Biodiversity Journal, 2023, 14 (1): 223–239 https://doi.org/10.31396/Biodiv.Jour.2023.14.1.223.239

Morphological description and ecological status of Hawkmoths (Lepidoptera Sphingidae) in selected areas of Bukidnon, Mindanao, Philippines

Michelle S. Suelo[1], Alma B. Mohagan[2], Aprille Joy M. Luceño[2], Chris Rey M. Lituañas[2], Joliesa Mae S. Toledo[2], Rona Mae P. Viernes[1] & Reggie Y. Dela Cruz[2]

[1]Central Mindanao University (CMU) Graduate Student
[2] Faculty of the Department of Biology, College of Arts and Sciences
Central Mindanao University, University Town, Musuan, Maramag, Bukidnon 8714 Philippines
*Corresponding author: michelle.suelo5@gmail.com

ABSTRACT Hawkmoths which belongs to order Lepidoptera and family Sphingidae are known for their vital ecological role on biodiversity. They are responsible for pollinating tropical flora due to the presence of their proboscis making Sphingidae family be considered of great ecological and economic importance. The light trapping technique was a successful method in the collection of hawkmoths species in selected areas of Vintar, Valencia City, Musuan and Bacusanon, Pangantucan, Bukidnon. A total of 54 individuals where collected which consist of 15 species belonging to 9 genera (*Acosmeryx, Ambulyx, Amplypterus, Cechenena, Daphnis, Hippotion, Marumba, Pergesa* and *Theretra*). Morphological description became the basis of its identification. Ecological status of each species based on the checklist of Hogenes & Treadaway revealed that among the species collected, three species are endemic to the Philippines and thesa are *Ambulyx bakeri, Ambulyx johnsoni* and *Ambulyx wilemani.* One species is categorized as rare (*Amplyterus panopus*), three species are uncommon and the rest of the species collected are all common and widely distributed to the Philippines.

KEY WORDS Hawkmoths; Lepidoptera; Light trapping; Sphingidae.

Received 28.10.2022; accepted 04.02.2023; published online 18.03.2023

INTRODUCTION

The Philippines, one of the world's 17 megadiversity countries, has a wealth of natural resources and is geographically situated in Southeast Asia (Fontanilla et al., 2014). Mindanao Island is one of the largest Island in the Philippines. Most of the researchers are interested in conducting their study due to the diversity of flora and fauna. Sphingidae is a family of moths belonging to Order Lepidoptera which is the second largest order in class Insecta (Johnson et al., 2016) and comprises approximately 157,000 species (Stöckl & Kelber, 2019; Cho et al., 2016; Sebua & Nuñeza, 2020; van Nieukerken et al., 2011). They are commonly known as hawkmoths, hummingbird moths or sphinx moth (Messenger, 1997; Devi & Ramaraju, 2015; Stöckl & Kelber, 2019). Hawkmoths larvae are known to have presence of caudal horn while adults are distinguished among others due to the presence of their proboscis which varies in length (Johnson et al. 2016), bullet-shaped body (Akkuzu et al., 2007) and rapid flying ability (Akkuzu et al., 2007; Mohagan et al., 2018; Stöckl & Kelber, 2019; Messenger,

1997; Suelo et al., 2020). Hawkmoths are usually nocturnal and crepuscular (Johnson et al., 2016) and they are attracted to artificial light source (Jonason et al., 2014). They use their olfactory and visual senses to find and recognize night blooming flowers (Stöckl & Kelber, 2019; Kelber et al., 2003) with muted colors like white or yellow which attracts them due to their heavy fragrance (Messenger, 1997). Most sphingidae are highly specialized, with each species adapted to live in a certain habitat that is needed for their survival because of the presence of the host plant. Temperature, altitude, rainfall are some factors that also affects them as well in order to live (Rafi et al., 2014).

