau.beta_1$, $tau.beta_2$, $tau.beta_3$) respectively (Appendix 7.1).

Hyperpriors for the model of abundance:

The next step is to specify priors of mean and standard deviation for intercepts and coefficients for both abundance and detection models. It is difficult to imagine a suitable prior on the logit scale for detection model and log scale for abundance model, but it is easily defining a uniform prior for the probability and then convert to the logit scale. For abundance model, prior for the mean number of individuals averaged across species at a site with mean elevation and at non-forested area, *lam0* distributed uniformly according to Beta distribution of Beta (1,1), so mean of intercept *mu.beta0* determined by logit(*lam0*), and prior for standard deviation of intercept, *sd.beta0* on Normal distribution is Uniform distribution (0,3). Since the analysis are working on the log scale and the predictors have been standardized to have SD = 1, the choice of prior is Uniform (-2,2) for all mean of coefficients ($mu.beta_1$, $mu.beta_2$, $mu.beta_3$) because it will be very surprised if the coefficients were outside the range ±2. The priors for standard deviation for coefficients ($sd.beta_1$, $sd.beta_2$, $sd.beta_3$) are Uniform (0,3), Uniform (0,2) and Uniform (0, 2) respectively. These supposed to be big enough and not show up as a constraint in the posterior (Appendix 7.1).

Hyperpriors for the model of detection:

For detection model (Appendix 7.1), prior for probability of detection on average covariates, *p0* distributed uniformly according to Beta distribution of Beta (1,1), so mean of intercept *mu.alpha0* determined by logit(*p0*), and prior for standard deviation of intercept,

sd.alpha0 on Normal distribution is Uniform distribution (0,5). Prior for mean of coefficients, $mu.alpha_1$ and $mu.alpha_2$ on Normal distribution is Uniform (-5,5), and prior for standard deviation of coefficients, *sd.alpha1* and *sd.alpha2* on Normal distribution is Uniform distribution (0,3).

Derived quantities:

There are a few derives quantities from the model, expected abundance on natural scale, mean detection on natural scale, number of occupied sites among the 16, and number of species at each site (Appendix 7.1).

7.2.3 JAGS Code

The full model in JAGS (Just Another Gibbs Sampler) codes (Appendix 7.1) will be passed to separate Open-Source Software JAGS version 4.3.0 based on R command in software R, then JAGS 4.3.0 return the output into R.

7.2.4 R code for preparations and running the model:

The covariates need to be included in the data to be passed to JAGS. All the covariates were standardized, so standard deviation equal 1 and mean equal 0. Then, all data set for JAGS will be bundled, summarized, and listed in 1 object called JAGSdata (Appendix 7.1).

For starting values, every species including augmented species were set to occur at every site, and the numbers of individual were set to not less than 5 for every species at every sites. Next, the parameters of interest were set. These 21 parameters are ("phi", "mp", "mlambda", "alpha0", "beta0", "alpha", "beta", "mu.beta0", "sd.beta0", "mu.beta", "sd.beta",

"p0", "mu.alpha0", "sd.alpha0", "mu.alpha", "sd.alpha", "Nsite", "Nocc.fs", "a", "N", "lam0", "lambda", "z") (Appendix 7.1).

Lastly, model will be run following the commands in Appendix 7.1. Number of Markov chains to run, n.chains = 10, number of iterations to run in the JAGS adaptive phase, n.adapt = 50000, total number of iterations per chain, n.iter = 500000, thinning rate, n.thin = 250, and parallel set to equal TRUE. For complex model like MSOM, deviance information criterion (DIC) is set to equal false, because it is not applicable here. An adaptation refers to the process of tuning or adapting the proposal distribution to optimize the MCMC sampling. Thinning is a way of reducing autocorrelation in the MCMC sample by subsampling the MCMC chain every prespecified number of iterations determined by the thinning interval. When parallel equals TRUE, MCMC chains were run in parallel on multiple CPU cores, so this optimized the running process in the computer (Plummer, 2017).

After a long run, the MCMC output was saved.

7.3 Result

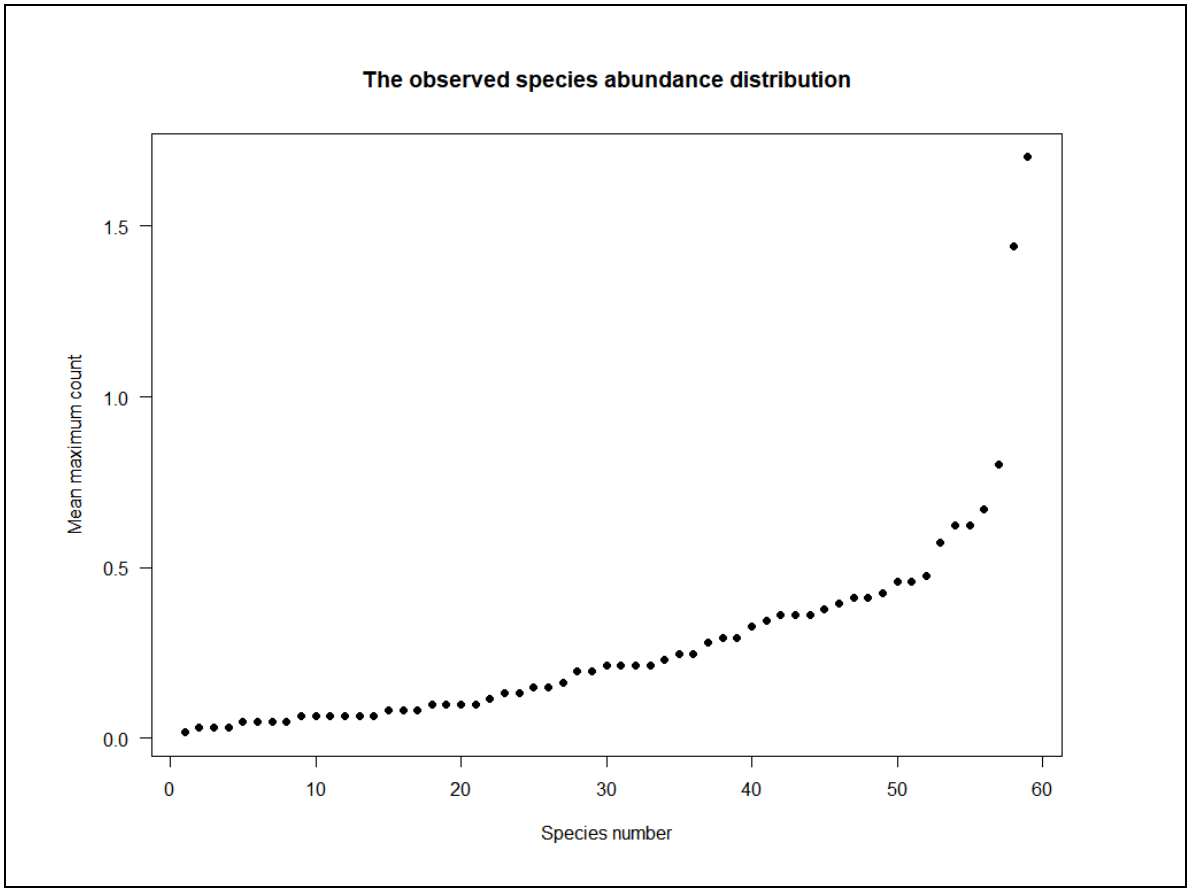


Figure 7.2: The distribution of abundance of observed species.

The first plot in Figure 7.2 above is the distribution of abundance of observed species, mean of maximum count of each 59 species sorted in inclining order.

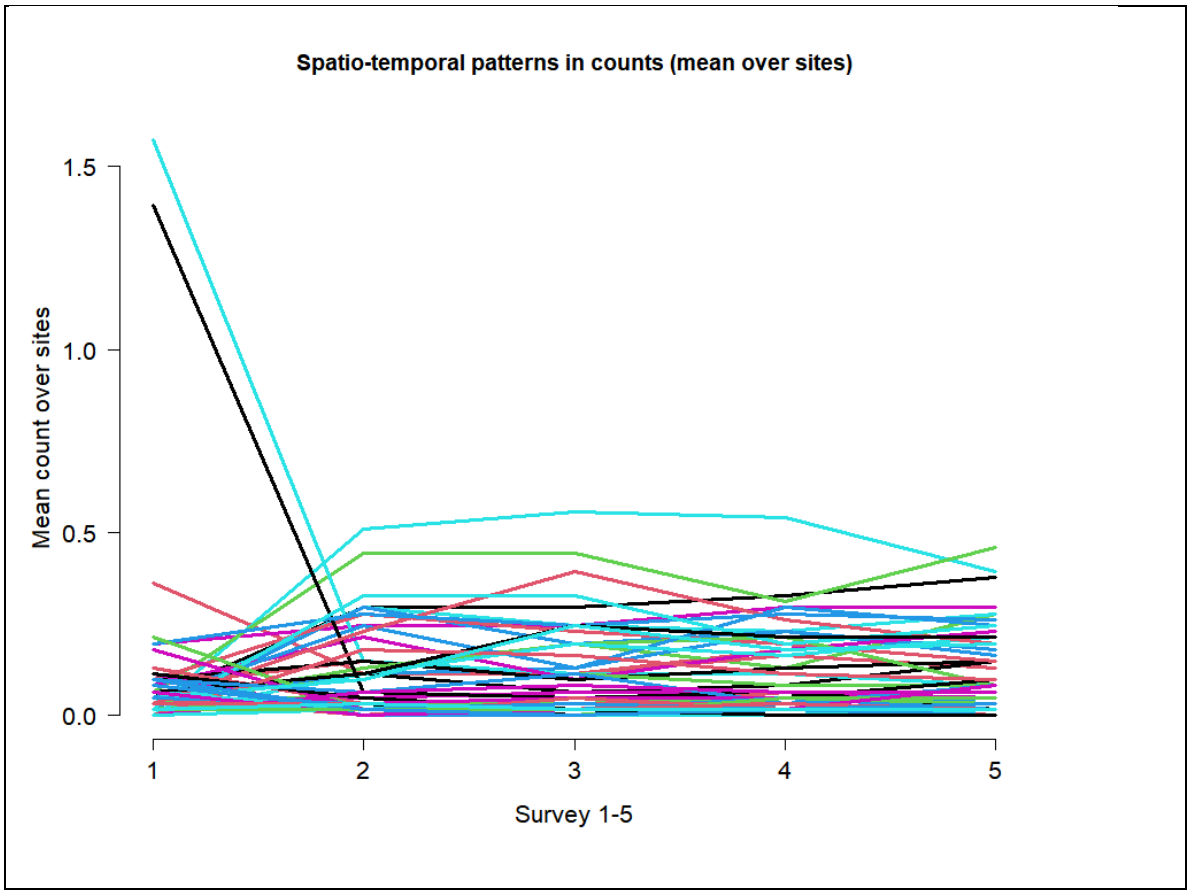


Figure 7.3: The Spatio-temporal patterns in counts.

The second plot in Figure 7.3 is spatio-temporal patterns in counts, mean count over sites for all 5 replicates survey of all 59 species.

The summary output of Markov Chain Monte Carlo from this Community N-mixture model with covariates is in Appendix 7.2. It took about 6.73 hours to run 10 chains, each with 2000 draws, and adaptation was sufficient. There are 23 parameters with 15122 nodes monitored.

The result of 16 parameters were selected to show the mean, standard deviation, median, lower 95% credible interval, upper 95% credible interval, Rhat and Monte Carlo Error as a percentage (Appendix 7.3). All Rhat were about 1, this indicated that all 10 chains

in iteration were converged, this mean estimated parameters were fine. Monte Carlo errors for all parameters not more than 5% were indicated enough effective sample size or sufficient draws from posterior distribution.

Another way to see if the model was right and estimated parameters were right too by looking at diagnostic plots of the same 16 selected parameters (Appendix 7.4). The posterior distributions for the coefficients are well cleared of the limits imposed by priors, so the model and estimated parameters were fine.

The results of Markov Chains are all in mathematical values, some in logit scale, some in probability, some in real values, so the best way to understand the results is to generate some plots. Since this model enables inferences at all three hierarchical levels; metacommunity, local community, and individual species, therefore examples of each will be given.

The number of counts across sites, in every survey occasion for each species influent by probability of detection and how many individuals available for detection. So, it is good to know what community detection probability is apart from species-specific probability of detection.

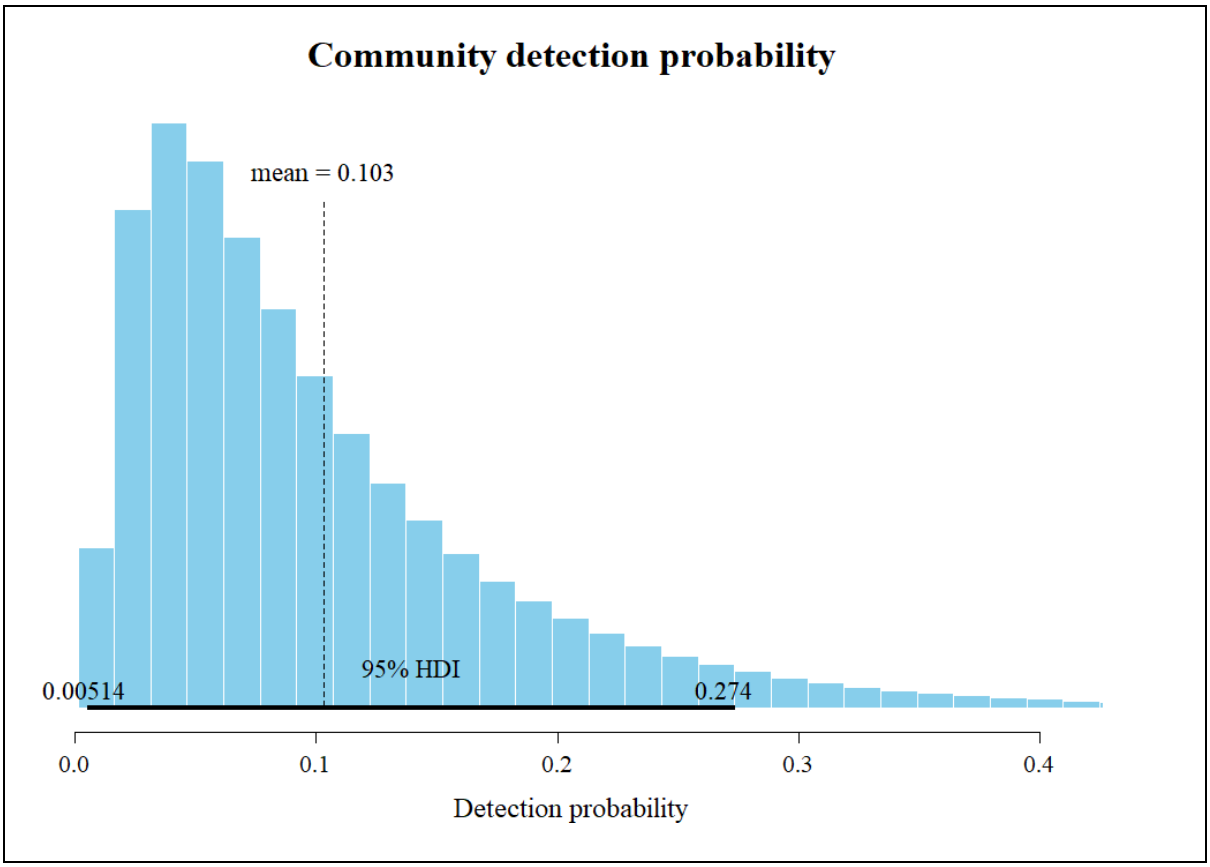


Figure 7.4: Plot for community detection probability at average survey duration (hour) and at mean of average body length (mm).

Figure 7.4 is plot for posterior community detection probability at average survey duration (hour) and at mean of average body length (mm). Based on the data and the prior, mean posterior community detection probability is 0.103 with 95% Highest Density Interval between 0.00514 to 0.275.

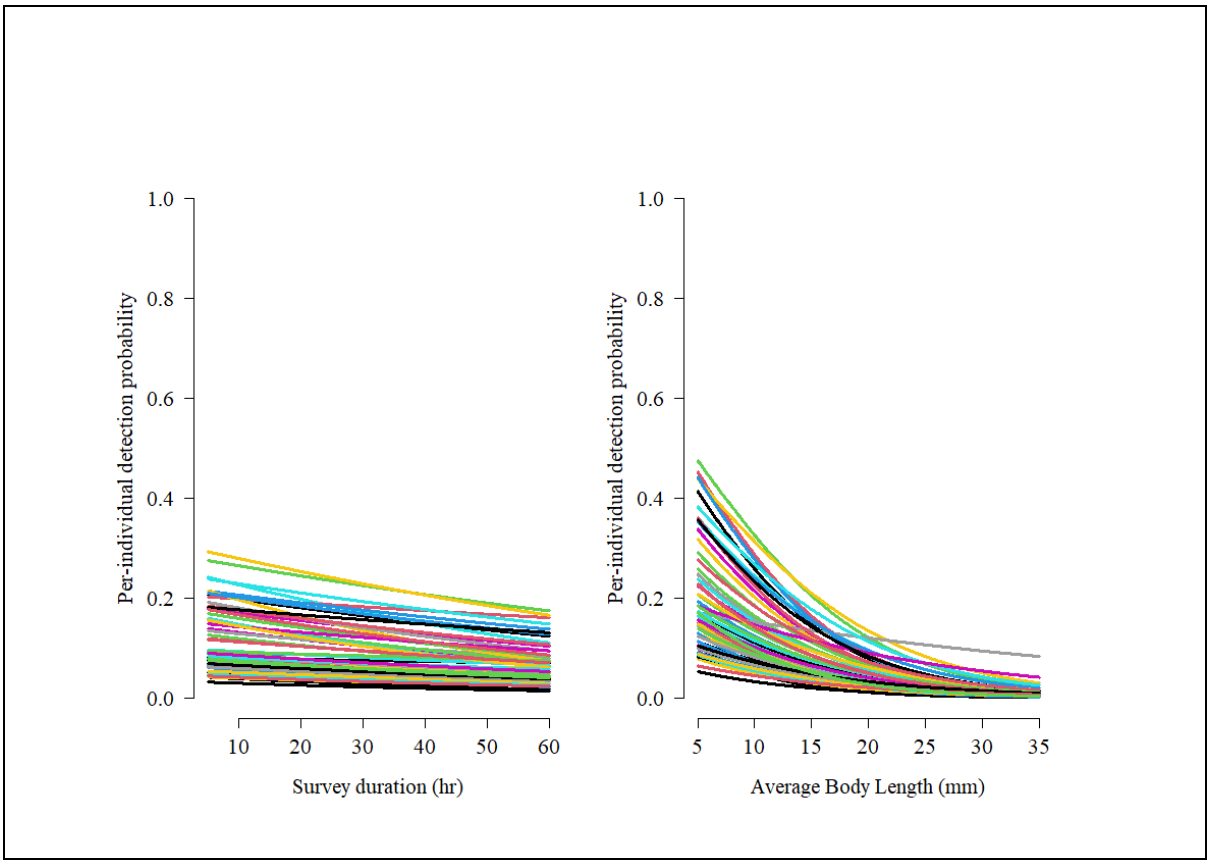


Figure 7.5: Plots for detection probability depend on survey duration (hour) and average body length (mm) for each of the 59 observed species.

Figure 7.5 above show species-specific predictions of detection probability (per individual) as a function of survey duration and average body length in any site under Community N-mixture model. Each line represents one of the 59 species observed in the survey. Probability of detection for each species were predicted went down with increase of survey duration. This happened due to the nature of specimen collection for taxonomical purposes, where collection was stopped when acquired "enough" sample. Probability of detection for each species were also predicted went down with increase of average body length. This is due to many specimens caught were smaller size species, not sure what is the reason.