Geographical barriers and climatic factors like maximum and minimum temperature, rainfall, wind and length season affects the distribution of hawkmoths species (Pittaway & Kitching, 2020). In tropical systems, the changes between the dry and rainy seasons creates impact on cycles of leaf availability of host plant to the larvae of hawkmoths which consequently determines the seasonal occurrence of adults (Primo et al., 2013). Elevations could also affect the distribution of hawkmoths species. Study of Mohagan et al. (2018) shows that the diversity of hawkmoths in Mt. Hamiguitan are higher in lower elevations due to the developing garden which could provide as their host plant. The family of sphingidae is divided into two subfamilies (Macroglossinae and Sphinginae), with five tribes. It is composed of 200-205 genera (Kawahara et al., 2009; Messenger, 1997). Hawkmoth species comprises about 1,450 species (Singh & Kaur, 2017; Rougerie et al., 2014; Kawahara et al., 2009; Primo et al., 2013) all over the world with about 117 species (Hogenes & Treadaway, 1998) occurring in the Philippines plus the discovery of one new species (*Macroglossum malitum* Zwick & Treadaway, 2001) on the island of Palawan in Mt. Mantalingahan (Zwick & Treadaway, 2001).

To identify the hawkmoth species, it is best to look at its wing shape, size, color patterns, characters of coloration and also the venation of the hindwings. However, patterns and characters of colors is difficult to the species that are very similar in terms of their morphology. Some examination also includes their genitalia. In females, the terminal segments of their abdomen have genital pore while in males they have claspers. Most females are larger than males (Messenger, 1997). Another basis on determining the sexuality of hawkmoth species by morphology is the presence of their frenulum, which keeps the hindwing in contact with the forewing. In female it is a brush of bristle like structure while in males, only a single strong bristle (Primo et al., 2013, Devi & Ramaraju, 2015). When examining the hindwing, it is better to look at the lack of a base for veins M1 and R1 which could characterize the sphingidae.

Due to the intensive study of their biology, life histories and morphology, this hawkmoth species plays a significant role in a variety of research program like pollination biology, biogeography and even conservation biology (Yen et al., 2003). Moths are known for their ecological role in biodiversity. They are responsible for 5% to 10% of the pollination of the tropical flora due to the presence of their proboscis which varies in length (Primo et al., 2013, Johnson et al., 2016), making Sphingidae family to be considered of great ecological and economic relevance (De Camargo et al., 2016).

MATERIAL AND METHODS

The study was conducted in selected areas of Bukidnon (Mindanao, Philippines) namely: Bacusanon Pangantucan (7°52’34” N, 124°42’28” E), Musuan (7°52’57” N, 125°3’49’’E) and Vintar, Valencia City (7°56’36” N,125°10’33’’ E) (Figs. 1–3). Gratuitous permit (No. R10 2021-25) and formal letter was secured prior to the conduct of the study.

This study used light trapping technique (Figs. 1–3) in order to collect nocturnal and crepuscular hawkmoth species. The light traps were used for 10 hours from 6pm to 4am, using 500 watts, 12 voltage tungsten bulbs with a source power of 22AC. White sheet was set up where insects will be trapped.

Important information was recorded in a field notebook that was taken along, including the date, site name, GPS coordinates, labels, humidity and temperature readings, start and end times, and time of day. A ruler was used to measure the length of the head, which includes the antennae, proboscis, and eyes, the abdomen, the thorax, which is subdivided into the prothorax, mesothorax, and metathorax, as well as the forewing and hindwing. Measurements were given in centimeters. The samples collected were photographed using a phone and

camera. Identification of the collected hawkmoth species were based on morphological structures and using Hogenes & Treadaway (1998) checklist at Central Mindanao University Museum Zoology Section. Confirmation of the species identification will be done by Dr. Alma B. Mohagan, a professor from the Department of Biology in Central Mindanao University.

Figures 1–3. Sampling sites. Fig. 1: site 1, Bacusanon Pangantucan (7°52’34” N, 124°42’28” E). Fig. 2: site 2, Musuan (7°52’57” N, 125°3’49”E). Fig. 3: site 3, Vintar, Valencia City (7°56’36” N,125°10’33” E) and Light Trapping Technique.

The collected adult hawkmoth species during light trap were paralyzed with an injection of absolute ethyl alcohol in its thorax (Lara-Pérez et al., 2017). The wings have been vouchered. Scissors were used to cut the right and left forewing and hindwing at the wing base and both are gently removed with forceps. The remainder of the body were preserved in a 15 ml/50 ml conical microcentrifuge tube/glass jar containing absolute ethyl alcohol for further study.

Wing vouchering step uses two different protocols depending on the size of an insect. Small wings were placed in a coin holder while large wings were stored in double laminated polypropylene bags. Dried forewing and hindwing of the small specimen were transferred using forceps while gripping at the base and spread carefully in the clear window of a cardboard coin holder. The coin holders were slowly closed and the edges are neatly stapled to keep the wings secure. Proper labelling was observed.

For large specimens, the dried wings were placed inside the 4"x6" according to their size in a biaxially oriented polypropylene (BOPP) bag. The bag is then trimmed by hand to fit the dimension of the wing. Then, it was placed within a plastic scotch thermal laminating film. The BOPP bag creates a protective layer for the wings and prevents the pouch plastic from adhering to the wing surfaces, enabling wings to be removed from the pouch without damaging them or their scales. The pouches were inserted into a laminator machine and the lamination process was repeated 2-3 times to ensure a tight seal. Proper label was observed (Cho et al., 2016).

RESULTS AND DISCUSSION

A total of 54 individuals belonging to 9 genera with 15 species were collected and paralyzed by injecting absolute ethyl alcohol on its thorax (Lara-Pérez et al., 2017). Body of hawkmoths were preserved individually inside a conical tube containing absolute ethyl alcohol while wings were laminated and placed in a binder each with proper labels.

Fifteen (15) species of hawkmoths were collected, namely *Acosmeryx socrates, Ambulyx bakeri, Ambulyx johnsoni, Ambulyx wilemani, Amplypterus panopus, Cechenena helops helops, Daphnis nerii, Hippotion rosetta, Hippotion celerio, Marumba amboinicus luzoni, Pergesa actea, Theretra alecto, Theretra clotho clotho, Theretra latreillii* and *Theretra silhetensis.* The species of hawkmoths were described based on their: a) general color of their eyes, thorax, abdomen, and the wings and b) length of the eyes, antennae, proboscis, prothorax, mesothorax, metathorax, forewing, hindwing, eight segments of the abdomen and spine. These morphological descriptions became the basis of identification. Morphological descriptions such as wing venation, color patterns, presence of bands and spots is important in identifying the species of hawkmoths. Eyespots were present on some species like *A. panopus* and *A. bakeri.* Eyespots may resemble eyes and could cause smaller predators to believe them to be the head of a larger animal (Kodandaramaiah, 2011). Male and female could be identified based on their frenulum, brush bristle like structure for female while male consist of only a single bristle (Primo et al., 2013; Devi & Ramaraju, 2015). Philippine hawkmoths consist of only 24 endemic species (Hogenes & Treadaway, 1998), of which 3 of this species found in Bukidnon, namely *A. bakeri, A. johnsoni* and *A. wilemani*. Hawkmoths are known for its rapid flying ability (Mohagan et al., 2018; Stöckl & Kelber, 2019). According to Akkuzu et al. (2007), they could travel as far as 40 km to 50 km if attracted by light, no doubt why this species is distributed widely.

Hawkmoths varied in their sizes. Their antennae ranged from 0.3 to 3.2 cm, proboscis ranged from 0 to 10.3 cm and eyes ranged from 0.3 to 0.6 cm. Hawkmoths proboscis is one of the hallmarks of their family Sphingidae (Miller, 1997) and according to Johnson et al. (2016), they are ideal organisms for exploring pollinator niches due to their crucial role's pollinator in most of the biodiverse regions of the earth. The thorax consists of three segments namely; prothorax ranging from 0.2 to 0.8 cm, mesothorax ranging from 0.2 to 0.6 cm and metathorax ranging from 0.1 to 0.4 cm. They all vary in color. Forewings ranged from 2.3 to 6.9 cm while hindwings ranged from 1.4 to 3.7 cm. Eight segments ranged from 1.4 to 3.6 cm and spine/setae ranged from 0.0 to 0.4 cm. Study of Hogenes & Treadaway (1998) showed that the measurements of their wings dis not conform with the recent findings of this study. According to Forewood (1980),

species may vary on sizes depending on the quantity and quality of food eaten during larval stage.