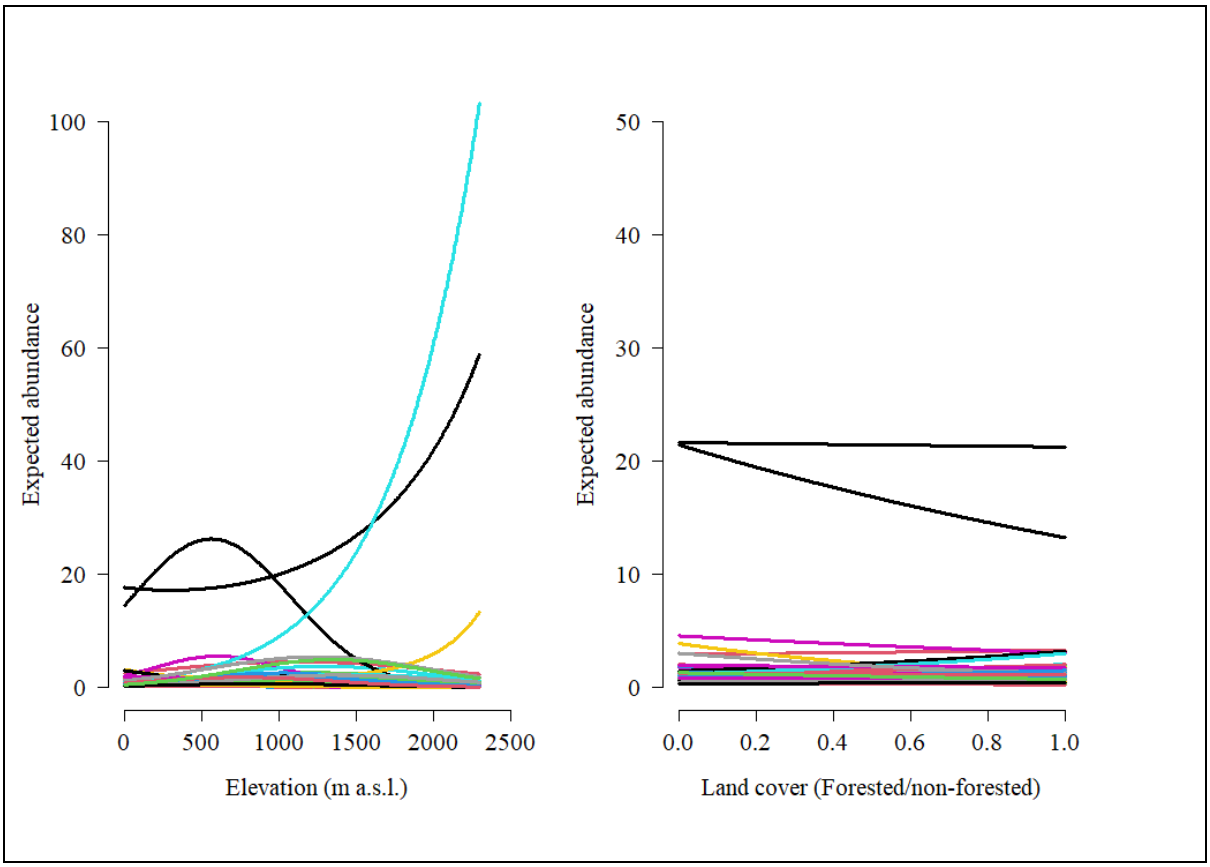


Figure 7.6: Plots for expected abundance at difference elevation (in meter above sea level and land cover (forested/non-forested) for each of the 59 observed species.

Figure 7.6 above show species-specific predictions of expected abundance probability as a function of elevation and land cover in any site under Community N-mixture model. Each line represents one of the 59 species observed in the survey. Under this model, it is possible to plot predictions of expected abundance of specific species of interest. There are 2 species occurred in high elevation habitat, and most of the species occurred in any elevation. Based on the data and this model analysis, there is insufficient evidence that the abundances of *Glenea* species affected by land cover (forested / non-forested area).

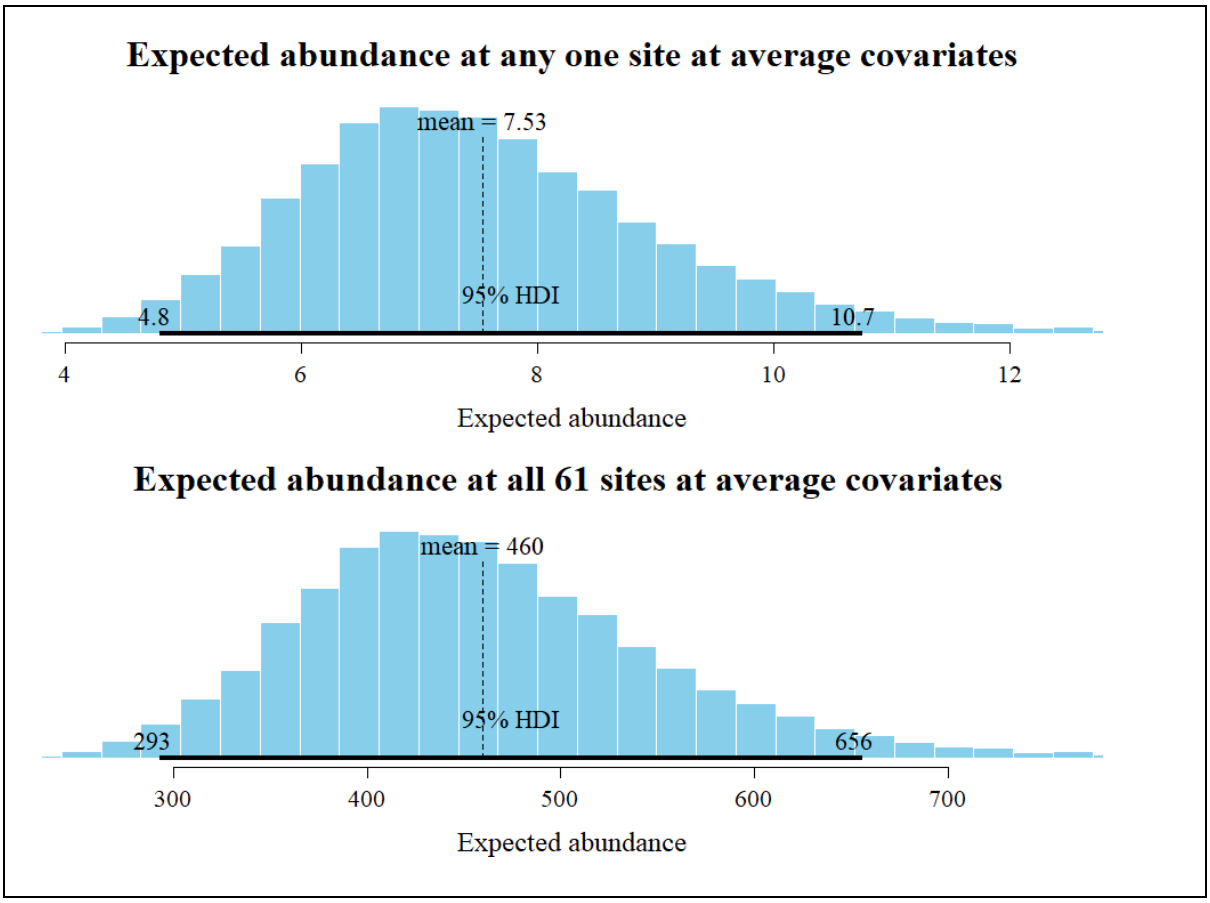


Figure 7.7: Expected abundance at any one site (above) and at all 61 sites (below) at average covariates.

Another metacommunity level inferences can be extracted from the result is expected abundance at any one site and expected abundance from all 61 sites at averaged covariates (Figure 7.7). The mean expected abundance at any one site at averaged covariates is 7.53 individuals with its 95% Highest Density Interval between 4.8 to 10.7 individuals. This expected abundance is from 1 visit if chosen any one site at random. The mean expected abundance all 61 sites at averaged covariates is 460 individuals with its 95% Highest Density Interval between 293 to 656 individuals. These abundances considered low for Cerambycidae, and this is expected because the data collections at the very beginning was

not designed to know how many they are, but to know what species were there. However, since the data were available, it is worthwhile to analyse it.

The expected number of species occurring at each site also can be derived from this Community N-mixture model, this is local community level inferences.

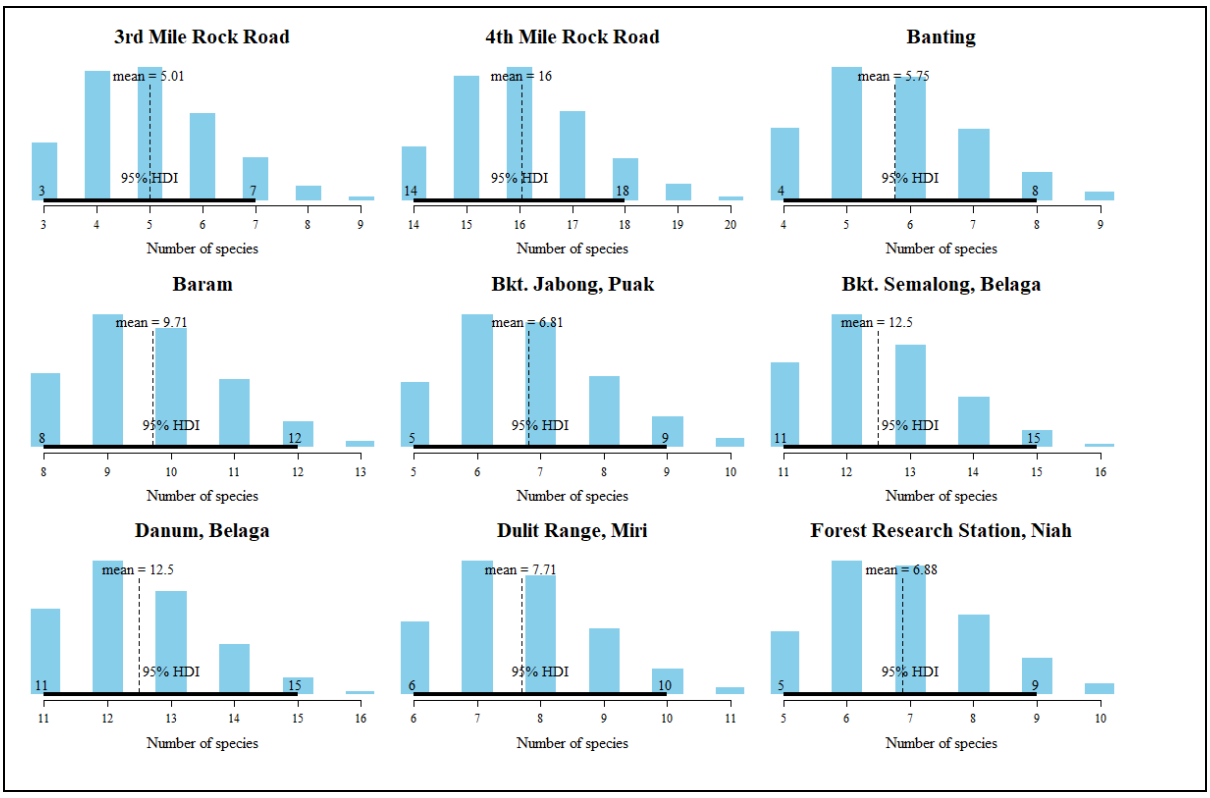


Figure 7.8: The estimated number of species occurring at first 9 sites.

Figure 7.8 are example plots of estimated number of species occurring at first 9 sites, it gives us mean estimated number and 95% Highest Density Interval as well.

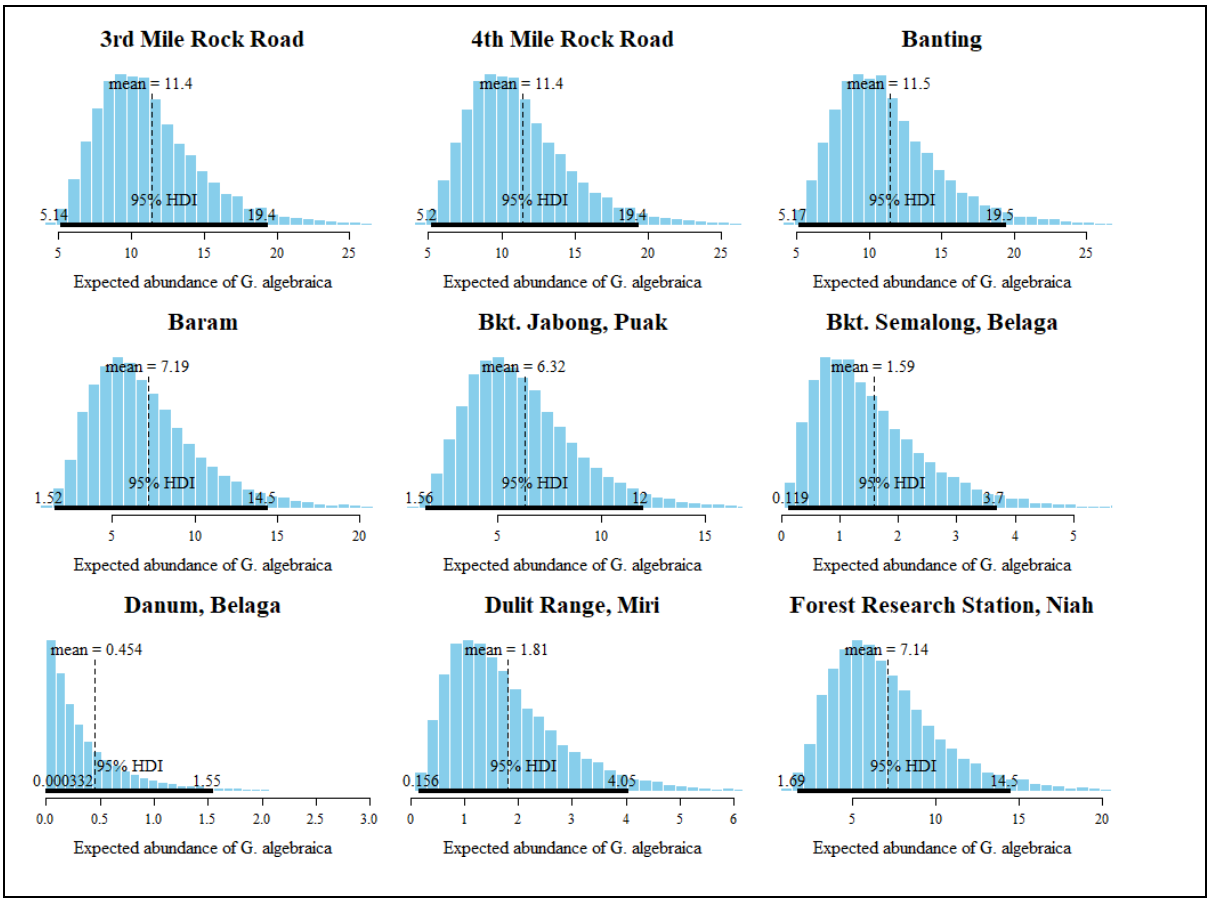


Figure 7.9: Expected abundance of *Glenea algebraica* at first 9 sites.

The third level inferences can be acquired from this hierarchical model is individual species inference. Figure 7.9 below is an example expected abundance of *Glenea algebraica* at first 9 sites, and the plots gives us the mean and 95% Credible Interval. The expected abundance for any species at any site is easily extracted from the result.

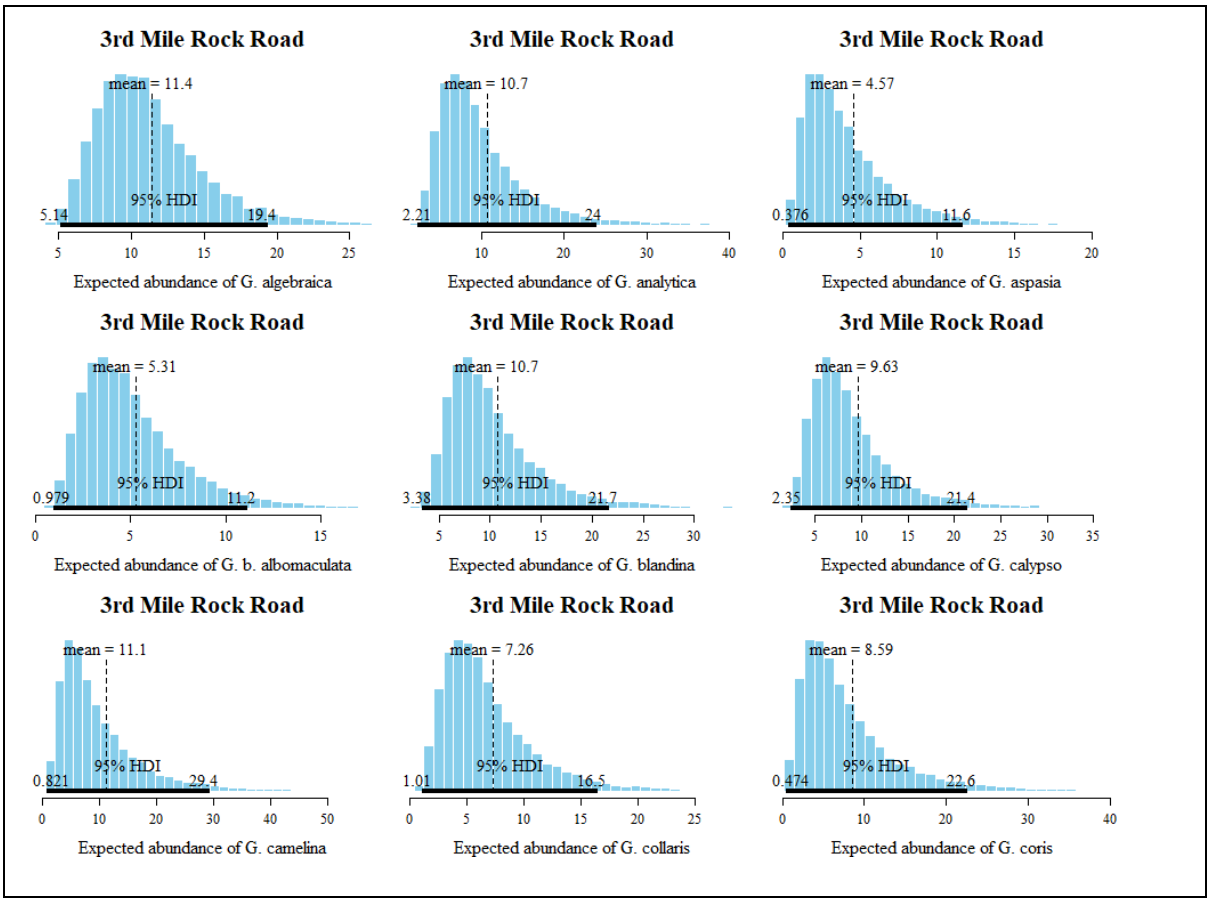


Figure 7.10: Expected abundance at 3rd Mile Rock Road for first 9 species.

Figure 7.10 is expected abundance of difference species at specific site like, for example the expected abundance at 3rd Mile Rock Road for first 9 species. The results of Community N-mixture model are providing this. So, this is example of result that is useful for wildlife management and monitoring.

7.4 Discussion

A lot of the trends were similar in the community occupancy model (Figures 6.4). The per-individual detection probability under the N-mixture model is obviously lower than the per-species detection probability under the occupancy model (because $P^* = 1 - (1 - p)N$, where P^* is the per-species detection probability, p is the per-individual detection probability, and N is local abundance). According to the N-mixture model, the p was anticipated to rise with survey duration, but in this instance, this did not occur because the data were not intended to predict abundance. The right study design will therefore be essential in the future to prevent this.

In Dorazio/Royle/Yamaura (DRY) community abundance model (Yamaura et al., 2012; Chandler et al., 2013) model, spatial patterns in the abundance of a community of species are described by a collection of elemental models for each species. Thus, this models are straight forward extensions to a community of species of any of the single-species models for abundance. The DRY model meets the main requirements for a flexible and robust community modelling framework: it allows workers to make inferences at all levels of a meta-community (species, community, metacommunity), and it explicitly deals with measurement error so that inferences can be made beyond just the sample of observed species, including estimation of species richness at multiple scales. Naturally, this object of inference includes the number of observed species at a point in time as well as the number of unobserved species. Only the DRY class of models allows for this generality and breadth of inference.

CHAPTER 8

GENERAL DISCUSSION

A total of 406 individuals were used to review and evaluate 59 species of the genus *Glenea*. There were 59 species available for evaluation, 41 species were redescribed, and 18 species were newly described. Systematic accounts of genus *Glenea* in this study were more comprehensive compared to the previous description because in this study every main external morphology was described in detail. So, it offers a good reference for another taxonomist.

The *Glenea* species of Sarawak are split into 6 distinct clusters, with the smallest cluster consisting of 3 species and the largest cluster consisting of 23 species, based on dendrogram reconstruction utilizing species morphological characteristics distances analysis in R. Since this is the first attempt at phenetics reconstruction based on the morphology of genus *Glenea* in Sarawak, there is no previous finding to compare. Therefore, this study provides useful information on the morphometrics of this genus. Despite the numerous, indisputable benefits of molecular data, it is crucial to keep gathering new morphological data for phenetics research and developing the techniques for morphology-based investigations.