Systematics

Acosmeryx socrates (Boisduval, 1875) Fig. 4

MATERIAL EXAMINED. Vintar, Valencia City (7°56'36" N,125°10'33'' E) and Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 3 males.

DESCRIPTION. This species has no common name. The head was dominantly covered with darker purple. Antennae ranged from 0.9 to 0.10 cm, proboscis (2.0 cm) and compound black eyes (0.3 cm). Dorsal part of the thorax dominantly covered dark violet with black line at the center with lighter violet at ventral part: prothorax (0.8 cm), mesothorax (0.4 cm) and metathorax (0.2 cm). Abdomen ranged from 2.8 cm to 3.0 cm and dominantly covered with dark purplish color on its dorsal part while heavy purple in color with darker lines on each segment on its ventral part. Setae is present at the anal end (0.2 cm). Forewings ranged from 3.0 to 3.3 cm. Dorsal part is dominantly colored light violet with darker bands, costal margin is straight, outer margin is convex and undulate, yellow spots near the median line. Ventral part is dominantly covered with light red orange with yellow band near the base and inner margin. Hindwing ranged from 1.7 to 1.9 cm. Dorsal part is light maroon at postmedial band, lighter at medial patch with yellow color near costal margin while ventral part is dominantly covered light maroon with dark bands.

DISTRIBUTION. *Acosmeryx socrates* is common and widely distributed throughout the Philippines as well as in Balabac, Bohol, Calamian, Cebu, Leyte, Luzon, Mindoro, Mindanao, Negros, Palawan, Panay, Samar and Tawi-Tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Ambulyx bakeri (Clark, 1929) Fig. 5

MATERIAL EXAMINED. Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 1 male.

DESCRIPTION. This species has no common name. The head was dominantly covered with heavy orange ventrally and ash white dorsally. The antennae measured 1.2 cm, proboscis 1.8 cm and compound black eyes 0.3 cm. Dorsal part of thorax is heavy yellow with two dark orange at the bottom sides while lighter orange ventrally: prothorax (0.6 cm), mesothorax (0.2 cm) and metathorax (0.2 cm). Abdomen measured 2.1 cm and dorsal part is dominantly covered heavy orange with two large dark orange spots at 6th segment. While ventral part consists of lighter orange on sides and dirty white at the middle. Setae were present at the anal end (0.1 cm). Forewing measured 4.2 cm. Dorsal part is heavy orange postmedial band with black spot near the tornus, lighter orange antemedial band with dark orange spot near the base and inner margin. Ventral part of its costal margin is straight coated with light to dark orange near the apex, outer membrane is convex with ash white near the apex and orange down to the anal angle. Hindwing measured 2.5 cm. Costal margin to discal cell light yellow color, medial patch light orange with dark bands, outer margin coated with dark brown on its dorsal part. Ventral part is dominantly covered with light orange with dark stripes. Outer margin coated with dark brown.

DISTRIBUTION. *Ambulyx bakeri* is endemic to the Philippines where it is common and widely distributed in Cebu, Leyte, Luzon, Marinduque, Mindoro, Mindanao, Negros, Panay, Samar, Siquijor (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Endemic Common (Hogenes & Treadaway, 1998).

Ambulyx johnsoni (Clark, 1917) Fig. 6

MATERIAL EXAMINED. Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 3 makles, 1 female.

DESCRIPTION. This species has no common name. The head was dominantly covered orange ventrally. The antennae ranged from 0.3 to 0.4 cm, proboscis reached up to 2.2 to 2.3 cm, dark orange compound eyes, 0.4 cm. Dorsal part of the thorax dominantly dark brown with black band near the base of the forewing while ventral part covered with dark orange color: prothorax (0.5 cm), mesothorax (0.3 cm) and metathorax (0.2 cm). Abdomen measured 2.5 cm and dorsal part is dominantly covered with dark brown

with thick black line at the center while ventral part is dominantly covered with dark orange color. Setae is present at the anal end (0.3 cm). Forewing ranged from 4.6 to 4.8 cm. Dorsal part is dominantly dark brown, some variations are light brown color, black eye spot present near the base above inner margin. Visible dark brown veins and darker postmedial line. Ventral part is heavy orange with black spots, dark brown postmedial line and light yellow near the base and above inner margin. Hindwing ranged from 2.7 to 2.9 cm. Dorsal part is light to heavy orange color with dark spots, two dark transverse band and white fringe near the tornus. Ventral part is light orange with dark spots and bands. Outer margin is convex and slightly undulant.

DISTRIBUTION. *Ambulyx johnsoni* is endemic to the Philippines where it is common and widely distributed in Cebu, Leyte, Luzon, Marinduque, Mindoro, Mindanao, Negros, Panay, Samar, Siquijor (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Endemic Common (Hogenes & Treadaway, 1998).

Ambulyx wilemani (Rothschild et Jordan, 1916) Fig. 7

MATERIAL EXAMINED. Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 2 males.

DESCRIPTION. This species has no common name. The head dominantly covered with white. Antennae ranged from 1.3 to 1.5 cm, proboscis (2.4 cm) and compound dark crimson eyes (0.3 cm). Dorsal part of thorax is covered with pearl river color with dark green band on both sides while ventral part is light orange: prothorax (0.4 cm), mesothorax (0.2 cm) and metathorax (0.1–0.2 cm). Abdomen ranged from 2.3 to 2.4 cm. Dorsal part dominantly covered with white and visible horizontal and vertical lines. Ventral part is similar to the ventral part of thorax with dark band on both sides and much darker lines on its segments. Setae was present near the anal end (0.2 cm). Forewing ranged from 4.4 to 4.5 cm. Dorsal part is dominantly covered dirty white and lighter antemedial band with the presence of two dark green spot near the costal margin and above the inner margin. Costal margin is straight, outer margin is slightly convex, undulant and with visible white to brown fringe and an inner margin is coated with pale yellow. Ventral part is dominantly covered with light orange with small black spots, outer margin is partially coated with pale white, inner margin is also partially coated with pale yellow. Hindwing ranged from 2.3 to 2.4 cm. Dorsal part is black and light orange bands on medial patch with dark spots near the apex, costal margin is slightly convex coated with yellow orange as well as on discal cell, outer margin is convex and undulant with white fringe near the tornus. Ventral part is dominantly covered with light orange with dark spots and bands, tornus area is much darker compared to the apex.

DISTRIBUTION. *Ambulyx wilemani* is endemic to the Philippines where it is common and widely distributed in Leyte, Luzon, Marinduque, Mindoro, Mindanao, Negros, Panay, Samar, Sibutu and Tawi-Tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Endemic Common (Hogenes & Treadaway, 1998).

Amplypterus panopus (Cramer, 1779) Fig. 8

MATERIAL EXAMINED. Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 3 females.

DESCRIPTION. This species is commonly known as mango hawkmoth. The head is dominantly covered with black dorsally and heavy orange ventrally. The antennae measured 2.1 cm, proboscis 2.2 cm and compound dark brown eyes (0.4 cm). Dorsal part of the thorax dominantly covered with black and heavy yellow to orange ventrally: prothorax (0.7 cm), mesothorax (0.4 cm) and metathorax (0.3 cm). Abdomen ranged from 3.2 to 3.6 cm. Dorsal part is covered with ash brown and black bands. While ventral part is dominantly covered heavy yellow to orange at the middle and dark brown on both sides. Setae were present at the anal end (0.2 cm). Forewing ranged from 7.1 to 8.0 cm. Costal margin is straight, outer margin is convex and undulant partially coated with black and with black fringe. Inner margin with slight curve and a present of large black spot that resembles a big eye near the tornus. Grayish antemedial band, light brown postmedial band with dark spots. Four black spots near the apex and below costal margin on its dorsal part. While ventral part is banded with dark brown and light brown with small dark spots at postmedial band, dark gray discal cell. Hind-