In the future, more research on the ecological and biological requirements of this genus can be investigated to determine why some species are grouped closely together. Due to the paucity of research on this genus, it has been very difficult to date to explain why these patterns occurred. When additional factors are gathered to demonstrate the relationship shown by the morphometrics analysis, a multivariate analysis can be performed. Because of their near proximity to one another, certain species were thought to be related because of the

way they feed, which makes them pests on living trees. While some species have a structure that is comparable to others, this suggests that these species can be key decomposers or foragers on dead trees.

Hierarchical multispecies models, such as the Multiple Species Occupancy Model (MSOM), offer a promising path forward because they produce a more process-driven estimate of diversity through the differentiation of the biological and sampling processes, incorporating both the detection process and the occurrence state. These powerful community models can describe patterns like covariate linkages in the local community (all species present at one site), the entire metacommunity, and other communities (regional pool of species in the wider area of study).

At the species level, about half of the observed species were shown to respond significantly to forest cover, but there was no observable relationship between forest cover and species richness at the community level (Figure 6.4 versus Figure 6.11). According to Hamer et al. (2021), occupancy increased with wetland extent and connectedness, suggesting that the current metacommunity model may also explain and match species-habitat linkages.

The examination of estimates for species and the extrapolation of species richness to a region, such as the entirety of Sarawak, have also been demonstrated as additional analyses. The result is a species richness map that has been detection-corrected and is accompanied by an uncertainty map (Figure 6.16).

Jaccard indices, for instance, have been computed to compare locales with respect to the species that exist there as well as the locations of various species (Figure 6.13, Figure 6.14, and Figure 6.15).

This study reveals that multi-species occupancy models (MSOMs), which handle detectability issues, offer flexible methods to achieve the main goal in ecological entomology, which is to estimate species distribution, community composition, or species-richness patterns. A similar result was demonstrated by Mourguiart et al. (2021), who sampled Orthoptera groups at 81 alpine grasslands sites in France using three sampling techniques: sighting, listening, and sweep netting.

Contrarily, the Community N-Mixture Model explicitly addresses measurement error to allow for conclusions to be drawn that go beyond just the sample of observed species, estimates species richness at multiple scales, and is based on the abundance of a community of species. As a result, it satisfies our primary criteria for a flexible and reliable community modelling framework.

The community occupancy model (Figure 6.4) showed fairly consistent trends. It is clear that the per-individual detection probability under the N-mixture model is lower than the per-species detection probability under the occupancy model because $P^* = 1 - (1 - p)N$, where P^* is the per-species detection probability, p is the per-individual detection probability, and N is local abundance. The N-mixture model predicted that the p would increase with survey duration, but because the data were not intended to predict abundance, this did not happen in this case. A suitable study design is therefore necessary to avoid this in the future.

As a general practice, entomology study is less popular in Sarawak. Therefore, the quality of the old collected specimens is poor and limited. So, this limits the application of DNA-based study. This study is intended to be a foundational resource for references in the future, a comprehensive checklist, and a contribution to our knowledge of this genus.

CHAPTER 9

CONCLUSION AND RECOMMENDATIONS

9.1 Conclusion

There are sixty localities of *Glenea* species in Sarawak excluding Pontianak, Kalimantan, Indonesia. The Appendix 8.1 shown that only twelve localities are over 1000 feet above sea level, with Mount Murud is the highest site; around 50 % or 30 localities are below 100 feet above sea level; thirteen localities located between 115 to 495 feet above sea level; and only five localities at the elevation between 570 to 837 feet above sea level. These pattern maybe due to the few factors: one is the accessibilities to the certain area, whereas the area with lower elevation is more accessible compared to the area with high elevation, so that more specimens can be collected because of higher survey effort. If we look carefully at the localities with lower elevation, we can see that these areas are close to human civilization even though most of the time of collection was at the end of 19th century to early 20th century, so we assumed that the researchers or collectors were prefer accessible areas. One of the reasons maybe also be species habitat preferences; that are *Glenea* species prefer lower elevation habitat compared to higher elevation, which is this theory we don't know. So, ecological and habitat preferences study is needed to answer this question.

Based on the data from Appendix 8.1, twenty-six species of *Glenea* were collected from Matang Road, followed by Kuching where twenty-four species were collected, and the third highest number of species collected from Lawas, with ten species. In the early 20th century, Matang and Kuching area were quite common for European researchers due to their accessibility and closeness to town. So, we believed that the efforts were quite high here, and resulted in the many species being caught here. Even though many species were

distributed abundantly in the southern part of Sarawak, the northern and centered part also had significant roles as the habitats of *Glenea* species. The study found out that the *Glenea* species occupied different forest types, such as mix dipterocarp forest, peat swamp forest, mangrove forest, and secondary forest in Sarawak. This genus *Glenea* distributed very well over Sarawak at different altitudes and different forest types, so this showed that this genus has high adaptability. Since they had high adaptability, they can pose a threat to timber industries as a potential pest.

The application of the community-versions of site-occupancy models and N-mixture models specifically, the Dorazio/Royle (DR) community occupancy model, also known as the Multiple Species Occupancy Model (MSOM) and the Dorazio/Royle/Yamaura (DRY) community abundance model, also known as the Community N-Mixture Model had been tested with the *Glenea* species data from Sarawak. In both models, a group of elemental models for each individual species depict geographical patterns in the presence/absence or abundance of a community of species. Hence, these models are simple extensions of any single-species model for occurrence and abundance to a community of species. Both the MSOM and the Community N-Mixture Model satisfy the primary criteria for a versatile and reliable framework for community modelling: they permit inferences to be made at all levels of a metacommunity (species, community, and metacommunity), and they explicitly deal with measurement error so that inferences can be made beyond just the sample of observed species, including estimation of species richness at various scales. Naturally, both the number of species that have been observed and the number of species that have yet to be observed are included in this object of inference. This generality and range of inference are only possible with models belonging to the MSOM/Community N-Mixture Model class.

One significant distinction between the MSOM/Community N-Mixture model and other recently developed community models that are otherwise comparable is that the MSOM/Community N-Mixture model contains an explicit description of the measurement error for occurrence or abundance (e.g., Gelfand et al., 2005; Ovaskainen et al., 2010; Clark et al., 2014; Pollock et al., 2014). All such inferences from community models will be biased to an unknown extent unless this measurement error is modest. False negatives are one of two potential flaws, but the MSOM/Community N-Mixture model only considers this one. False-negative errors are much more likely to occur than false-positive errors, particularly in well-designed surveys and for taxa that are relatively easy to identify. However, there must be many situations in which species misidentifications can be a serious problem, particularly in the burgeoning Internet-based citizen-science programmes that are now springing up all over the world, and where observer quality is extremely variable, generally unknown, and frequently suspect (Kery and Royle, 2015).

9.2 Recommendations

Even though morphological taxonomic method able to classify genus *Glenea* into species level, it is recommended to try DNA-based methods to compare the results. Loss of habitat is unavoidable due to rapid land development in Sarawak; therefore, the proper collection or sampling of this genus need to do immediately. Since the species of this genus can be found in all different forest types, sampling should be done throughout Sarawak.

What steps will the MSOM/Community N-Mixture model's development and associated community models take next? The first is that these models will be applied much more frequently. These models provide insightful and comprehensive perspectives into

societies at various scales and are mechanically incredibly sensible. Also, the necessary data are often available, particularly the MSOM detection/non-detection statistics (Kery and Royle, 2015). A MSOM/Community N-Mixture model can be viewed as simply representing the most logical method of integrating data on all species in a community or a subset of them (Ovaskainen and Soininen, 2011). Hence, grouping the species together in a single study and specifying community hyperparameters to define the mean and the variability across species seems like a sensible thing to do if the goal is to characterise a community by some average over the species that appear in it. This precisely leads to the MSOM/Community N-Mixture model, which has also been independently identified (Gelfand et al., 2005) and often rediscovered since 2005. (e.g., Ovaskainen et al., 2010; Ovaskainen and Soininen, 2011). Use of these models is therefore strongly advised.

Additionally, MSOM is an unquestionably sophisticated hierarchical model that many potential users lack the necessary expertise to employ. Even though the software that runs them is publicly available and example code for frequently used models can be found online, better user-friendly MSOM and Community N-Mixture model implementations would encourage and promote their use. A significant first step towards achieving this goal would be the creation of a package that completely implements these models in the R environment. In addition, the creation of specialised software to run these models would facilitate their use, much like EstimateS (http://purl.oclc.org/estimates) did for conventional measures of species diversity or Presence (http://www.mbr-pwrc.usgs.gov/software/presence.html) did for single-species occupancy models. Another significant accomplishment was the creation of a dynamic, multi-season MSOM, which gives a technique to quantify beta diversity and assess metacommunity dynamics by

modelling change in occupancy between sample periods as local colonisation and extinction characteristics (Dorazio, et. al., 2010).

The logical final extension is to allow for time. In this chapter, every model was predicated on closure. In addition to Fukaya and Royle (2013), Henden et al. (2013), Tobler et al. (2015); Dorazio et al. (2010) have expanded the community model to include colonization/extinction dynamics. Starting with the fundamental dynamic occupancy model for a single species (MacKenzie et al., 2003; Royle and Kery, 2007), this extension is conceptually simple and applies the same concepts of treating species-level parameters as fixed or random effects and of accounting for or not accounting for unseen species via data augmentation.

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APPENDICES

Appendix 4.1: Morphological characteristics of genus *Glenea* Newman of Sarawak (Borneo).

No.:	Code:	Characteristics:
1	Blk	Black
2	Gr	Grey
3	Br	Brown
4	Rd	Red
5	Or	Orange
6	Yl	Yellow
7	Wt	White
8	Blu	Blue
9	B	Blotched (maculatus)- the color disposed in broad, irregular blotches.
10	B1p	One pair blotch.
11	B2p	Two pair blotches.
12	B3p	Three pair blotches.
13	Sp	Spotted (guttatus)- the color disposed in small spots.
14	Sp1p	One pair spot.
15	Sp2p	Two pair spots.
16	Sp3p	Three pair spots.
17	Sp4p	Four pair spots.
18	Sp5p	Five pair spots.
19	Sp6p	Six pair spots.
20	D	Dotted (punctatus)- the color disposed in very small round spots.
21	D1p	One pair dot.
22	D2p	Two pair dots.
23	D3p	Three pair dot.
24	D4p	Four pair dots.
25	D5p	Five pair dots.
26	TB1p	Tranversed banded (fasciatus)- when there is a pair of tranverse stripe of one color crossing another.
27	TB2p	Tranversed banded (fasciatus)- when there are two pairs of tranverse stripes of one color crossing another
28	St1	Striped (vittatus)- when there is a longitudinal stripe of one color crossing another.
29	St2	Striped (vittatus)- when there are two longitudinal stripes of one color crossing another.
30	St3	Striped (vittatus)- when there are three longitudinal stripes of one color crossing another.
31	St4	Striped (vittatus)- when there are four longitudinal stripes of one color crossing another.
32	St5	Striped (vittatus)- when there are five longitudinal stripes of one color crossing another.
33	St1p	Striped (vittatus)- when there is a pair of longitudinal stripes of one color crossing another.
34	St2p	Striped (vittatus)- when there are two pair of longitudinal stripes of one color crossing another.
35	St3p	Striped (vittatus)- when there are three pair of longitudinal stripes of one color crossing another.
36	St4p	Striped (vittatus)- when there are four pair of longitudinal stripes of one color crossing another.
37	St5p	Striped (vittatus)- when there are five pair of longitudinal stripes of one color crossing another.
38	h1	Head with the front as long as wide.
39	h2	Head with the front longer than wide.
40	h3	Frons somewhat broader than long.

41	h4	Head slightly smallerer than prothorax.
42	h5	Head equal in width with prothorax.
43	h6	Feebly flattened between the antennal tubercles.
44	h7	Broadly concave between antennal tubercles.
45	h8	Feebly, broadly depressed between the antennal tubercles.
46	h9	Occiput convex at middle of base.
47	h10	Occiput weakly convex at middle of base.
48	h11	With a narrow, smooth, longitudinal carina extending from epistoma to vertex.
49	h12	Frons with a fine longitudinal furrow extending from epistoma to occiput.
50	h13	Frons with a fine longitudinal furrow extending from vertex to occiput.
51	h14	Surface sparsely, coarsely, irregularly punctate.
52	h15	Finely densely punctured.
53	h16	Finely sparsely punctured.
55	h17	Densely clothed with recumbent hairs.
54	h18	Sparsely clothed with inconspicuous, recumbent and erect hairs.
56	h19	Sparsely clothed with short, inconspicuous hairs on median part.
57	h20	Gena fairly shorter than inferior eyelobe
58	h21	Antennae slender.
59	h22	Antennae fairly longer than body.
60	h23	Antennae about as long as the body.
61	h24	Antennae shorter than the body
62	p1	Pronotum as wide as long.
63	p2	Pronotum distinctly longer than wide.
68	p3	Prothorax slightly rounded at the sides.
69	p4	Margin wider at base.
70	p5	Almost parallel-sided at apical half and narrowed from behind to middle.
71	p6	Almost parallel-sided for apical half and weakly narrow at apex.
72	p7	Sides feebly, arcuately rounded anteriorly.
73	p8	Feebly constricted behind middle.
74	p9	Strongly constricted behind middle.
75	p10	Surface densely clothed with recumbent hair.
76	p11	Surface densely clothed with short erect hair.
77	p12	Finely densely punctured.
78	p13	Surface densely, coarsely, irregularly punctate.
79	p14	Surface sparsely, coarsely, irregularly punctate.
80	p15	Feebly punctate at sides.
81	p16	Punctures nearly concealed by the pubescence.
82	s1	Scutellum tranverse late ovovatus, rounded at apex.
83	s2	Scutellum broad, feebly concave.
84	s3	Scutellum broad, nearly flat.
85	s4	Scutellum trapezoidal.
86	s5	Scutellum triangular.
87	e1	Elytra broader than prothorax at base, x time as long as the basal width.
88	e2	Elytra strongly carinate and deflexed at the sides.
89	e3	Elytra feebly carinate and moderately deflexed at the sides.
90	e4	Almost straightly narrowed posteriorly to the point of a short distance before apices, then fairly narrowed to obliquely truncate apices with sutural and marginal spines.
91	e5	Surface coarsely, sparsely, irregularly punctate basally.
92	e6	Surface coarsely, rather densely punctate basally.

93	e7	The punctures becoming obsolete toward apices.
94	e8	The punctures becoming finer and sparser apically.
95	e9	With lateral carinae incomplete.
96	e10	Deflexed sides with two longitudinal rows of coarse puncture on basal two thirds.
97	e11	Tapering posteriorly.
98	e12	The pubescence nearly hiding the punctures in fresh specimens.