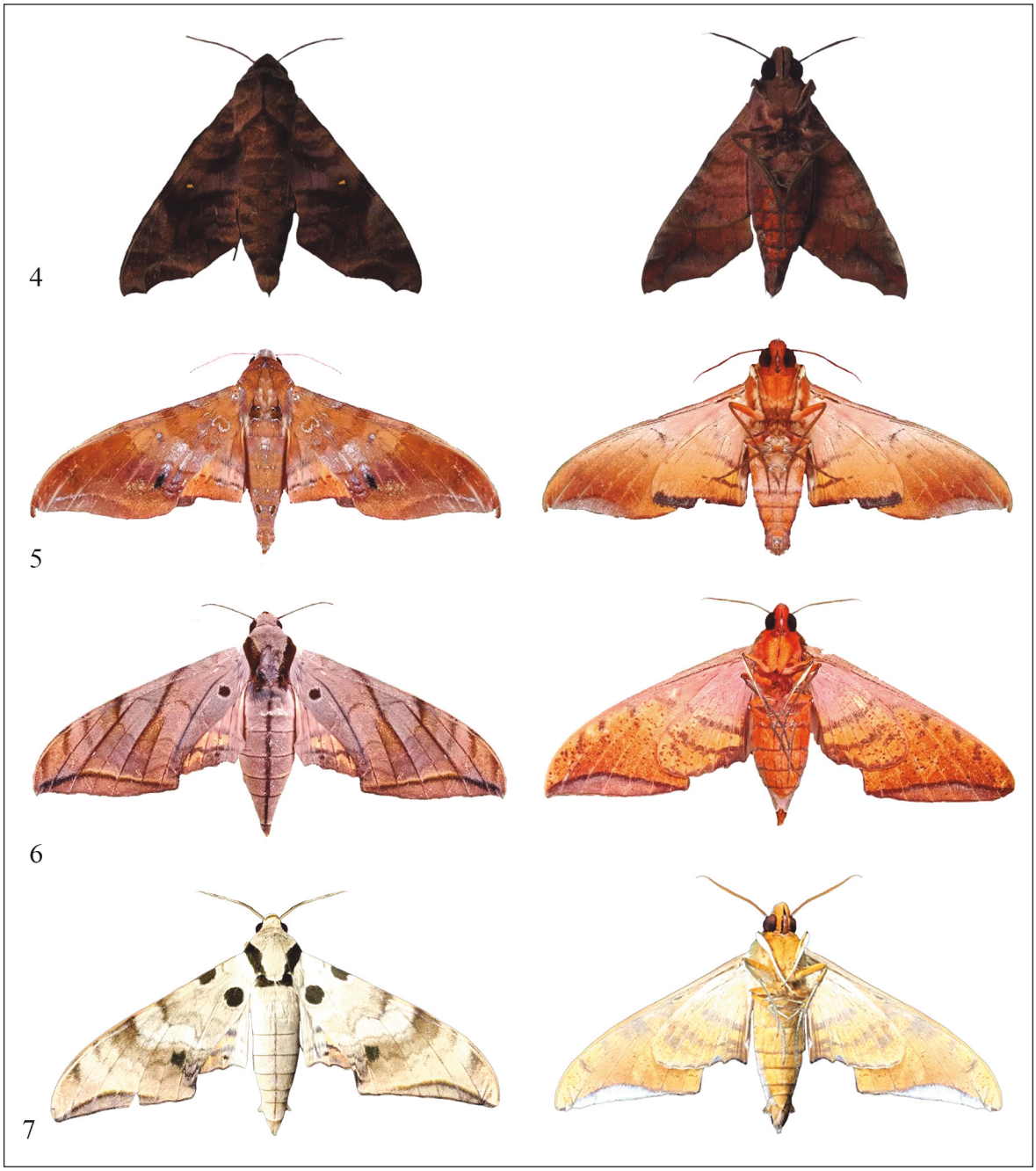

Figure 4. *Acosmeryx socrates*, male, dorsal and ventral view. Figure 5. *Ambulyx bakeri*, male, dorsal and ventral view. Figure 6. *Ambulyx johnsoni*, male, dorsal and ventral view. Figure 7. *Ambulyx wilemani*, male, dorsal and ventral view.

wing ranged from 4.0 cm to 4.3 cm. Costal margin is straight coated with light yellow from base to median line, outer margin is outer margin is slightly convex coated with black color and an inner margin slightly undulant. Yellow discal cell, pink banded with black at medial patch, black median line and postmedial band on its dorsal part while ventral part is banded with dark and light brown.