Appendix 6.1: R Codes for Data wrangling

```
# Import data from separate files for sites, species, and counts and
# construct the various data objects needed for analysis:
# sites, sps, SimG: data frames corresponding to the data files for sites, species and count data
# C, Y: site x rep x species array with counts or detection/nondetection
# Ysum: site x species matrix with number of reps where the species was detected
# nreps: the number of replicate surveys at each site
# maxRep: the maximum number of replicate surveys at any site
# nsites: the number of sites = nrow(sites)
# nsps: number of species observed pooled over all sites = nrow(sps)
# Sobs: number of species observed at each site
# obs.occ: number of sites at which each species was observed
# fc: simulated forest cover in percentage (%)
# dur: simulated survey duration in hour
# el: elevation at each site (m)
# landC: land cover in 2 categories, forested and non-forested
# swk: Sarawak map in shapefile in CRS: Sarawak-Timbalai48 / RSO Borneo
# cord.RSO: coordinates for the sites
# demSwk: Digital Elevation Model map of Sarawak
# lcSwk: land cover of Sarawak in 19 categories
# lcSwk2cat: land cover of Sarawak in 2 categories forested and non-forested
# demdf: Digital Elevation Model in data frame format
# lcdf: land cover in data frame format


# Read in the species, site and counts data:
# ------------------------------------------
sps <- read.csv("Glenea_spp.csv", comment="#") # file for species
str(sps)
```

```
sites <- read.csv("Glenea_site.csv", comment="#") # file for sites
str(sites)

SimG <- as.matrix(read.csv("GleneaOcc.csv", row.names=1)) # file for count
data
head(SimG)
dim(SimG)

# C is a 3-D array of counts, sites x reps x sps
(nsites <- ncol(SimG))
(nreps <- 5)
(nsps <- nrow(SimG))
(maxRep <- 5)

# array for simulated count data

C <- array(NA, c(nsites, nreps, nsps  ))
dimnames(C) <- list(colnames(SimG), NULL, rownames(SimG))
str(C)

set.seed(124) # to make sure same data created
C[,1,] <- SimG
for(i in 1:nsites)
      for(k in 1:nsps)
            C[i,2:5,k] <- rpois(nreps-1, SimG[k,i]) #returns n random
numbers from the
                                                    #Poisson distribution
x ~ P(lambda)
# Another simulation option, where we simulated "0" detection = "0.1"
#C[,1,] <- SimG
#for(i in 1:nsites)
#     for(k in 1:nsps)
#           C[i,2:5,k]                  <-                  rpois(nreps-1,
ifelse(SimG[k,i]==0,0.1,SimG[k,i])) ## replaces all 0 with 0.1

sum(is.na(C))

C[,,1:3]

# Y is detection/nondetection array
```

```
Y <- (C > 0) * 1
dim(Y)
range(Y)
sum(is.na(Y)) == 0
str(Y)
Y[,,1:3]

#=============================================================
# simulating forest cover (%) and duration of survey (hour)
# Values for each parameter

nSites <- 61
nrep <- 5
trueSp <- 59*2
omega <- 0.5
nspec <- trueSp * omega
mean.psi <- 0.3
sig.lpsi <- 2
sig.beta.lpsi = 0
mu.beta.lpsi = 0.3
mean.p = 0.4
sig.lp = 1
mu.beta.lp = 1
sig.beta.lp = 0



# Generate detection history adapted from AHMbook::simComm function
y.all <- y.obs <- p <- array(NA, c(nSites, nrep, nspec))
dimnames(y.all) <- dimnames(y.obs) <- dimnames(p) <- list(paste("site",
1:nSites, sep = ""), paste("rep", 1:nrep, sep = ""), paste("sp", 1:nspec,
sep = ""))
z <- psi <- matrix(NA, nSites, nspec)
dimnames(z) <- dimnames(psi) <- list(paste("site", 1:nSites, sep = ""),
paste("sp", 1:nspec, sep = ""))
detected.at.all <- rep(NA, nspec)

fc <- round(runif(nSites,10,100),digit=0)
dur <- round(matrix(runif(nSites * nrep,8,8*7), ncol = nrep),digit=1)
mu.lpsi <- ifelse(mean.psi == "1", 500, qlogis(mean.psi))
mu.lp <- ifelse(mean.p == "1", 500, qlogis(mean.p))
```

```
beta0 <- rnorm(nspec, mu.lpsi, sig.lpsi)
beta1 <- rnorm(nspec, mu.beta.lpsi, sig.beta.lpsi)
alpha0 <- rnorm(nspec, mu.lp, sig.lp)
alpha1 <- rnorm(nspec, mu.beta.lp, sig.beta.lp)
for (k in 1:nspec) {
  psi[, k] <- plogis(beta0[k] + beta1[k] * fc)
  for (j in 1:nrep) {
    p[, j, k] <- plogis(alpha0[k] + alpha1[k] * dur[,j])
  }
}
for (k in 1:nspec) {
  z[, k] <- rbinom(nSites, 1, psi[, k])
}
occurring.in.sample <- apply(z, 2, max)
for (k in 1:nspec) {
  for (i in 1:nSites) {
    for (j in 1:nrep) {
      y.all[i, j, k] <- rbinom(1, z[i, k], p[i, j, k])
    }
  }
}

#=================================================================
# Get observed number of occupied sites for each species
tmp <- apply(Y, c(1,3), max, na.rm = TRUE)
## Y is sites x reps x species, and we used c(1,3) in the call to apply,
## so tmp is sites x species with 1 if species detected at the site
dim(tmp) ## check
range(tmp)
## Now we sum across SITES for each SPECIES:
sort(obs.occ <- apply(tmp, 2, sum, na.rm = TRUE))

# Plot species 'occurrence frequency' distribution
## Note that obs.occ is sorted here too.

par(mfrow = c(2, 1), mar = c(5,5,5,4))
plot(sort(obs.occ), xlab = "Species number", main="Species 'occurrence
frequency' distribution",
      ylab = "Number of sites with detections",las=1,pch=16)
```

```
# Get observed number of species for each site, Sobs
tmp1 <- apply(Y, c(1,3), max, na.rm = TRUE)
## This time we sum across SPECIES for each SITE:
sort(Sobs <- apply(tmp1, 1, sum))      # Compute and print sorted species counts
str(tmp1)


par(mfrow = c(1, 1), mar = c(5,5,5,4))
plot(table(Sobs), xlim = c(0, 30), xlab = "Observed number of species", ylab = "Number of sites",
      main="The observed number of species for each site, Sobs",frame = FALSE,las=1)
abline(v = mean(Sobs, na.rm = TRUE), col = "blue", lwd = 3, lty=3)
par(mfrow = c(1, 1))


# Collapse 3D detection/nondetection data to 2D detection frequencies
Ysum <- apply(Y, c(1,3), sum, na.rm = TRUE) # number of times species detected at each site
dim(Ysum)
range(Ysum)
head(Ysum)


# NEW: Produce maps of Sarawak showing the sample sites and some other stuff
# ------------------------------------------------------------------------------
library(raster)
library(maptools)
library(rgdal)
library(sp)
library(rgeos)
# Converting coordinates:
# Then you must set your existing coordinate system. Because otherwise, R will treat your x and y as plain data,
# not coordinate. In this case we are going to convert the existing lat-long coordinates to
# RECTIFIED SKEW ORTHOMORPHIC PROJECTION (RSO) (easting-northing system).


# Read data
```

```
sites <- read.csv("Glenea_site.csv", comment="#") # file for sites


(cord.decTmp <- SpatialPoints(cbind(sites$Long, sites$Lat),
proj4string=CRS("+proj=longlat")))


# Transform the CRS or Coordinate Reference System to RSO by setting the
EPSG to 29873 for WGS 84,

# RSO Timbalai 48


(cord.RSO <- spTransform(cord.decTmp, CRS("+init=epsg:29873")))


swk <- readOGR(dsn="SARAWAK",layer="Sarawak-Timbalai48(m)") # dsn=data
source name, layer=shapefile name

summary(swk)


# Plotting points

par(mfrow = c(1, 2),las=1)

plot(cord.decTmp, axes = TRUE, main = "Lat-Long Coordinates", cex.axis =
0.95)

plot(cord.RSO, axes = TRUE, main = "Timbalai 1948 / RSO Borneo (m) (EPSG
29873) Coordinates", col = "red", cex.axis = 0.95)

par(mfrow = c(1, 1))


# plot on Sarawak's shapefile

par(mfrow = c(1, 1),las=1,family="serif")

plot(swk, main = "Timbalai 1948 / RSO Borneo (m) (EPSG 29873)
Coordinates",col="lightgreen")

plot(cord.RSO, axes = TRUE, col = "red", cex.axis = 0.95,add=TRUE, pch=19,
cex=0.5)

par(mfrow = c(1, 1))


# Read raster in VRT format - Geospatial Data Abstraction Library (GDAL)
virtual format

#=============================================================================
===============

fn <- "C:/Ngumbang/Education/PhD in Quantitative
Ecology/MSOM/MYS_elevation_countrymask/MYS_msk_alt.vrt"


dem <- raster(fn) # Digital elevation model (DEM) for Malaysia from DIVA-
GIS (2020)

proj4string(dem) # Get or set a coordinate reference system (projection)

proj4string(swk)
```

```
dem2 <- projectRaster(dem, crs=proj4string(swk)) # Project a Raster object following crs of Sarawak-Timbalai48 / RSO Borneo
proj4string(dem2)

demSwk <- crop(dem2, swk) # returns or crop a geographic subset of an object as specified by an Extent object

plot(demSwk)
plot(swk, add=TRUE)
plot(cord.RSO, axes = TRUE, col = "red", cex.axis = 0.95,add=TRUE, pch=19, cex=0.5)
summary(demSwk)



#====================================
fc <- "C:/Ngumbang/Education/PhD in Quantitative Ecology/MSOM/MYS_landcover_mask/MYS_msk_cov.vrt"

lc <- raster(fc) # land cover for Malaysia from DIVA-GIS (2020)
proj4string(lc)
proj4string(swk)

lc2 <- projectRaster(lc, crs=proj4string(swk), method = "ngb")
proj4string(lc2)



lc3 <- crop(lc2, swk) # land cover for Sarawak
plot(lc3)
plot(swk, add=TRUE)
summary(lc3)
table(values(lc3))

lcSwk <- lc3
lcSwk[values(lc3 > 19)] <- NA # land cover for Sarawak excluding Water Bodies (natural & artificial)
table(values(lcSwk))

lcSwk[values(lcSwk > 8)] <- 0 # land cover in categories more than 8 = non-forest
table(values(lcSwk))
```

```
lcSwk[values(lcSwk > 0)] <- 1 # land cover i category 8 or less = forested area
table(values(lcSwk))

plot(lcSwk)
plot(swk, add=TRUE)

lcSwk2cat <- lcSwk # land cover in 2 categories, 1 = forested, 0 = non-forest
table(values(lcSwk2cat))

plot(lcSwk2cat)
plot(swk, add=TRUE)



# make a data frame
lcdf <- as.data.frame(lcSwk2cat, xy=TRUE)
dim(lcdf)
head(lcdf)
str(lcdf)
summary(lcdf)

demdf <- as.data.frame(demSwk, xy=TRUE)
dim(demdf)
head(demdf)
str(demdf)
summary(demdf)

# Extracting values from Glenea survey points
el <- round(extract(demSwk,cord.RSO),digit=1) # Extract elevation from Glenea points
el[40] <- 3.0 # Put in Pontianak's elevation

landC <- round(extract(lcSwk2cat,cord.RSO),digit=1) # Extract elevation from Glenea points
landC[c(18,40)] <- 0 # Put in Pontianak and Kuching land cover
landC[59] <- 1 # Put in Teluk Assam land cover
```

```
# Produce elevation and forest maps of Sarawak

oldpars <- par(mfrow = c(1,2), mar = c(1,1,3,5))

# Elevation map

r1 <- rasterFromXYZ(data.frame(x = demdf$x, y = demdf$y, z = demdf$MYS_msk_alt))

mapPalette <- colorRampPalette(c("grey", "yellow", "orange", "red"))

plot(r1, col = mapPalette(100), axes = FALSE, box = FALSE, main ="Elevation (m)")

plot(swk, add=TRUE)

plot(cord.RSO, axes = TRUE, col = "red", cex.axis = 0.95,add=TRUE, pch=19, cex=0.5)

# Forest cover map

r2 <- rasterFromXYZ(data.frame(x = lcdf$x, y = lcdf$y, z = lcdf$MYS_msk_cov))

mapPalette <- colorRampPalette(c("grey", "lightgreen", "darkgreen"))

plot(lcSwk, col = mapPalette(100), axes = F, box = FALSE, main = "Land cover (categorical)")

plot(swk,add=TRUE)

plot(cord.RSO, axes = TRUE, col = "red", cex.axis = 0.95,add=TRUE, pch=19, cex=0.5)

par(oldpars)


# Save the full data set

save(sites, sps,C, Y, Ysum, nreps, nsites, maxRep, nsps, Sobs, obs.occ, fc,dur,

      el, landC, swk, cord.RSO, demSwk, lcSwk, lcSwk2cat, demdf, lcdf,

file="Glenea_data_full.RData")
```

Appendix 6.2 Global Land Cover Class according to Land Cover Classification System

	GLC Global Class (according to LCCS terminology)
1.	**Tree Cover, broadleaved, evergreen** *LCCS >15% tree cover, tree height >3m* (Examples of sub-classes at regional level* : *closed > 40% tree cove; open 15-40% tree cover)*
2.	**Tree Cover, broadleaved, deciduous, closed**
3.	**Tree Cover, broadleaved, deciduous, open** *(open 15-40% tree cover)*
4.	**Tree Cover, needle-leaved, evergreen**
5.	**Tree Cover, needle-leaved, deciduous**
6.	**Tree Cover, mixed leaf type**
7.	**Tree Cover, regularly flooded, fresh water** (& brackish)
8.	**Tree Cover, regularly flooded, saline water,** (daily variation of water level)
9.	**Mosaic:** **Tree cover / Other natural vegetation**
10.	**Tree Cover, burnt**
11.	**Shrub Cover, closed-open, evergreen** (Examples of sub-classes at reg. level *: (i) sparse tree layer)
12.	**Shrub Cover, closed-open, deciduous** (Examples of sub-classes at reg. level *: (i) sparse tree layer)
13.	**Herbaceous Cover, closed-open** (Examples of sub-classes at regional level *: (i) natural, (ii) pasture, (iii) sparse trees or shrubs)
14.	**Sparse Herbaceous or sparse Shrub Cover**
15.	**Regularly flooded Shrub and/or Herbaceous Cover**
16.	**Cultivated and managed areas** (Examples of sub-classes at reg. level *: (i) terrestrial; (ii) aquatic (=flooded during cultivation), and under terrestrial: (iii) tree crop & shrubs (perennial), (iv) herbaceous crops (annual), non-irrigated, (v) herbaceous crops (annual), irrigated)
17.	**Mosaic:** **Cropland / Tree Cover / Other natural vegetation**
18.	**Mosaic:** **Cropland / Shrub or Grass Cover**
19.	**Bare Areas**
20.	**Water Bodies** (natural & artificial)
21.	**Snow and Ice** (natural & artificial)
22.	**Artificial surfaces and associated areas**

Appendix 6.3: R code for MSOM part A

```
#  Part A : main community-level parameters
#  Species richness maps, inference about regional richness,
#  species accumulation curves and other community ecology inferences
#  based on z matrix
library(jagsUI)
library(wiqid)
library(mcmcOutput)
# Bundle and summarize data set
load(file="Glenea_data_full.RData")
ls()
# Specify model in JAGS language
#================================================================================
modelText <- "model {
  # Augmentation process:this is the 'parameter expansion'
  for(k in 1:M){
    w[k] ~ dbern(omega)           # Metacommunity membership indicator
  }                               # (or data augmentation variable)
  # Ecological model for latent occurrence z (process model)
  for(k in 1:M){
    for (i in 1:nsites) {
      logit(psi[i, k]) <- lpsi[k] + betalpsi1[k] * ele[i] +
             betalpsi2[k] * ele2[i] + betalpsi3[k] * forest[i]
      z[i,k] ~ dbern(w[k] * psi[i, k])
    }
  }
  # Observation model for observed detection frequencies
  for(k in 1:M){
    for (i in 1:nsites) {
      for(j in 1:nreps) {
        logit(p[i, j, k]) <- lp[k] + betalp1[k] * DUR[i,j]
        Y[i, j, k] ~ dbern(z[i,k] * p[i, j, k])
      }
    }
  }
  # Priors
```

```
omega ~ dbeta(1.5,3)
# Priors for species-specific effects in occupancy and detection
for(k in 1:M){
  lpsi[k] ~ dnorm(mu.lpsi, tau.lpsi)    # Hyperparams describe community
  betalpsi1[k] ~ dnorm(mu.betalpsi1, tau.betalpsi1)
  betalpsi2[k] ~ dnorm(mu.betalpsi2, tau.betalpsi2)
  betalpsi3[k] ~ dnorm(mu.betalpsi3, tau.betalpsi3)
  lp[k] ~ dnorm(mu.lp, tau.lp)
  betalp1[k] ~ dnorm(mu.betalp1, tau.betalp1)
}
# Hyperpriors
# For the model of occupancy
mu.psi ~ dbeta(1,1)
mu.lpsi <- logit(mu.psi)  ######
tau.lpsi <- 1/(sd.lpsi)^2
sd.lpsi ~ dunif(0,10)  # just needs to be sensibly big and not show
                       # up      as a constraint in the posterior
mu.betalpsi1 ~ dunif(-5,5)
tau.betalpsi1 <- 1/(sd.betalpsi1)^2
sd.betalpsi1 ~ dunif(0, 10)
mu.betalpsi2 ~ dunif(-5,5)
tau.betalpsi2 <- 1/(sd.betalpsi2)^2
sd.betalpsi2 ~ dunif(0,5)
mu.betalpsi3 ~ dunif(-5,5)
tau.betalpsi3 <- 1/(sd.betalpsi3)^2
sd.betalpsi3 ~ dunif(0,10)

# For the model of detection
mu.p ~ dbeta(1,1)
mu.lp <- logit(mu.p) #######
tau.lp <- 1/(sd.lp)^2
sd.lp ~ dunif(0, 5)
mu.betalp1 ~ dunif(-5,5)
tau.betalp1 <- 1/(sd.betalp1)^2
sd.betalp1 ~ dunif(0, 3)

# Derived quantities
for(k in 1:M){
```

```
    Nocc.fs[k] <- sum(z[,k])      # Number of occupied sites for each
species
  }
  for (i in 1:nsites) {
    Nsite[i] <- sum(z[i,])        # Number of occurring species at each
site
  }
  Ntotal <- sum(w[])              # Total metacommunity size
} "
writeLines(modelText, con="model10.jags")
# ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^

# Organise data
# Augment data set: now we need the full 3D Y array
nz <- 100                    # Use for vague prior on Ntotal: M = 59 + 100
( M <- nsps + nz )
Yaug <- array(0, dim=c(nsites, maxRep, M)) # array with only zeroes
# Create same NA pattern in augmented species as in the observed species
NApattern <- dur / dur
Yaug <- sweep(Yaug, c(1, 2), NApattern, "*")
mean(is.na(Yaug)) == mean(is.na(Y)) # should be same proportion of NAs
Yaug[,,1:nsps] <- Y      # copy into it the observed data

# Standardise the covariates (mean = 0, sd = 1)
ele <- (el - mean(el)) / sd(el)
forest <- (landC - mean(landC)) / sd(landC)
DUR <- (dur - mean(dur) )/ sd(dur)

# Bundle and summarize data set for JAGS
jagsData <- list(Y = Yaug, nsites = nsites, nreps = nreps, M = M,
  nspec = nsps, ele = ele, ele2 = ele^2, forest = forest, DUR = DUR)

str(jagsData)

# Starting values
wst <- rep(1, M)                    # Simply set everybody at 'occurring'
zst <- array(1, dim = c(nsites, M)) # ditto for z
inits <- function() list(w = wst, z = zst)
```

```
## Work with main model parameters
## ================================

# Parameters monitored : Only main structural parameters
wanted1 <- c("omega", "Ntotal", "Nocc.fs","Nsite","lpsi", "lp","mu.lpsi",
"sd.lpsi",
                  "mu.betalpsi1", "sd.betalpsi1", "mu.betalpsi2",
                  "sd.betalpsi2", "mu.betalpsi3", "sd.betalpsi3",
                  "mu.lp", "sd.lp", "mu.betalp1", "sd.betalp1","z","w")

# Call JAGS from R, check traceplots and summarize posteriors
memory.limit(30000) # increase memory size allocated for R

out10 <- jags(jagsData, inits, wanted1, "model10.jags", DIC=FALSE,
  n.chains = 10, n.adapt = 1000, n.burnin = 0, n.iter = 2e5, n.thin = 100,
parallel = TRUE )

 save(out10, file="out10.RData") # do this after a long run!
```

Appendix 6.4: Summary of Markov Chain Monte Carlo (mcmc) output for 20 parameters with 10410 nodes that were monitored.

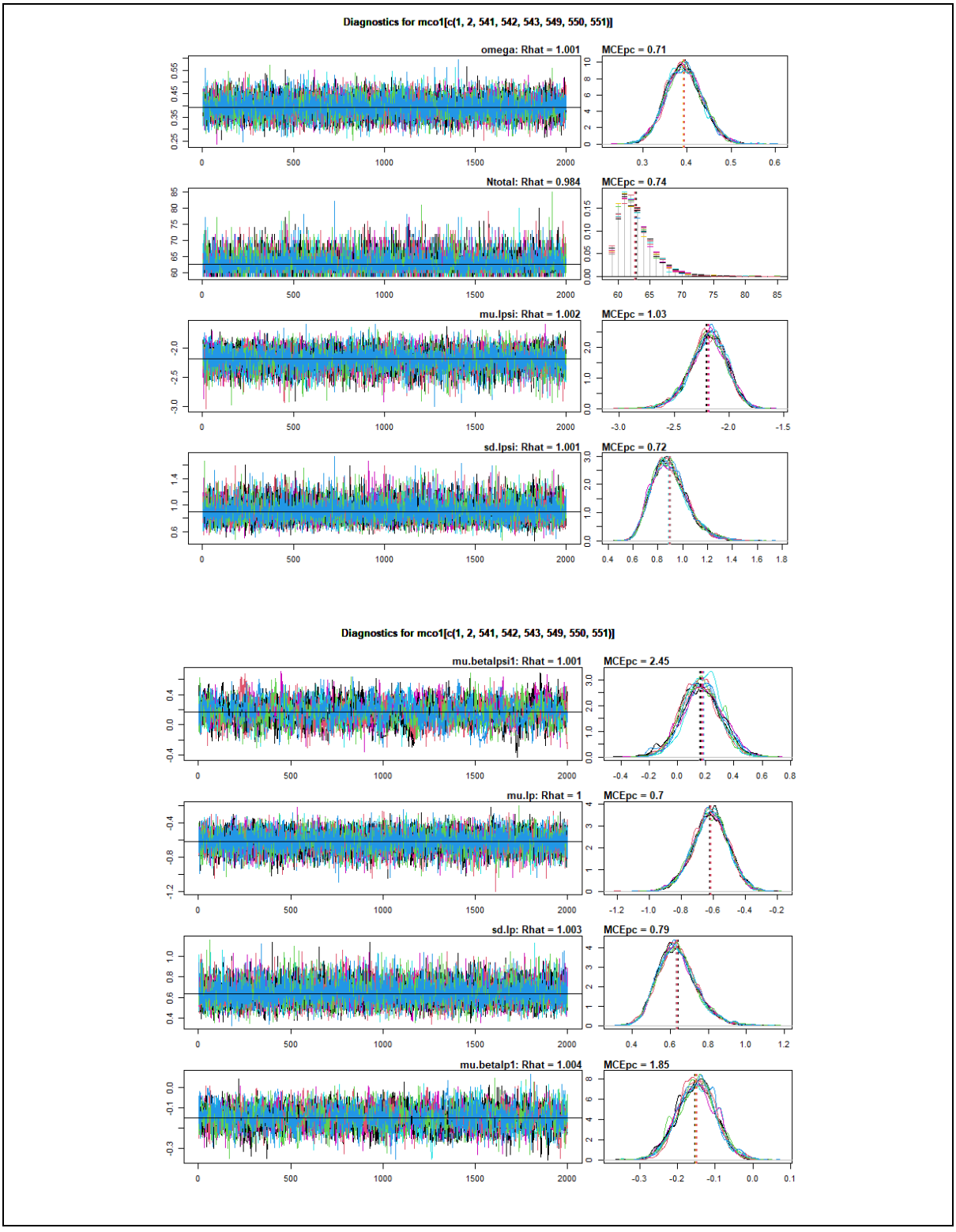
```
> ( mco1 <- mcmcOutput(out10) ) # default, load everything
Object of class 'mcmcOutput'; approx. size 1.67 GB
MCMC values from jagsUI object ‘out10’
Model definition file: model10.jags
Model run date: 2020-09-16 14:01:54
MCMC chain generation took 9.9 hrs
Adaptation was sufficient.
The output has 10 chains each with 2000 draws.
It has 20 parameters with 10410 nodes monitored:
             nodes
omega            1
Ntotal           1
Nocc.fs        159
Nsite           61
lpsi           159
lp             159
mu.lpsi          1
sd.lpsi          1
mu.betalpsi1     1
sd.betalpsi1     1
mu.betalpsi2     1
sd.betalpsi2     1
mu.betalpsi3     1
sd.betalpsi3     1
mu.lp            1
sd.lp            1
mu.betalp1       1
sd.betalp1       1
z             9699
w              159
```

Appendix 6.5: Summary output of 8 selected parameters.

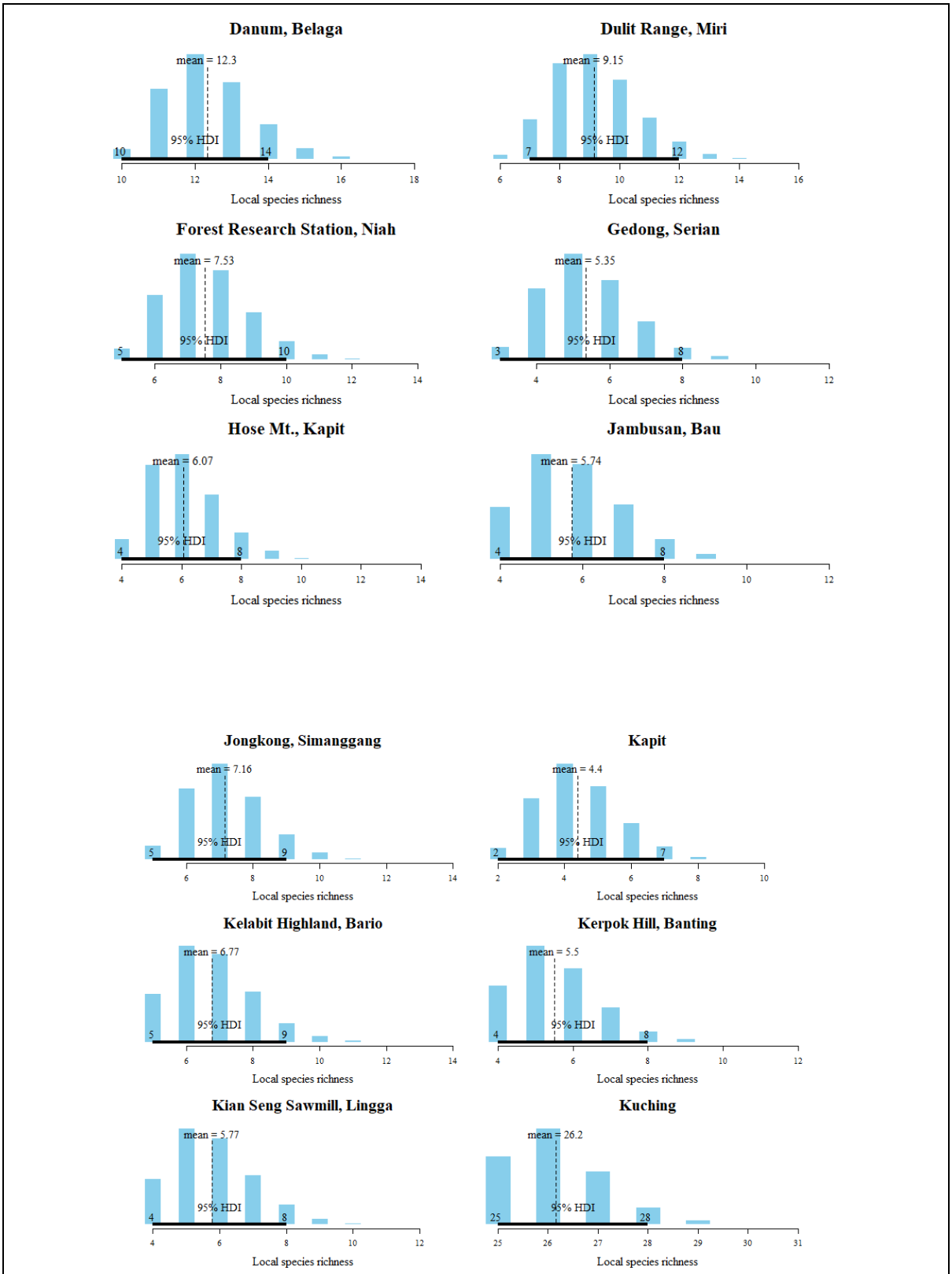
```
> summary(mco1[c(1,2,541,542,543,549,550,551)])
MCMC values from matrix 'out'
The object has 8 nodes with 2000 draws for each of 10 chains.
l95 and u95 are the limits of a 95% Highest Density Credible Interval.
Rhat is the estimated potential scale reduction factor:
        largest is 1.00; NONE are greater than 1.10.
MCEpc is the Monte Carlo standard error as a percentage of the posterior SD:
        largest is 2.5%; NONE are greater than 5%.

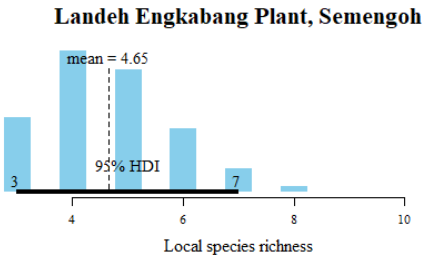
               mean      sd   median   l95    u95   Rhat  MCEpc
omega         0.393   0.042  0.392  0.314  0.477  1.001 0.708
Ntotal        62.740  2.675  62.000 59.000 68.000 0.984 0.745
mu.lpsi      -2.191  0.169 -2.182 -2.521 -1.858  1.002 1.032
sd.lpsi       0.897  0.148  0.884  0.632   1.196  1.001 0.720
mu.betalpsi1 0.169  0.139  0.168 -0.104   0.440  1.001 2.454
mu.lp         -0.618 0.111 -0.616 -0.847 -0.410  1.000 0.698
sd.lp          0.636 0.103  0.629   0.449  0.850  1.003 0.786
mu.betalp1   -0.149 0.051 -0.149 -0.251 -0.052  1.004 1.852
```

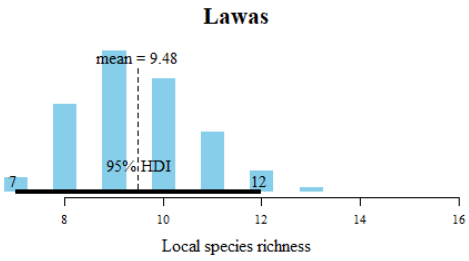
Appendix 6.6: Diagnostic plot for 8 selected parameters.

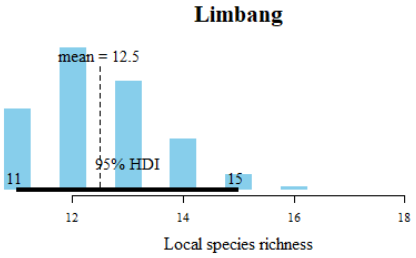


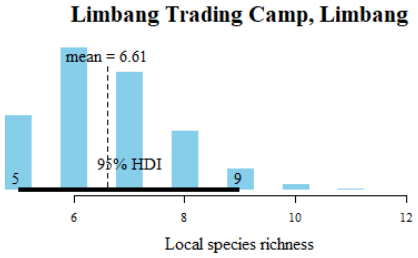
Appendix 6.7: Estimated species richness of *Glenea* at each site.

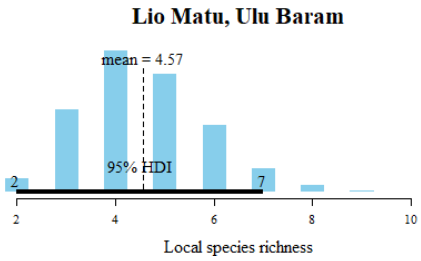


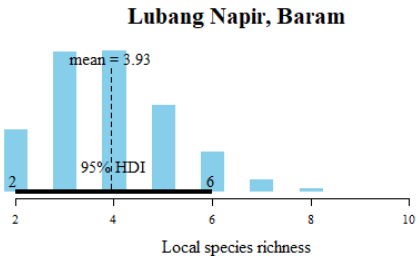

Landeh Engkabang Plant, Semengoh
mean = 4.65
95% HDI
3
7
4
6
8
10
Local species richness

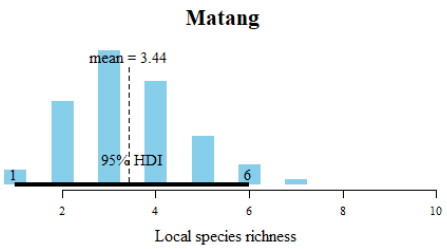

Lawas
mean = 9.48
95% HDI
7
12
8
10
12
14
16
Local species richness

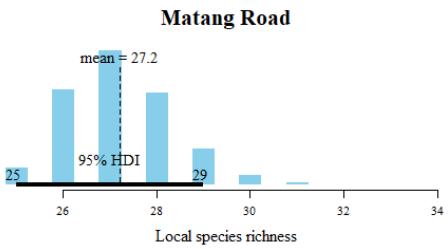

Limbang
mean = 12.5
95% HDI
11
15
12
14
16
18
Local species richness

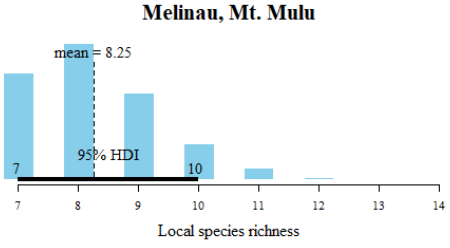

Limbang Trading Camp, Limbang
mean = 6.61
95% HDI
5
9
6
8
10
12
Local species richness

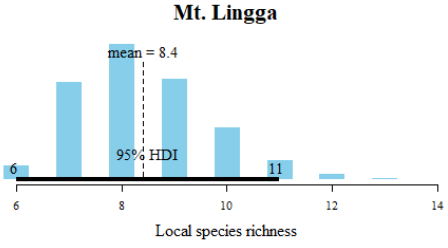

Lio Matu, Ulu Baram
mean = 4.57
95% HDI
2
7
2
4
6
8
10
Local species richness

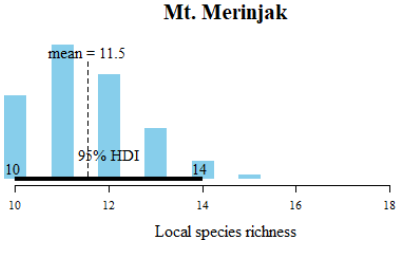

Lubang Napir, Baram
mean = 3.93
95% HDI
2
6
2
4
6
8
10
Local species richness

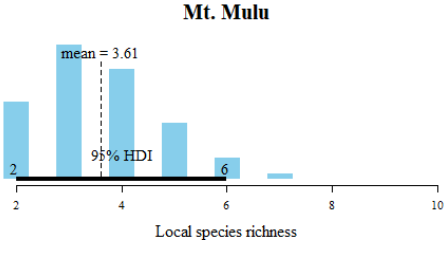

Matang
mean = 3.44
95% HDI
1
6
2
4
6
8
10
Local species richness

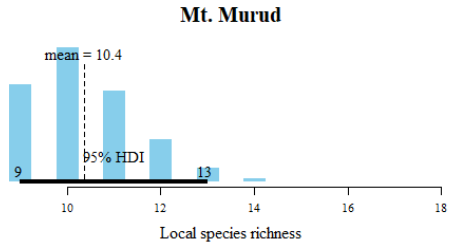

Matang Road
mean = 27.2
95% HDI
25
29
26
28
30
32
34
Local species richness

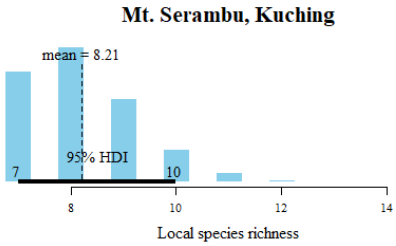

Melinau, Mt. Mulu
mean = 8.25
95% HDI
7
10
7
8
9
10
11
12
13
14
Local species richness

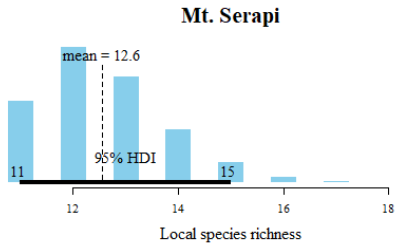

Mt. Lingga
mean = 8.4
95% HDI
6
11
6
8
10
12
14
Local species richness

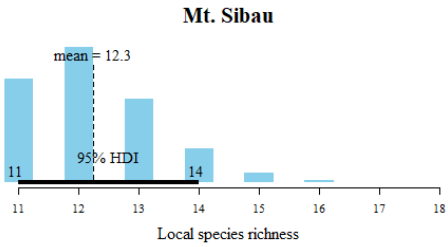

Mt. Merinjak
mean = 11.5
95% HDI
10
14
10
12
14
16
18
Local species richness

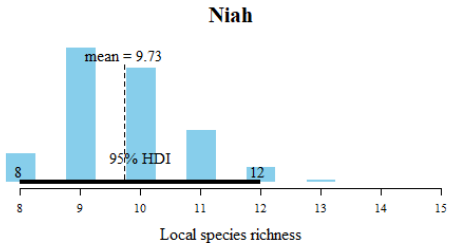

Mt. Mulu
mean = 3.61
95% HDI
2
6
2
4
6
8
10
Local species richness

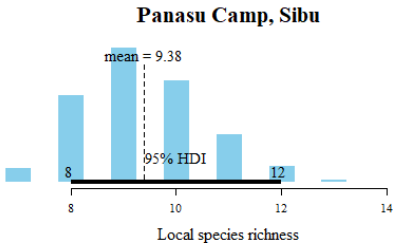

Mt. Murud
mean = 10.4
95% HDI
9
13
10
12
14
16
18
Local species richness

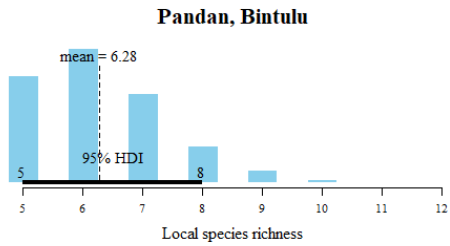

Mt. Serambu, Kuching
mean = 8.21
95% HDI
7
10
8
10
12
14
Local species richness

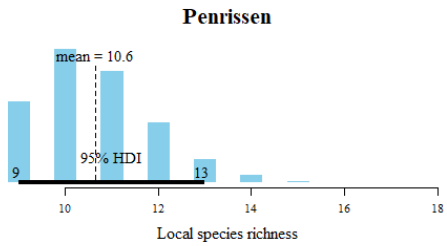

Mt. Serapi
mean = 12.6
95% HDI
11
15
12
14
16
18
Local species richness

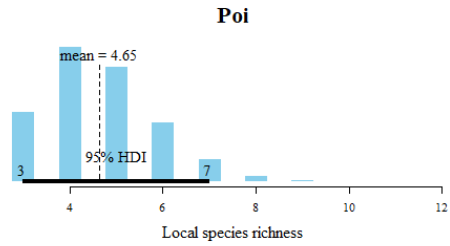

Mt. Sibau
mean = 12.3
95% HDI
11
14
11
12
13
14
15
16
17
18
Local species richness

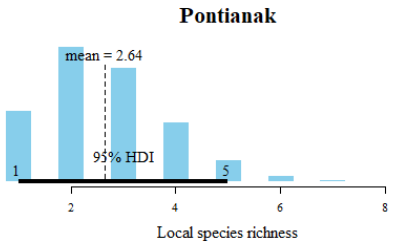

Niah
mean = 9.73
95% HDI
8
12
8
9
10
11
12
13
14
15
Local species richness

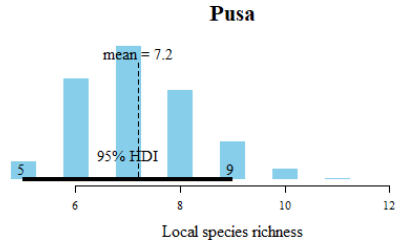

Panasu Camp, Sibu
mean = 9.38
95% HDI
8
12
8
10
12
14
Local species richness

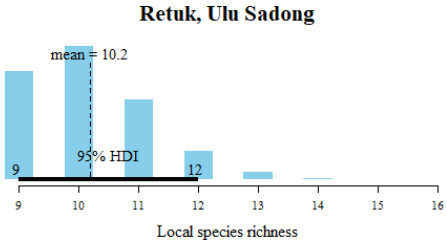

Pandan, Bintulu
mean = 6.28
95% HDI
5
8
5
6
7
8
9
10
11
12
Local species richness