DISTRIBUTION. *Amplypterus panopus* is rare in the Philippines and distributed in Bongao and Palawan (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Rare (Hogenes & Treadaway, 1998).

Cechenena helops helops (Walker, 1856) Fig. 9

MATERIAL EXAMINED. Vintar, Valencia City (7°56'36" N, 125°10'33'' E) and Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 1 male, 1 female.

DESCRIPTION. This species is commonly known as spotted green hawkmoth. The head was dominantly covered heavy orange with white line above the eyes. The antennae measured 1.8 cm, proboscis 6.4 cm and compound mint green eyes 0.4 cm. Dorsal part of thorax is dominantly covered with heavy orange with the presence of pilose hairs on both sides. Ventral part was dominantly covered with white color: prothorax (0.6 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen measured 3.1 cm. Dorsal part dominantly covered with heavy orange. Ventral part dominantly covered with light orange with small black spots. Setae were present at the anal end (0.3 cm). Forewing measured 5.3 cm. Dorsal wing colors include white, light to heavy orange, pale green and pale brown patches. Costal margin is straight with pointed apex, outer margin is convex and inner margin is slightly undulate. Black spots present on each vein. Ventral part dominantly covered light orange with black spots, postmedian band is much lighter compared to antemedial band, apex is much darker and with white fringe near the tornus. Hindwing measured 3.1 cm. Dorsal part is with black medial path, yellow discal cell and outer margin heavy undulate with white fringe. Ventral part is similar with the color of ventral forewing, light orange with small spots and visible seven round spots located before postmedial line.

DISTRIBUTION. *Cechenena helops helops* is common to the Philippines and widely distributed in Balabac, Dinagat, Leyte, Luzon, Marinduque, Mindanao, Mindoro, Negros, Palawan, Panay, Samar and Siquijor (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Daphnis nerii (Linnaeus, 1758) Fig. 10

MATERIAL EXAMINED. Musuan, Bukidnon (7°52'57" N, 125°3'49''E), 1 male, 1 female.

DESCRIPTION. This species is commonly known as oleander hawkmoth. The head was dominantly covered with white on its dorsal and ventral part. The antennae ranged from 0.3 to 0.4 cm, proboscis (4.3 cm) and compound black eyes (0.3–0.4 cm). The dorsal part of its thorax is dominantly colored light green with white hairs while ventral part is dominantly covered with white color: prothorax (0.5–0.6 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen ranged from 2.1 to 2.3 cm and its dorsal part is dark green on both sides while lighter green at the center. White lines are visible every segment. Dark brown on its 8th segment near its anal part. Setae were present at anal end (0.1 cm). Forewing ranged from 3.1 to 3.3 cm and its dorsal part is dominantly covered with green and white of different variations. Costal margin is straight, while outer margin is slightly undulant while its ventral part is dominantly light green in color. White line is present from its apex to the middle of inner margin. Hindwing ranged from 2.0 to 2.1 cm and its dorsal coloration is similar to its forewing, however, inner margin is white color while discal cell near the base is darker in color. Ventral part is dominantly darker coloration compared to its dorsal part. White line on its median part is white. White spot is also present at discal cell.

DISTRIBUTION. *Daphnis nerii* is uncommon and widely distributed throughout the Philippines like in Cebu, Leyte, Luzon, Marinduque, Negros (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Uncommon (Hogenes & Treadaway, 2021).

Hippotion rosetta (Swinhoe, 1892) Fig. 11

MATERIAL EXAMINED. Vintar, Valencia City-3 (7°56'36" N, 125°10'33'' E) and Bacusanon, Pangantucan, Bukidnon (7°52'34" N, 124°42'28" E), 5 males.