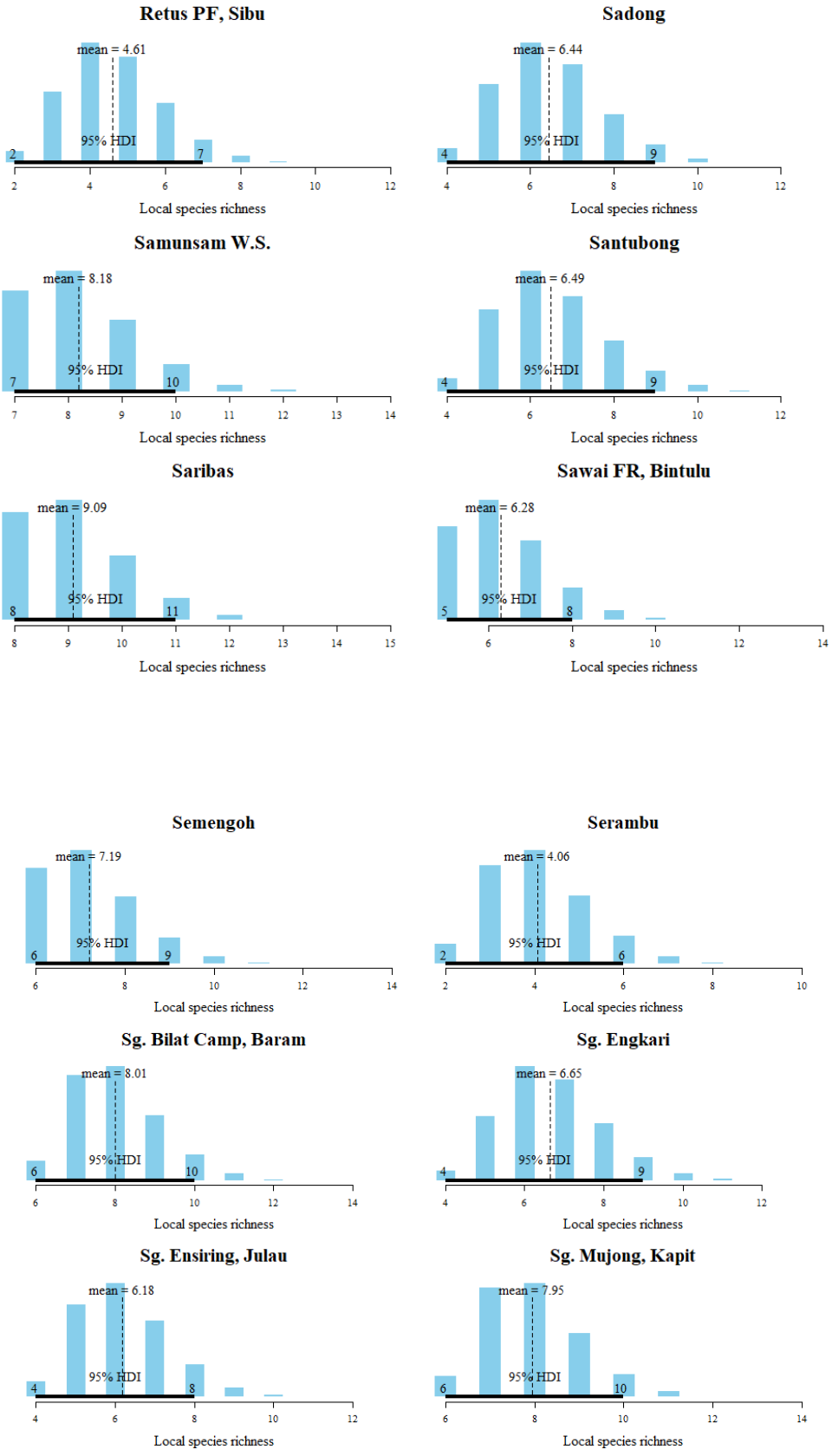

Penrissen
mean = 10.6
95% HDI
9
13
10
12
14
16
18
Local species richness

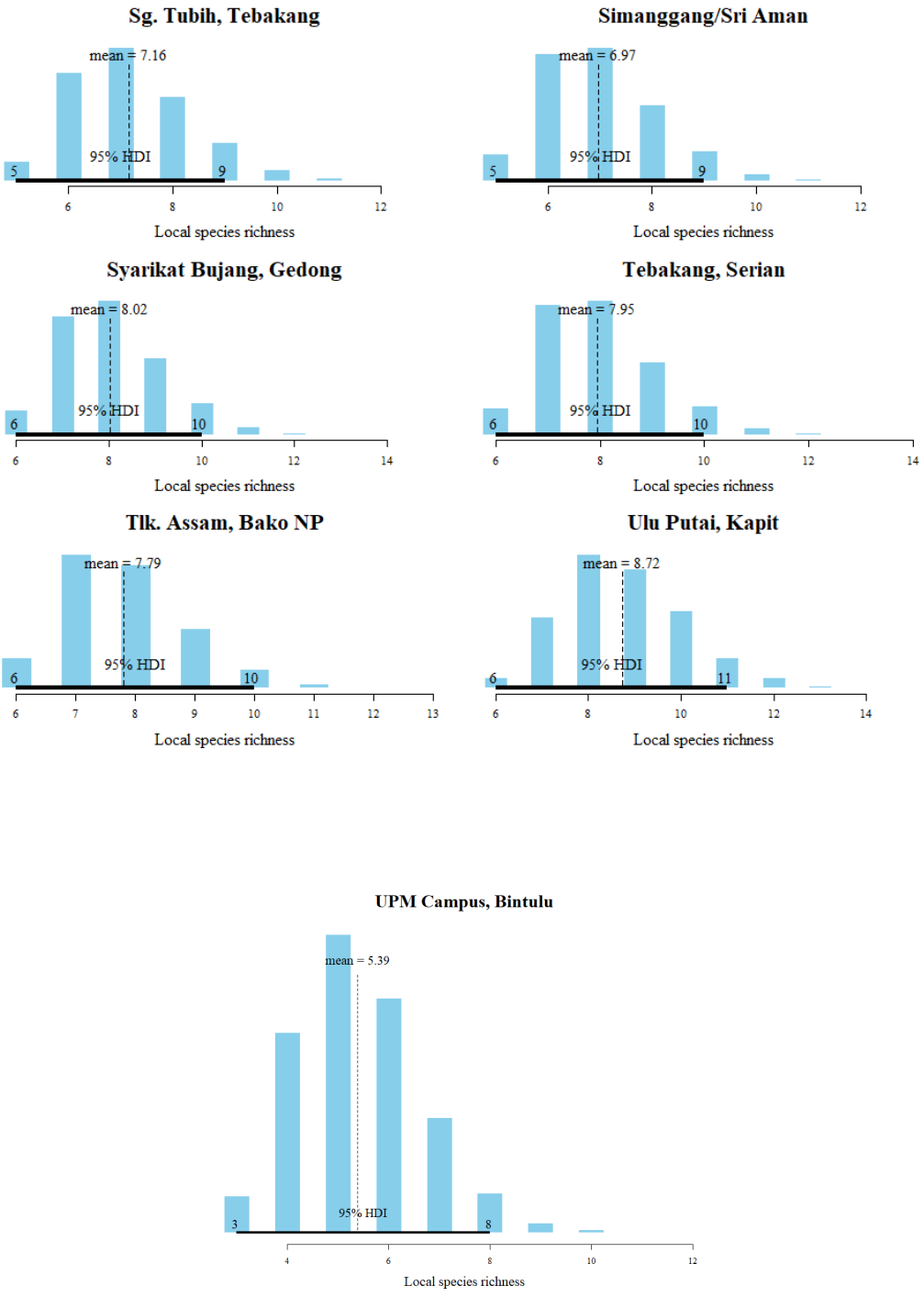

Poi
mean = 4.65
95% HDI
3
7
4
6
8
10
12
Local species richness


Pontianak
mean = 2.64
95% HDI
1
5
2
4
6
8
Local species richness

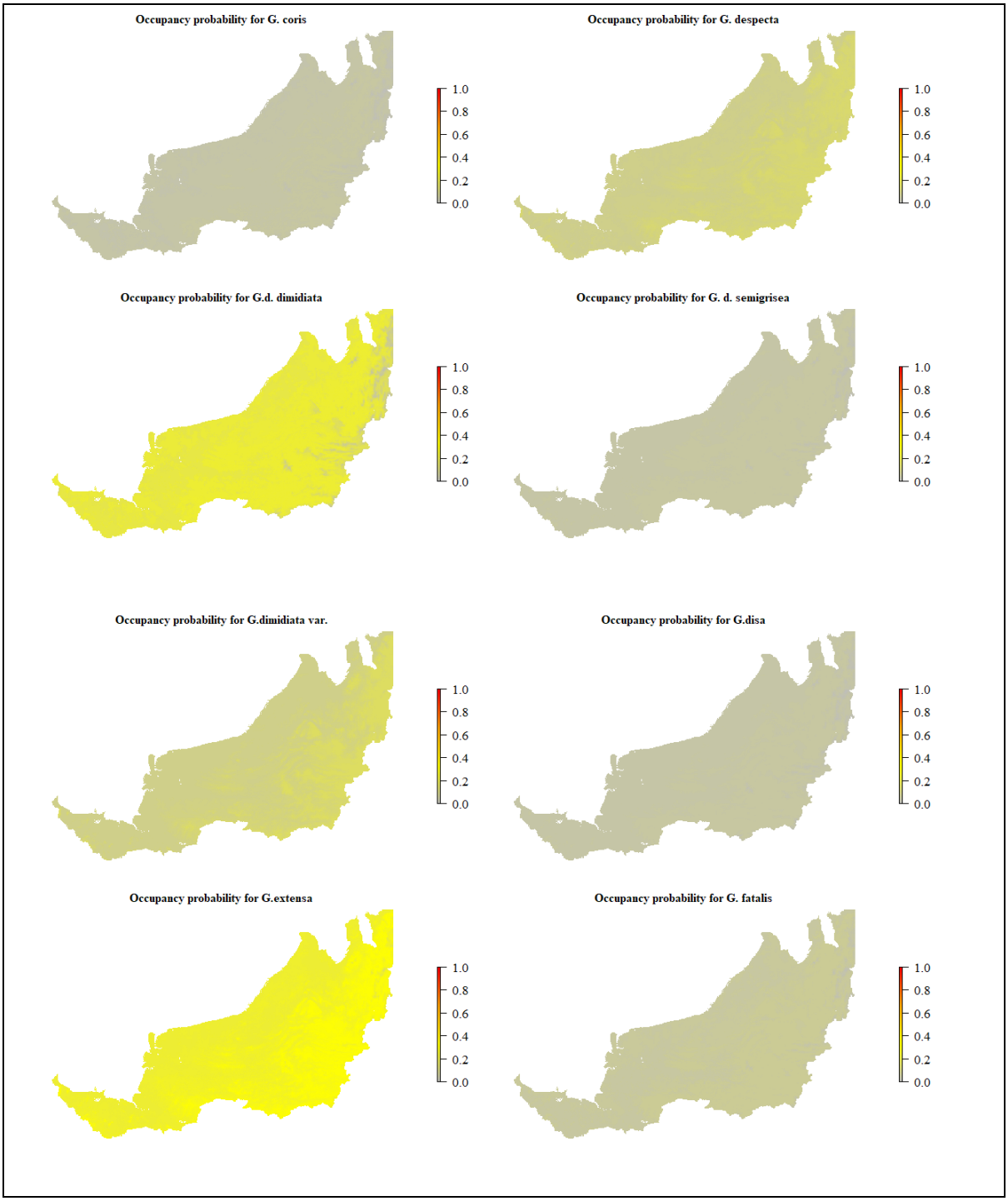

Pusa
mean = 7.2
95% HDI
5
9
6
8
10
12
Local species richness

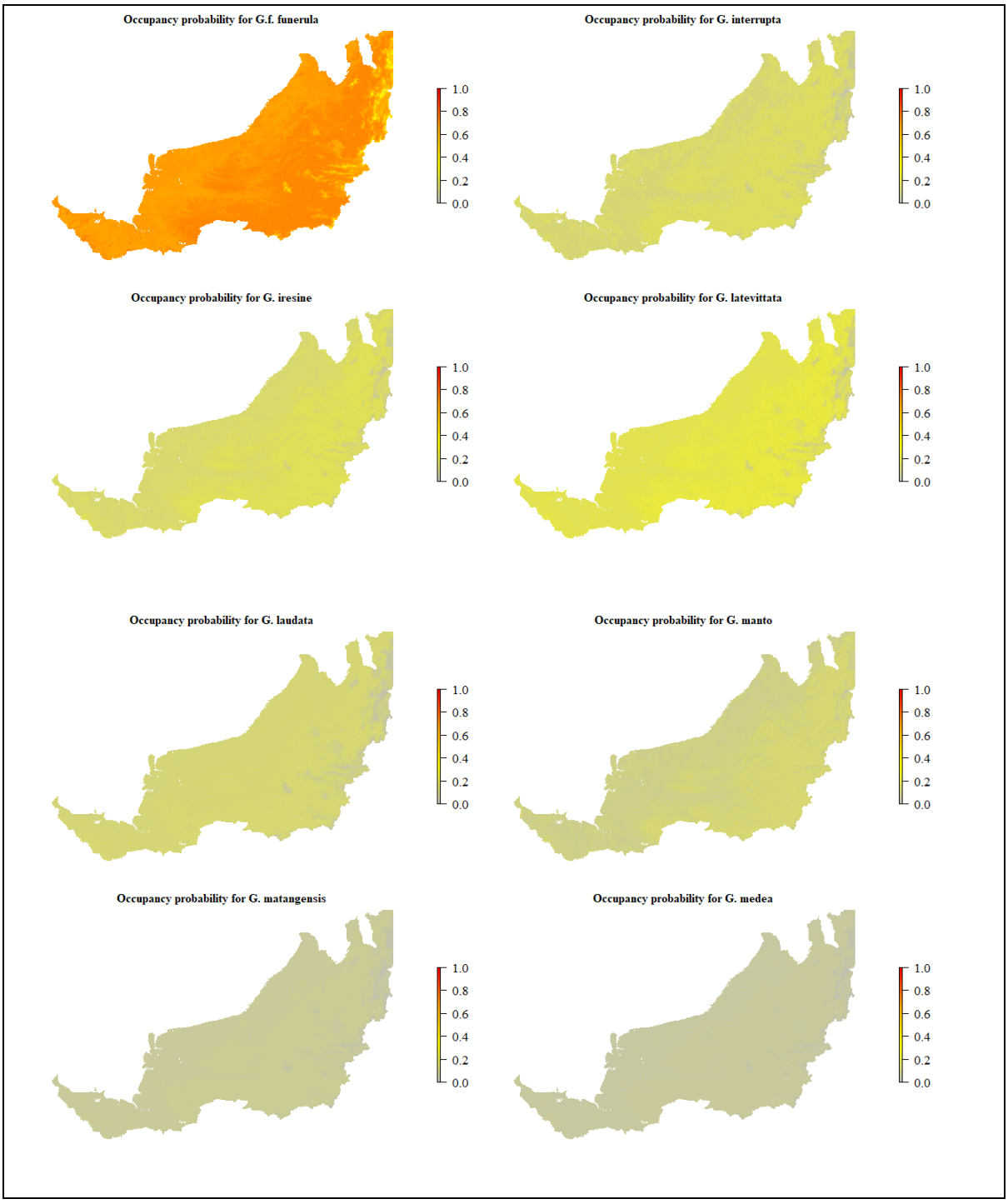

Retuk, Ulu Sadong
mean = 10.2
95% HDI
9
12
9
10
11
12
13
14
15
16
Local species richness

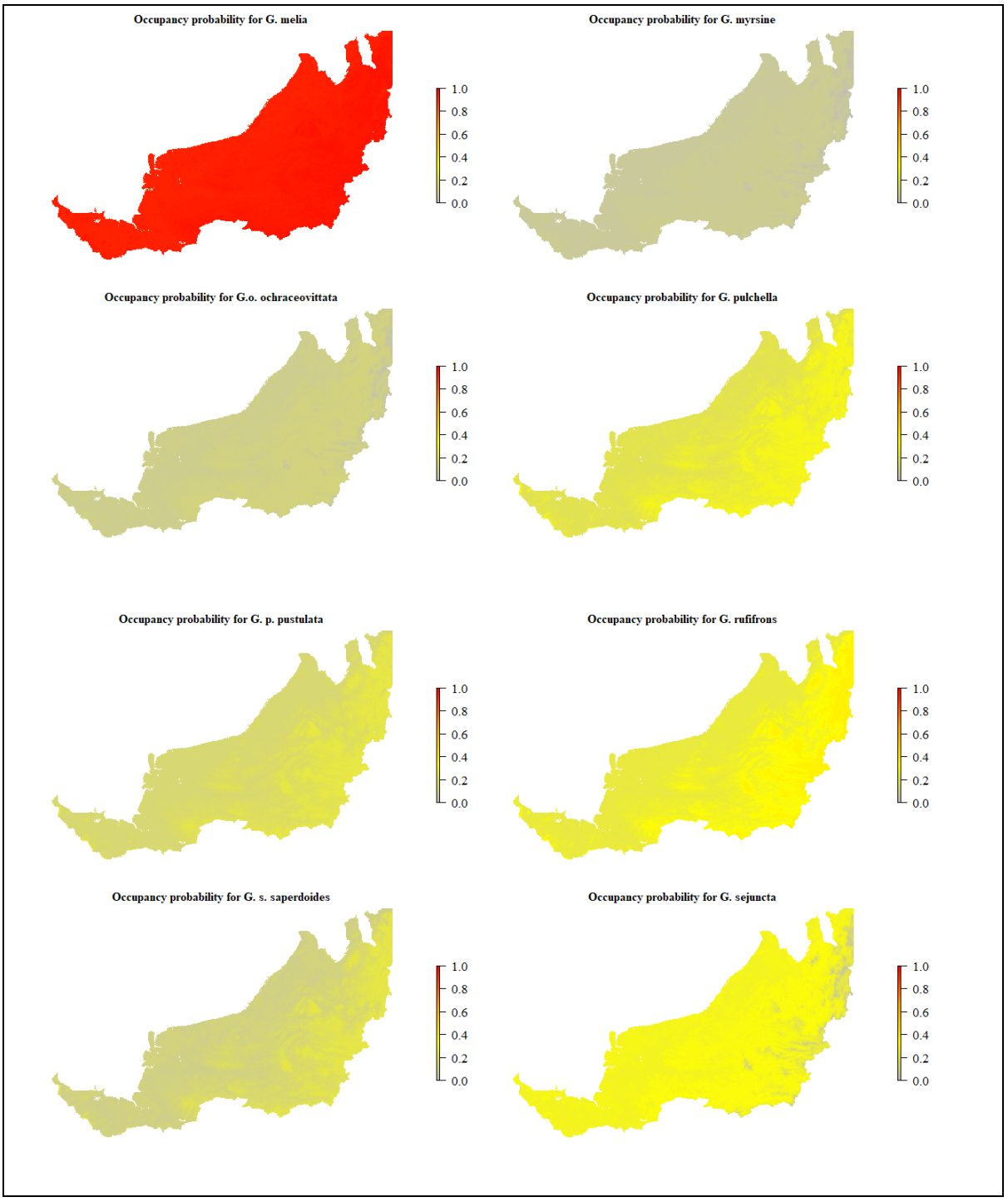

Retus PF, Sibu
mean = 4.61
95% HDI
2
7
Local species richness
Sadong
mean = 6.44
95% HDI
4
9
Local species richness
Samunsam W.S.
mean = 8.18
95% HDI
7
10
Local species richness
Santubong
mean = 6.49
95% HDI
4
9
Local species richness
Saribas
mean = 9.09
95% HDI
8
11
Local species richness
Sawai FR, Bintulu
mean = 6.28
95% HDI
5
8
Local species richness
Semengoh
mean = 7.19
95% HDI
6
9
Local species richness
Serambu
mean = 4.06
95% HDI
2
6
Local species richness
Sg. Bilat Camp, Baram
mean = 8.01
95% HDI
6
10
Local species richness
Sg. Engkari
mean = 6.65
95% HDI
4
9
Local species richness
Sg. Ensiring, Julau
mean = 6.18
95% HDI
4
8
Local species richness
Sg. Mujong, Kapit
mean = 7.95
95% HDI
6
10
Local species richness

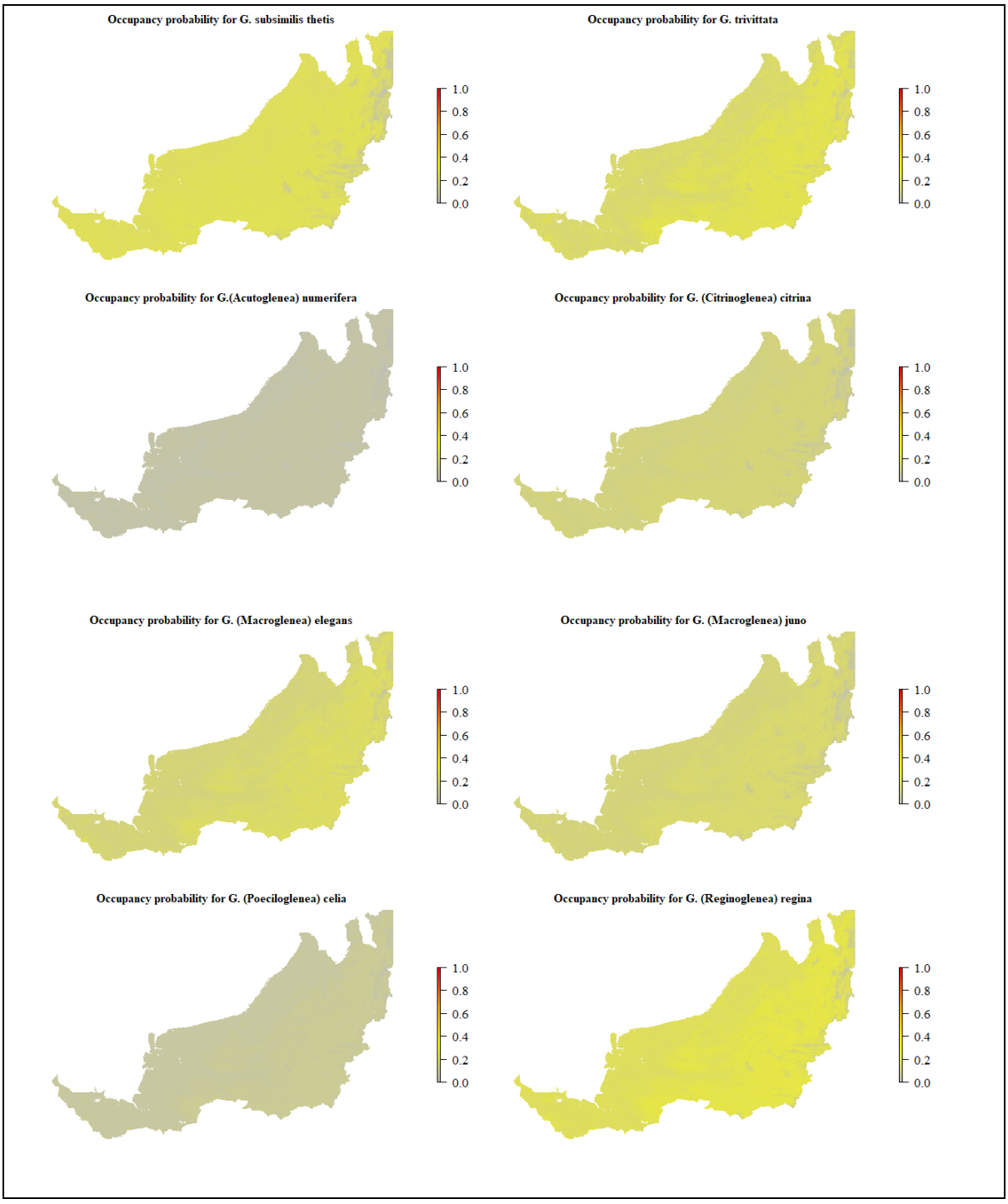

Sg. Tubih, Tebakang
mean = 7.16
95% HDI
5
9
6
8
10
12
Local species richness
Simanggang/Sri Aman
mean = 6.97
95% HDI
5
9
6
8
10
12
Local species richness
Syarikat Bujang, Gedong
mean = 8.02
95% HDI
6
10
6
8
10
12
14
Local species richness
Tebakang, Serian
mean = 7.95
95% HDI
6
10
6
8
10
12
14
Local species richness
Tlk. Assam, Bako NP
mean = 7.79
95% HDI
6
10
6
7
8
9
10
11
12
13
Local species richness
Ulu Putai, Kapit
mean = 8.72
95% HDI
6
11
6
8
10
12
14
Local species richness
UPM Campus, Bintulu
mean = 5.39
95% HDI
3
8
4
6
8
10
12
Local species richness

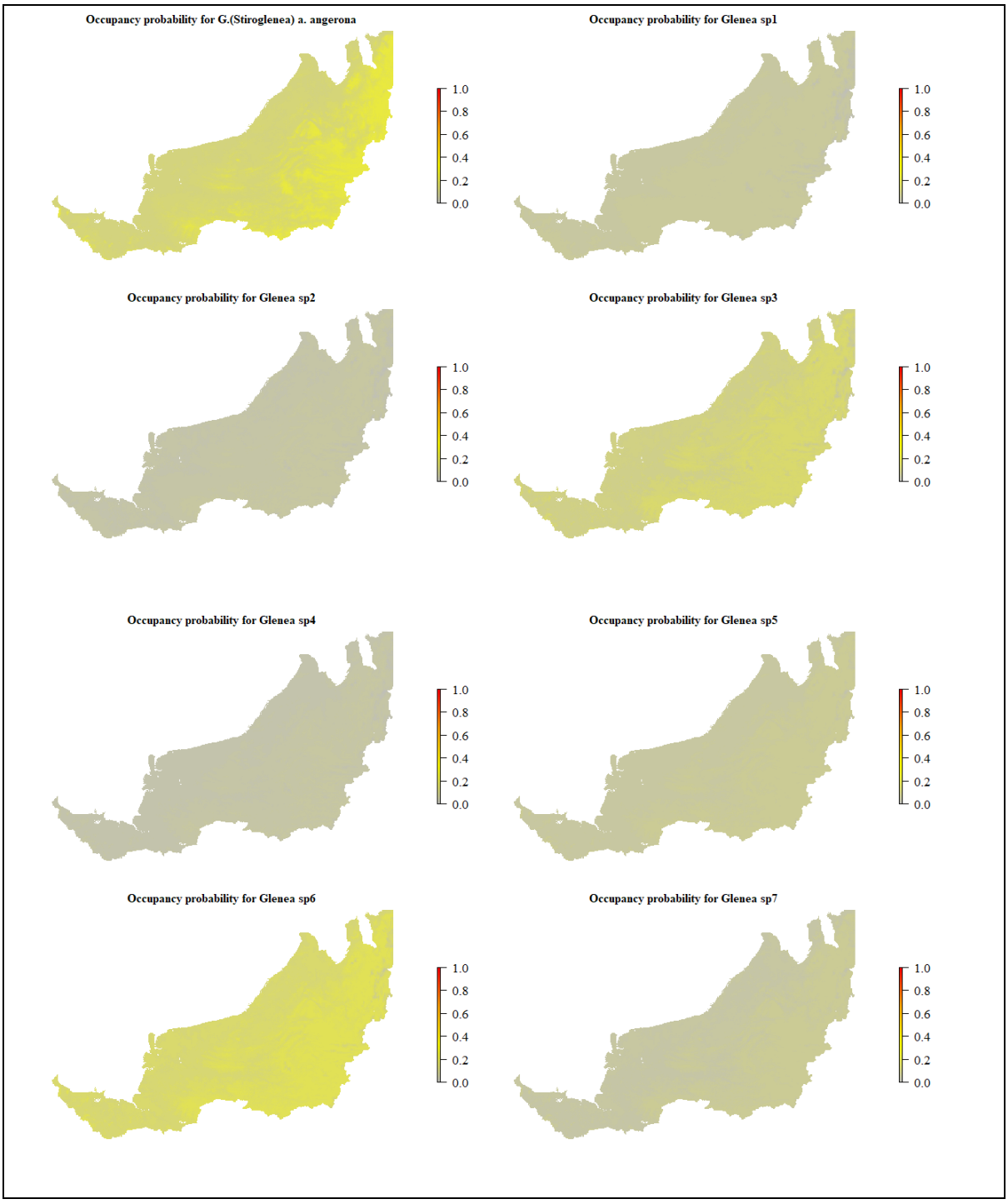
Appendix 6.8: Multispecies Species Distribution Model (SDM) maps for observed species based on species-specific effects of occupancy on elevation and land cover.

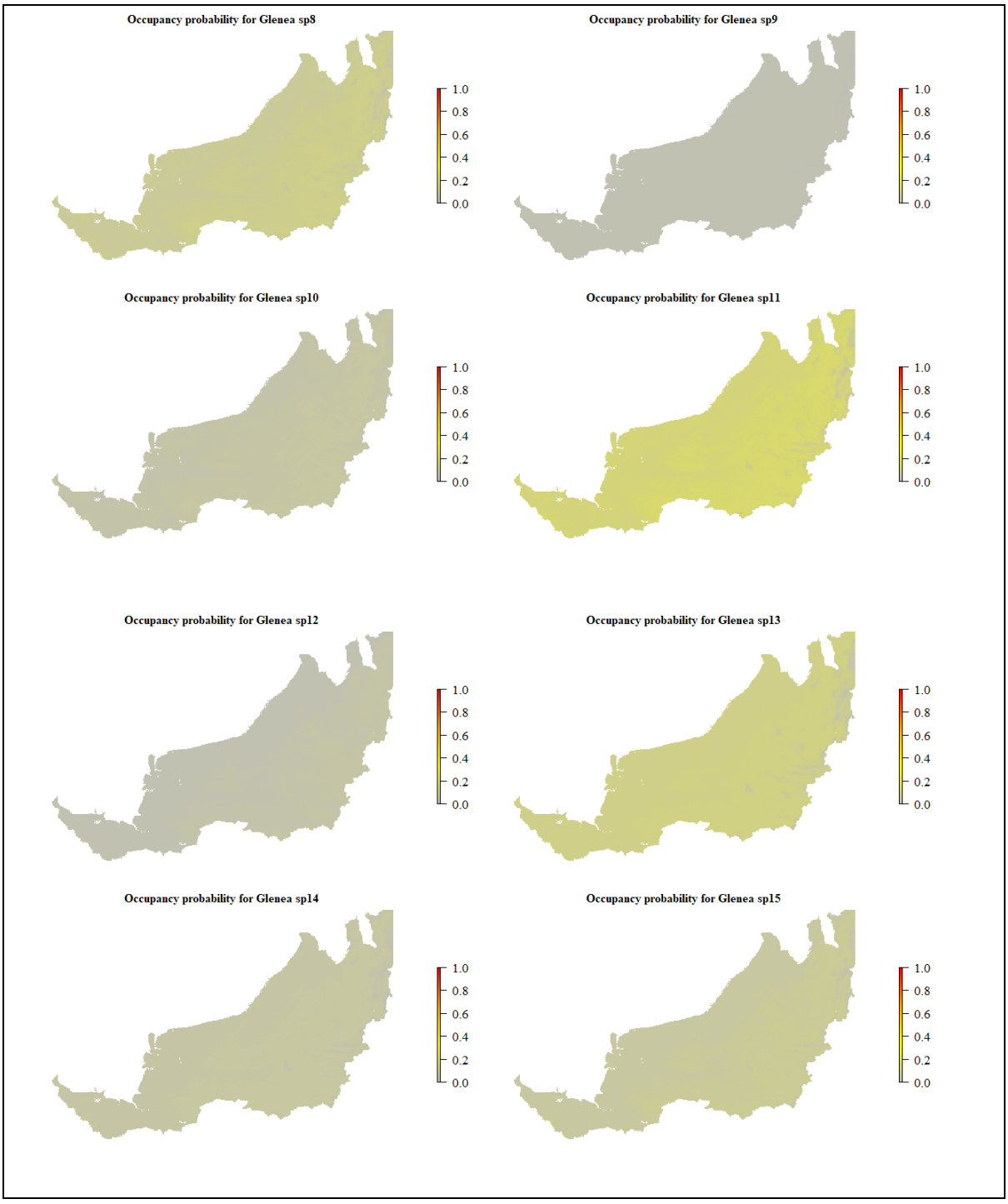


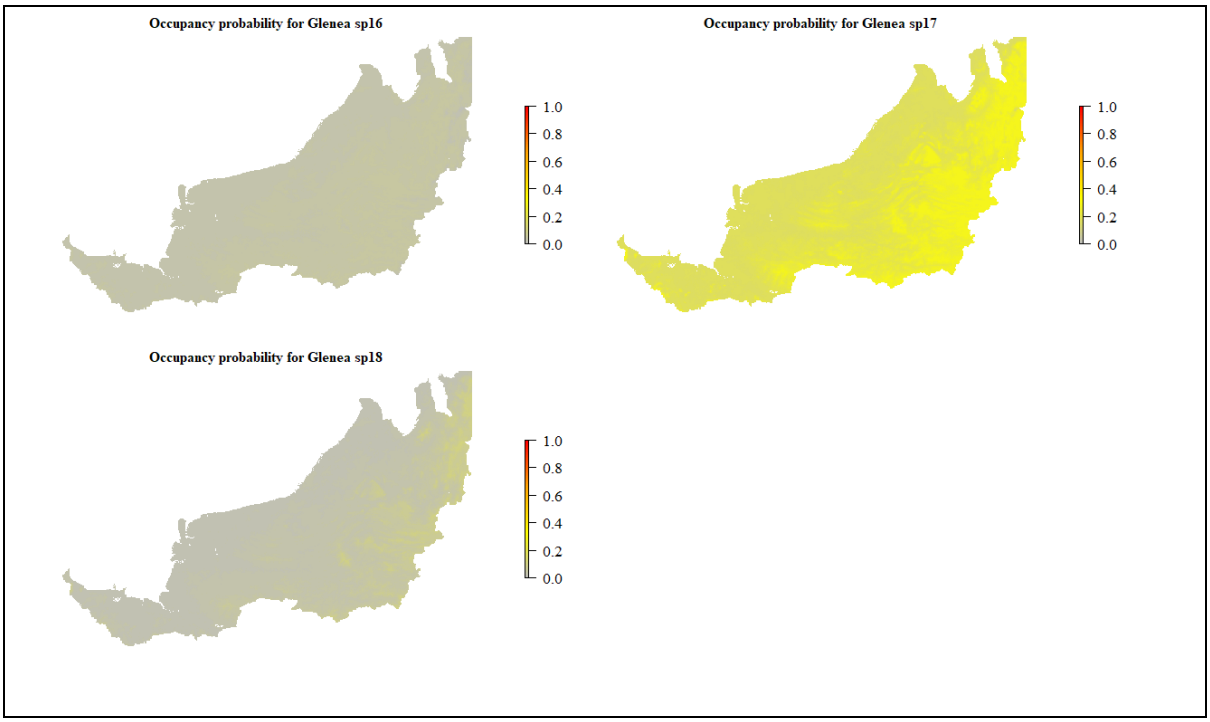

Occupancy probability for G.f. funerula
Occupancy probability for G. interrupta
Occupancy probability for G. iresine
Occupancy probability for G. latevittata
Occupancy probability for G. laudata
Occupancy probability for G. manto
Occupancy probability for G. matangensis
Occupancy probability for G. medea
1.0
0.8
0.6
0.4
0.2
0.0


Occupancy probability for G. melia
Occupancy probability for G. myrsine
Occupancy probability for G.o. ochraceovittata
Occupancy probability for G. pulchella
Occupancy probability for G. p. pustulata
Occupancy probability for G. rufifrons
Occupancy probability for G. s. saperdoides
Occupancy probability for G. sejuncta
1.0
0.8
0.6
0.4
0.2
0.0


Occupancy probability for G. subsimilis thetis
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. trivittata
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G.(Acutoglenea) numerifera
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. (Citrinoglenea) citrina
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. (Macroglenea) elegans
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. (Macroglenea) juno
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. (Poecilоglenea) celia
1.0
0.8
0.6
0.4
0.2
0.0
Occupancy probability for G. (Reginoglenea) regina
1.0
0.8
0.6
0.4
0.2
0.0


Occupancy probability for G.(Stiroglenea) a. angerona
Occupancy probability for Glenea sp1
Occupancy probability for Glenea sp2
Occupancy probability for Glenea sp3
Occupancy probability for Glenea sp4
Occupancy probability for Glenea sp5
Occupancy probability for Glenea sp6
Occupancy probability for Glenea sp7
1.0
0.8
0.6
0.4
0.2
0.0


Occupancy probability for Glenea sp8
Occupancy probability for Glenea sp9
Occupancy probability for Glenea sp10
Occupancy probability for Glenea sp11
Occupancy probability for Glenea sp12
Occupancy probability for Glenea sp13
Occupancy probability for Glenea sp14
Occupancy probability for Glenea sp15
1.0
0.8
0.6
0.4
0.2
0.0



Appendix 7.1: R code for Community N-Mixture Model

```
# Community N-mixture models
# ------------------------------------------------------------------------
library(jagsUI)
library(wiqid)
library(mcmcOutput)
memory.limit(30000)
load(file="Glenea_data_full.RData")
Yc <- C #  organizing counts into a 3-D array that call Yc
plot(table(Yc), main="Distribution of observed counts", xlab="Count",
ylab="Frequency", lwd=5)
# Extremely skewed distribution of observed counts,
# so Zero-inflation is better model
# Observed maximum and mean maximum count per species
tmp <- apply(Yc, c(1,3), max, na.rm = TRUE)
sort(round(meanmax <- apply(tmp, 2, mean, na.rm = TRUE), 3)) # mean of max
sort(obs.max.C <- apply(tmp, 2, max, na.rm = TRUE))           # max
# Plot observed species abundance distribution
plot(sort(meanmax), xlab = "Species number", ylab = "Mean maximum count",
      main="The observed species abundance distribution", las=1, pch=16)
```

```
# Spatio-temporal patterns in counts (mean over sites)
tmp <- apply(Yc, c(2,3), mean, na.rm = TRUE)
matplot(tmp, type = "l", lty = 1, lwd = 3, xlab = "Survey 1-5",las=1,
  ylab = "Mean count over sites", frame = F, cex.lab = 1.3, cex.axis =
1.3,
  main="Spatio-temporal patterns in counts (mean over sites)")

# Specify model in JAGS language vvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvvv
#================================================================
modelText <- "
model {
# Ecological model for true abundance (process model)
for(k in 1:nspec){
  for (i in 1:nsite){
    a[i,k] ~ dbern(phi[k])   # zero-inflation
    N[i,k] ~ dpois(a[i,k] * lambda[i,k])
    log(lambda[i,k]) <- beta0[k] + beta[k,1] * ele[i] +
      beta[k,2] * ele2[i] + beta[k,3] * forest[i]
    # Compute presence/absence matrix z (for N > 0) from latent abundance
    z[i,k] <- step(N[i,k]-1)  # returns TRUE if N >= 0
  }
}
# Observation model for replicated counts
for(k in 1:nspec){
  for (i in 1:nsite){
    for (j in 1:nrep){
      Yc[i,j,k] ~ dbin(p[i,j,k], N[i,k])
      logit(p[i,j,k]) <- alpha0[k] + alpha[k,1] * DUR[i,j]+ alpha[k,2] *
BL[k,1]
    }
  }
}
# Community priors (with hyperparameters) for species-specific parameters
for(k in 1:nspec){
  phi[k] ~ dunif(0,1)                              # Zero-inflation
  alpha0[k] ~ dnorm(mu.alpha0, tau.alpha0)         # Detection intercepts
  alpha[k, 1] ~ dnorm(mu.alpha[1], tau.alpha[1]) # Slopes detection
  alpha[k, 2] ~ dnorm(mu.alpha[2], tau.alpha[2]) # Slopes detection
```

```
  beta0[k] ~ dnorm(mu.beta0, tau.beta0)            # Abundance intercepts
  for(v in 1:3){
    beta[k, v] ~ dnorm(mu.beta[v], tau.beta[v])    # Slopes abundance
  }
}
# Hyperpriors for community hyperparameters
# abundance model
lam0 ~ dunif(0, 10) # mean number of individuals averaged across species
at a site with mean elevation and at non-forested area
mu.beta0 <- log(lam0)  ############
sd.beta0 ~ dunif(0, 3)
tau.beta0 <- 1/(sd.beta0)^2
sd.beta[1] ~ dunif(0, 3)
sd.beta[2] ~ dunif(0, 2)
sd.beta[3] ~ dunif(0, 2)
for(v in 1:3){
  mu.beta[v] ~ dunif(-2, 2)
  tau.beta[v] <- 1/(sd.beta[v]^2)
}
# detection model
p0 ~ dbeta(1, 1)
mu.alpha0 <- logit(p0)  ############
sd.alpha0 ~ dunif(0, 5)
sd.alpha[1] ~ dunif(0, 3)
sd.alpha[2] ~ dunif(0, 3)
tau.alpha0 <- 1/(sd.alpha0)^2
for(v in 1:2){
  mu.alpha[v] ~ dunif(-5, 5)
  tau.alpha[v] <- 1/(sd.alpha[v]^2)
}
# Other derived quantities
for(k in 1:nspec){
  mlambda[k] <- phi[k] * exp(beta0[k]) # Expected abundance on natural
scale
  logit(mp[k]) <- alpha0[k]     # Mean detection on natural scale
  Nocc.fs[k] <- sum(z[,k])      # Number of occupied sites among the 61
}
for (i in 1:nsite) {
  Nsite[i] <- sum(z[i,])        # Number of species occurring at each site
```

```
}
}  "
writeLines(modelText, "model11.jags")
# ^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^^
# Standardise the covariates (mean = 0, sd = 1)
ele <- (el - mean(el)) / sd(el)
forest <- (landC - mean(landC)) / sd(landC)
DUR <- (dur - mean(dur) )/ sd(dur)
BL<- as.matrix(with(sps, (ABL - mean(ABL,na.rm=TRUE))/sd(ABL,na.rm=TRUE)))
# Bundle and summarize data set
JAGSdata <- list(Yc = C, nsite = nsites, nrep = nreps,
  nspec = nsps, ele = ele, ele2 = ele^2, forest = forest, DUR = DUR, BL=BL)
str(JAGSdata)
# Initial values
ast <- matrix(rep(1, nsps*nsites), nrow = nsites)
some.more <- 5  # May have to play with this until JAGS is happy
Nst <- apply(Yc, c(1,3), max, na.rm = TRUE) + some.more
inits <- function() list(a = ast, N = Nst)
# Parameters monitored
params <- c ("phi", "mp", "mlambda", "alpha0", "beta0", "alpha", "beta",
"mu.beta0","sd.beta0","mu.beta","sd.beta","p0","mu.alpha0","sd.alpha0",
"mu.alpha","sd.alpha","Nsite","Nocc.fs","a","N","lam0", "lambda","z")
# Call JAGS from R, check convergence and summarize posteriors
out11 <- jags(JAGSdata, inits, params, "model11.jags", DIC=FALSE,
  n.chains = 10, n.adapt = 50000, n.iter = 5e5, n.thin = 250, parallel =
TRUE)
save(out11, file="out11.RData") # do this after a long run!
```

Appendix 7.2: The summary output of Markov Chain Monte Carlo from Community N-mixture model with covariates.

```
> (mco11 <- mcmcOutput(out11))
Object of class 'mcmcOutput'; approx. size 2.42 GB
MCMC values from jagsUI object ‘out11’
Model definition file: model11.jags
Model run date: 2020-09-16 21:13:25
MCMC chain generation took 6.73 hrs
Adaptation was sufficient.
The output has 10 chains each with 2000 draws.
It has 23 parameters with 15122 nodes monitored:
              nodes
lam0           1
mu.beta0      1
sd.beta0      1
mu.beta       3
sd.beta       3
p0             1
mu.alpha0     1
sd.alpha0     1
mu.alpha      2
sd.alpha      2
phi            59
mp             59
mlambda       59
alpha0        59
beta0         59
alpha         118
beta          177
Nsite         61
Nocc.fs      59
a              3599
N              3599
lambda       3599
z              3599
```

Appendix 7.3: Summary output of 16 selected parameters.

```
> summary(mco11[1:16])

MCMC values from matrix 'out'

The object has 16 nodes with 2000 draws for each of 10 chains.

l95 and u95 are the limits of a 95% Highest Density Credible Interval.

Rhat is the estimated potential scale reduction factor:

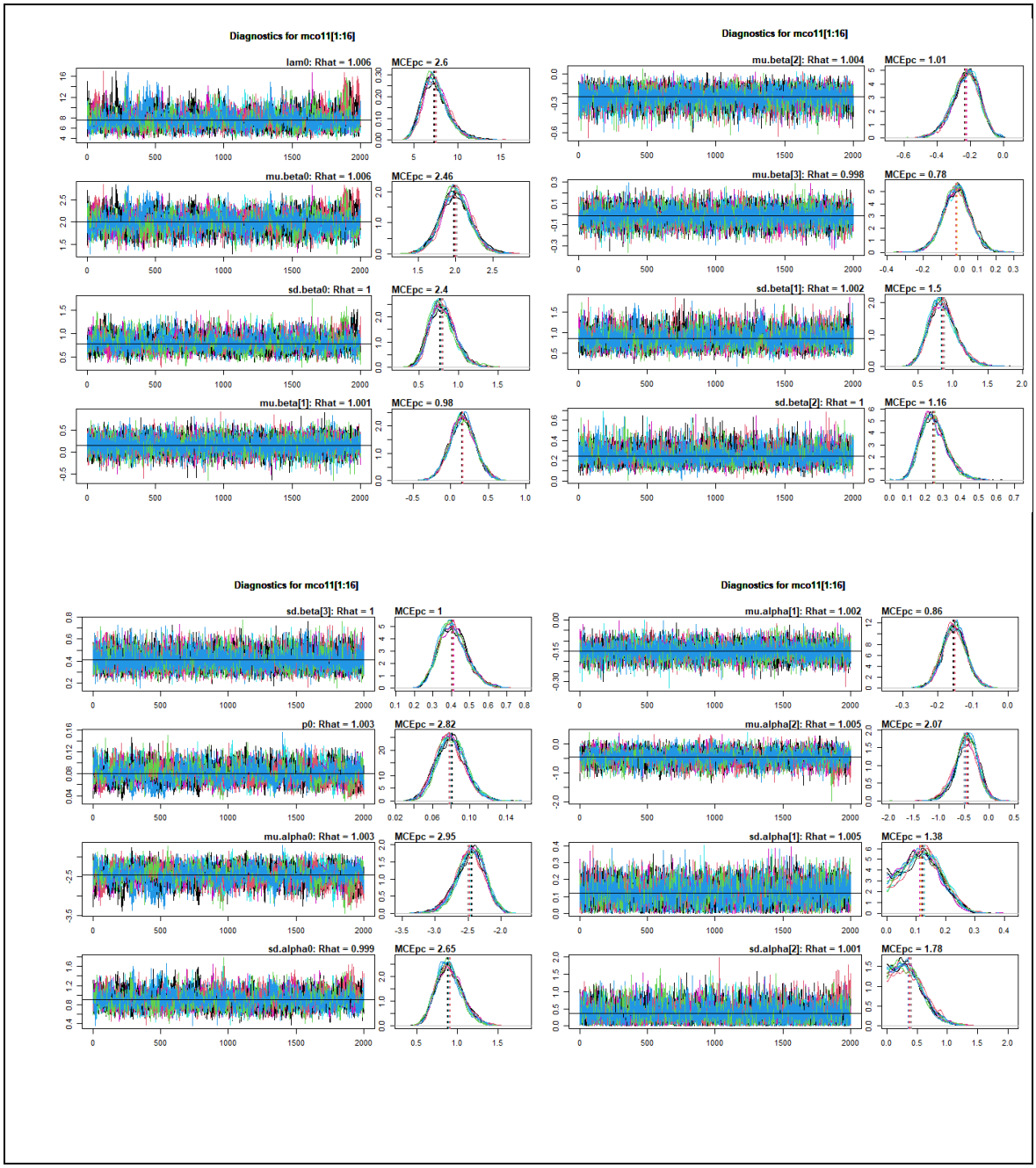
        largest is 1.01; NONE are greater than 1.10.

MCEpc is the Monte Carlo standard error as a percentage of the posterior SD:

        largest is 2.9%; NONE are greater than 5%.

              mean      sd    median  l95    u95    Rhat  MCEpc
lam0          7.534  1.567  7.347   4.805 10.747 1.006 2.600
mu.beta0      1.999  0.202  1.994   1.587  2.387  1.006 2.457
sd.beta0      0.792  0.164  0.780   0.481  1.116  1.000 2.397
mu.beta[1]    0.156  0.174  0.154 -0.191  0.495  1.001 0.979
mu.beta[2]   -0.230  0.084 -0.224 -0.396 -0.071 1.004 1.015
mu.beta[3]   -0.017  0.077 -0.017 -0.169  0.139  0.998 0.779
sd.beta[1]    0.855  0.201  0.840   0.488  1.263  1.002 1.499
sd.beta[2]    0.248  0.078  0.241   0.107  0.406  1.000 1.162
sd.beta[3]    0.409  0.080  0.403   0.266  0.575  1.000 1.000
p0            0.080  0.016 0.079   0.050  0.112  1.003 2.817
mu.alpha0    -2.464  0.222 -2.452 -2.904 -2.035 1.003 2.949
sd.alpha0     0.903  0.166  0.890   0.594  1.243  0.999 2.654
mu.alpha[1] -0.153 0.035 -0.153 -0.223 -0.083  1.002 0.863
mu.alpha[2] -0.455 0.228 -0.447 -0.903 -0.006  1.005 2.070
sd.alpha[1]  0.120  0.065  0.118  0.000  0.231  1.005 1.384
sd.alpha[2]  0.374  0.251  0.340  0.000  0.836  1.001 1.775
```

Appendix 7.4: Diagnostic plot for 16 selected parameters.



Appendix 8.1: Localities and number of collected specimens.

No.	Localities	Distribution frequency	Latitude (in minute)	Longitude (in minute)	Altitude (ft a.s.l)
			North (N)	East (E)	
1	Matang Road	26	1°35.796’	110°03.537’	51
2	Kuching	24	1°33.221’	110°20.614’	56
3	Lawas	10	4°51.698’	115°24.370’	29
4	4th Mile Rock Road	8	1°30.965’	110°20.151’	39
5	Mt. Sibau	7	0°52.758’	110°33.486’	495
6	Bkt. Semalong, Belaga	7	2°54.572’	114°01.914’	1067
7	Limbang	7	4°45.557’	115°00.395’	16
8	Mt. Merinjak	6	1°13.087’	110°10.765’	2554
9	Retuk, Ulu Sadong	6	1°05.724’	110°28.734’	234
10	Mt. Serapi	6	1°35.188’	110°11.583’	2517
11	Penrissen	5	1°16.526’	110°09.014’	2650
12	Niah	5	3°52.303’	113°42.887’	34
13	Ulu Putai, Kapit	5	1°48.956’	113°58.493’	803
14	Danum, Belaga	4	2°02.182’	114°27.798’	2228
15	Mt. Murud	4	3°55.907’	115°31.122’	7209
16	Sg. Mujong, Kapit	4	2°09.736’	113°30.007’	364
17	Baram	3	4°00.820’	114°22.797’	40
18	Semengoh	3	1°24.164’	110°18.857’	170
19	Dulit Range, Miri	3	3°22.013’	114°10.081’	3276
20	Samunsam W.S.	3	1°56.246’	109°36.251’	78
21	Banting	2	1°17.172’	111°12.511’	39
22	Hose Mt., Kapit	2	2°15.195’	113°43.877’	4476
23	Sawai FR, Bintulu	2	3°32.548’	113°40.320’	115
24	Saribas	2	1°37.736’	111°11.370’	47
25	Kelabit Highland, Bario	2	3°45.003’	115°26.998’	3529
26	Simanggang/Sri Aman	2	1°14.180’	111°27.856’	36
27	Tebakang, Serian	2	1°06.051’	110°30.294’	90
28	Melinau, Mt. Mulu	2	4°04.357’	114°49.629’	181
29	Kerpok Hill, Banting	2	1°16.267’	111°12.039’	150

Appendix 8.1 (Continue)

30	Limbang Trading Camp, Limbang	2	4°44.996’	115°00.066’	20
31	Matang	1	1°36.664’	110°09.558’	69
32	Tlk. Assam, Bako NP	1	1°43.200’	110°26.762’	83
33	Mt. Lingga	1	1°15.383’	111°09.291’	2245
34	UPM Campus, Bintulu	1	3°12.358’	113°05.559’	92
35	Jambusan, Bau	1	1°24.975’	110°11.021’	190
36	Sg. Bilat Camp, Baram	1	4°33.913’	114°01.633’	14
37	Syarikat Bujang, Gedong	1	1°14.917’	110°41.455’	21
38	Gedong, Serian	1	1°14.453’	110°41.294’	28
39	Pusa	1	1°36.401’	111°17.411’	38
40	Serambu	1	1°26.485’	110°13.151’	75
41	Pandan, Bintulu	1	3°09.180’	113°22.143’	36
42	Kapit	1	2°00.912’	112°56.317’	170
43	3th Mile Rock Road	1	1°31.376’	110°20.399’	22
44	Santubong	1	1°44.299’	110°19.509’	837
45	Forest Research Station, Niah	1	3°49.442’	113°45.760’	62
46	Panasu Camp, Sibu	1	2°19.795’	111°32.965’	18
47	Retus PF, Sibu	1	2°36.696’	111°58.018’	72
48	Kian Seng Sawmill, Lingga	1	1°21.752’	111°09.638’	22
49	Landeh Engkabang Plant, Semengoh	1	1°23.979’	110°19.482’	163
50	Mt. Serambu, Kuching	1	1°25.281’	110°13.435’	1556
51	Pontianak	1	S 0°01.441’	109°03.537’	10
52	Bkt. Tabang, Puak	1	2°48.076’	112°55.826’	227
53	Poi	1	2°03.338’	112°17.007’	58
54	Mt. Mulu	1	4°02.332’	114°54.120’	5372
55	Lio Matu, Ulu Baram	1	3°10.128’	115°13.870’	757
56	Sadong	1	1°28.890’	110°42.831’	28
57	Sg. Engkari	1	1°21.962’	111°58.017’	714
58	Sg. Ensiring, Julau	1	1°39.616’	112°01.690’	379
59	Long Napir, Baram	1	4°10.860’	115°08.415’	570
60	Sg. Tubih, Tebakang	1	1°05.995’	110°24.221’	153
61	Jongkong, Simanggang	1	1°15.950’	111°34.332’	59

APPENDIX 4

Character Matrix

											1									2								
No	**Species**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**0**	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
1	*G. camelina*	1	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0	0	0	0	1	1	0
2	*G. albomaculata*	1	0	0	1	1	0	1	1	0	0	0	1	1	0	1	0	1	0	0	1	1	0	0	0	0	0	1	0	0
3	*G. pustulata*	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	0	0	0	0	0	1	0
4	*G. myrsine*	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	1	0
5	*G. coris*	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	0	1	1
6	*G. matangensis*	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	0	1	1
7	*G. blandina*	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	0	1	1
8	*G. pulchella*	1	1	1	0	0	0	1	0	1	0	0	1	0	0	1	0	1	1	0	1	0	0	1	1	1	0	1	0	0
9	*G. juno*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
10	*G. elegans*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
11	*G. trivittata*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
12	*G. ochraceovittata*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	0	0
13	*G. thetis*	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
14	*G. medea*	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
15	*G. interrupta*	1	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	1	0
16	*G. manto*	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	0	0
17	*G.funerula*	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
18	*G. fatalis*	1	0	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	1	1	0	1	0	0	0	0	0	0
19	*G. udutera*	1	1	1	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	0	1	0	1	1	1	0	0	0	0
20	*G. semigresa*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	0	0	0
21	*G. lanthe*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	0	0	0
22	*G. melia*	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
23	*G. aspasia*	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	0	0	0	0	0
24	*G. extensa*	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0	1	1	1	0	1	0	0
25	*G. saperdoides*	1	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	0	0
26	*G. latervittata*	1	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	0
27	*G. citrina*	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0	1	0	0	0	1	0	0
28	*G. celia*	1	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1
29	*G. iresine*	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	0
30	*G. disa*	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	1	1	0	0	1	0	0
31	*G. calypso*	1	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1	1	0	0	0	1	1	0
32	*G. algebraica*	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1	0	0	1	1	0	1	0	0	0	1	0	0
33	*G. analytica*	1	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	0
34	*G. despecta*	1	1	0	1	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	0
35	*G. sejuncta*	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0	1	1	1	0	1	0	0
36	*G. regina*	1	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0	0	1	1	1	0	0	0
37	*G. rufifrons*	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	1	1	0	0
38	*G. angerona*	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	1	0	1	0	0	0	0	0	0
39	*G. collaris*	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
40	*G. udutera* var.	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0	1	1	0	0	1	0	0
41	*G. numerifera*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	1	0	1	0	0
42	*Glenea* sp 1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	1	0	1	1	0	1	1	0	0
43	*Glenea* sp 2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	0
44	*Glenea* sp 3	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1
45	*Glenea* sp 4	1	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0
46	*Glenea* sp 5	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0
47	*Glenea* sp 6	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1
48	*Glenea* sp 7	1	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	1	0
49	*Glenea* sp 8	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	1	1	0
50	*Glenea* sp 9	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	0	1	1	0
51	*Glenea* sp 10	1	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0	1	1	0	0	0	1	0
52	*Glenea* sp 11	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	1	0	1	1	0	0
53	*Glenea* sp 12	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1
54	*Glenea* sp 13	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0
55	*Glenea* sp 14	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0
56	*Glenea* sp 15	1	1	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0	1	1	0	0	1	1	0
57	*Glenea* sp 16	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	0	0
58	*Glenea* sp 17	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	1	1	0	1	1	0	0	1	1	0
59	*Glenea* sp 18	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1	1	0	0	0	0	1	1

APPENDIX 5

Character Matrix

		Coloration																				
		Antennae						Head								Prothorax							
No.	Species	Blk	Br	Rd	Yl	Wt	Blu	Blk	Gr	Br	Rd	Or	Yl	Wt	Blu	Blk	Gr	Br	Rd	Or	Yl	Wt	Blu
1	*G. camelina*	1	1	0	1	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0
2	*G. albomaculata*	1	0	0	1	1	0	1	1	0	0	0	1	1	0	1	0	1	0	0	1	1	0
3	*G. pustulata*	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
4	*G. myrsine*	1	0	0	0	1	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
5	*G. coris*	1	0	0	0	0	0	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
6	*G. matangensis*	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
7	*G. blandina*	1	0	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
8	*G. pulchella*	1	1	1	0	0	0	1	0	1	0	0	1	0	0	1	0	1	1	0	1	0	0
9	*G. juno*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
10	*G. elegans*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
11	*G. trivittata*	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
12	*G. ochraceovittata*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
13	*G. thetis*	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
14	*G. medea*	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
15	*G. interrupta*	1	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0
16	*G. manto*	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
17	*G.funerula*	1	1	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
18	*G. fatalis*	1	0	0	0	0	0	1	0	1	1	0	1	1	0	1	0	0	0	0	1	1	0
19	*G. dimidiata dimidiata*	1	1	1	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	0	1	0
20	*G. dimidiata semigresa*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
21	*G. lanthe*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
22	*G. melia*	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
23	*G. aspasia*	1	1	0	0	0	0	1	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0
24	*G. extensa*	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0
25	*G. saperdoides*	1	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
26	*G. latevittata*	1	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0
27	*G. citrina*	1	0	0	0	0	0	1	0	0	0	0	1	0	0	1	0	0	0	0	1	0	0
28	*G. celia*	1	0	0	0	0	1	1	0	0	0	0	0	0	1	1	0	0	0	0	0	0	1
29	*G. iresine*	1	0	0	0	0	0	1	0	0	0	0	0	0	1	1	0	0	0	0	0	1	1
30	*G. disa*	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0
31	*G. calypso*	1	1	0	0	0	0	1	0	0	0	0	1	1	1	1	0	0	0	1	1	1	1
32	*G. algebraica*	1	0	0	0	0	0	1	0	0	0	0	1	1	1	1	0	1	0	0	1	1	0
33	*G. analytica*	1	1	0	0	0	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0
34	*G. despecta*	1	1	0	1	1	0	1	0	1	0	0	1	0	0	1	0	1	0	0	1	0	0
35	*G. sejuncta*	1	1	0	0	0	0	1	0	1	1	0	1	1	0	1	0	1	1	0	1	1	0
36	*G. regina*	1	1	0	0	0	0	0	0	1	1	1	0	0	0	1	0	1	1	1	0	0	0
37	*G. rufifrons*	1	0	0	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0	1	0	0	0
38	*G. angerona*	1	0	0	0	0	0	1	1	0	0	0	0	1	0	1	1	0	0	0	0	1	0
39	*G. collaris*	1	0	0	0	0	0	1	0	0	0	0	0	1	0	1	0	0	0	0	0	1	0
40	*G. dimidiata* var.	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	0	0
41	*G. numerifera*	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
42	*Glenea* sp 1	1	1	0	0	0	0	1	0	1	0	1	1	0	0	1	0	1	0	1	1	1	0
43	*Glenea* sp 2	1	0	0	0	0	0	1	0	0	0	0	0	0	0	1	0	0	0	0	0	1	0
44	*Glenea* sp 3	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
45	*Glenea* sp 4	1	0	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
46	*Glenea* sp 5	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
47	*Glenea* sp 6	1	0	0	0	0	0	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1
48	*Glenea* sp 7	1	0	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0
49	*Glenea* sp 8	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
50	*Glenea* sp 9	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
51	*Glenea* sp 10	1	1	0	0	0	0	1	0	1	0	0	0	1	0	1	0	1	0	0	0	1	0
52	*Glenea* sp 11	1	1	0	0	1	1	1	0	1	0	0	0	1	1	1	0	1	0	0	0	1	1
53	*Glenea* sp 12	1	0	0	0	0	1	1	0	0	0	0	1	1	1	1	0	0	0	0	1	1	1
54	*Glenea* sp 13	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
55	*Glenea* sp 14	1	1	0	0	0	0	1	0	1	0	0	1	1	0	1	0	1	0	0	1	1	0
56	*Glenea* sp 15	1	1	0	0	0	0	1	0	0	0	0	1	1	0	1	0	0	0	0	1	1	0
57	*Glenea* sp 16	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	1	1	0
58	*Glenea* sp 17	1	0	0	0	0	0	1	0	0	0	0	1	1	0	1	0	1	0	0	1	1	0
59	*Glenea* sp 18	1	0	0	0	0	1	1	0	0	0	0	0	1	1	1	0	0	0	0	0	1	1

Appendix 6: The distances of morphological characteristics among genus *Glenea*.

	G. albomaculata	G. pustulata	G. myrsine	G. coris
G. pustulata	0.48571429			
G. myrsine	0.49333333	0.35384615		
G. coris	0.61627907	0.51315789	0.30985915	
G. matangensis	0.58333333	0.53246753	0.37837838	0.29729730
G. blandina	0.50602410	0.44736842	0.35526316	0.36250000
G. pulchella	0.50000000	0.61538462	0.54430380	0.55952381
G. juno	0.67857143	0.52112676	0.58227848	0.50632911
G. elegans	0.65517241	0.52000000	0.52500000	0.48780488
G. trivittata	0.65517241	0.55844156	0.52500000	0.46913580
G. ochraceovittata	0.51315789	0.49295775	0.37142857	0.33333333
G. thetis	0.65000000	0.54285714	0.46478873	0.38028169
G. medea	0.54430380	0.42028986	0.36619718	0.45569620
G. interrupta	0.48717949	0.44444444	0.27536232	0.39743590
G. manto	0.45714286	0.56338028	0.44285714	0.54430380
G.funerula	0.53333333	0.49275362	0.41428571	0.48051948
G. fatalis	0.52702703	0.50724638	0.52702703	0.58024691
G. d. dimidiata	0.56097561	0.52631579	0.47435897	0.47560976
G. d. semigresa	0.53164557	0.49315068	0.39726027	0.40259740
G. laudata	0.54545455	0.54794521	0.45205479	0.41333333
G. melia	0.60975610	0.52054795	0.46666667	0.44871795
G. aspasia	0.61728395	0.54794521	0.53246753	0.58333333
G. extensa	0.56321839	0.53086420	0.51764706	0.51685393
G. saperdoides	0.46153846	0.50000000	0.36486486	0.39240506
G. latevittata	0.51282051	0.64197531	0.48051948	0.46250000
G. citrina	0.58441558	0.67948718	0.58974359	0.61904762
G. celia	0.71428571	0.67532468	0.58441558	0.48684211
G. iresine	0.61538462	0.55714286	0.43478261	0.39436620
G. disa	0.52000000	0.52112676	0.35294118	0.42666667
G. calypso	0.58823529	0.50000000	0.44871795	0.37179487
G. algebraica	0.46835443	0.54430380	0.32876712	0.35897436
G. analytica	0.50000000	0.57692308	0.42666667	0.46913580
G. despecta	0.40540541	0.58227848	0.51250000	0.59550562
G. sejuncta	0.52941176	0.51250000	0.51764706	0.51685393
G. regina	0.65116279	0.70588235	0.68539326	0.66304348
G. rufifrons	0.67105263	0.62318841	0.58333333	0.59740260
G. angerona	0.56578947	0.50724638	0.42857143	0.53164557
G. collaris	0.53521127	0.46875000	0.35937500	0.41428571
G. dimidiata var.	0.56962025	0.57333333	0.48000000	0.44155844
G. numerifera	0.46250000	0.39726027	0.38961039	0.43373494
Glenea sp 1	0.49397590	0.56626506	0.50000000	0.53333333
Glenea sp 2	0.66250000	0.46969697	0.45714286	0.45945946
Glenea sp 3	0.58227848	0.56756757	0.55128205	0.53086420
Glenea sp 4	0.51250000	0.49333333	0.40000000	0.46341463
Glenea sp 5	0.52941176	0.54878049	0.42500000	0.40963855
Glenea sp 6	0.54666667	0.46268657	0.42857143	0.38888889
Glenea sp 7	0.55128205	0.51388889	0.37142857	0.42105263
Glenea sp 8	0.55681818	0.50617284	0.31578947	0.30379747
Glenea sp 9	0.53012048	0.49350649	0.33783784	0.34615385
Glenea sp 10	0.50000000	0.36764706	0.28985507	0.43037975
Glenea sp 11	0.55555556	0.59090909	0.44047619	0.38823529
Glenea sp 12	0.56976744	0.48051948	0.52380952	0.43373494
Glenea sp 13	0.45454545	0.49333333	0.40000000	0.46341463
Glenea sp 14	0.37837838	0.50000000	0.36486486	0.41250000
Glenea sp 15	0.52564103	0.44285714	0.34285714	0.43589744
Glenea sp 16	0.42105263	0.48000000	0.36486486	0.41250000
Glenea sp 17	0.46153846	0.45945946	0.34246575	0.37179487
Glenea sp 18	0.68181818	0.53333333	0.53750000	0.48148148
G. camelina	0.52857143	0.50769231		