DESCRIPTION. This species is commonly known as Swinhoe's striated hawkmoth. The head was dominantly covered with ash white color at ventral part with white line above the eye. The antennae measured 0.8 cm, proboscis reached up to 2.7 cm and dark compound eyes 0.3 cm. The dorsal part of the thorax is dominantly colored heavy brown and yellow to ash white ventrally: prothorax (0.4 cm), mesothorax

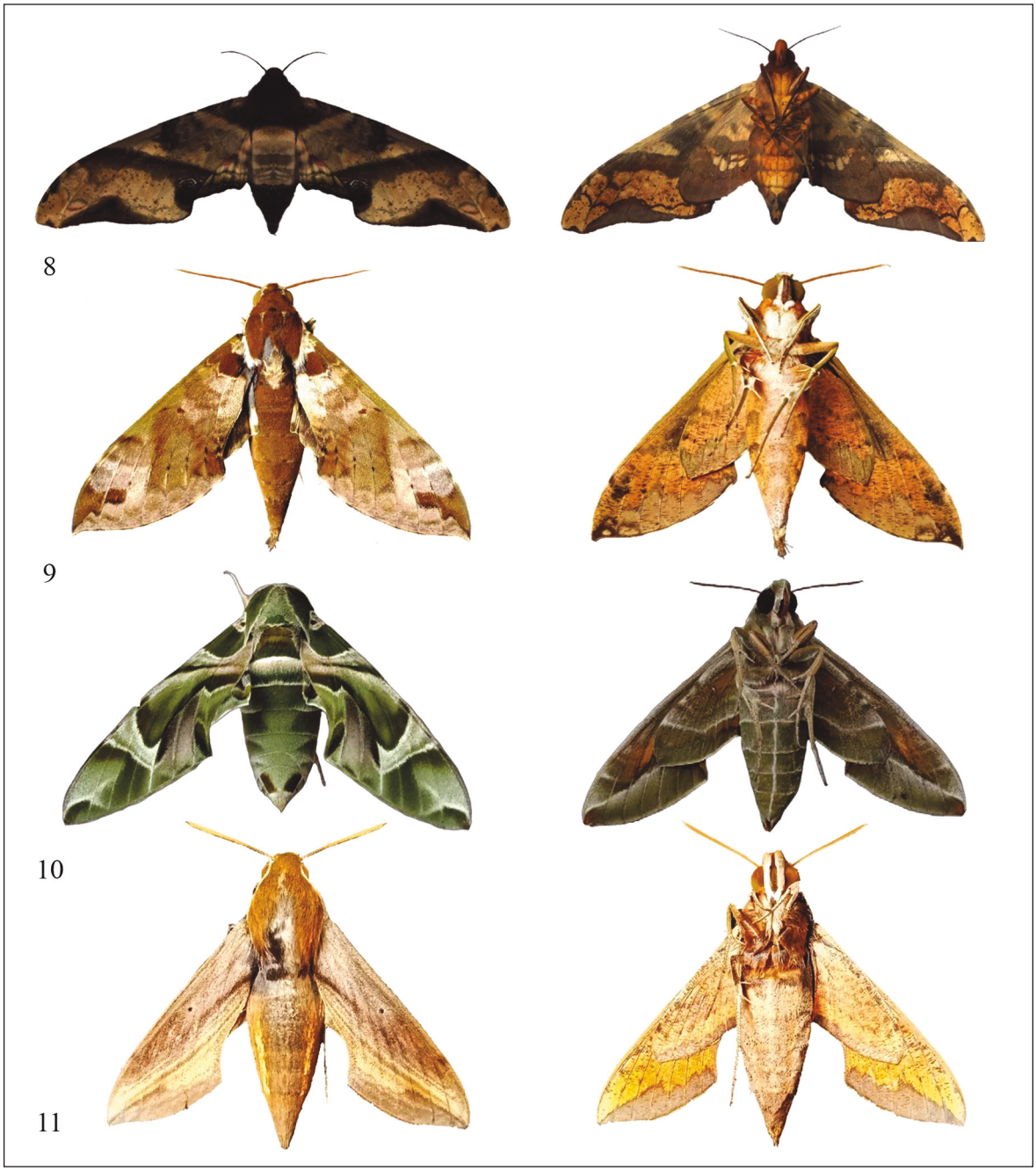

Figure 8. *Amplypterus panopus*, female, dorsal and ventral view. Figure 9. *Cechenena helops helops*, male, dorsal and ventral view. Figure 10. *Daphnis nerii*, male, dorsal and ventral view. Figure 11. *Hippotion rosetta*, male, dorsal and ventral view.

(0.2–0.3 cm) and metathorax (0.2 cm). Abdomen measured 1.4–1.6 cm. Dorsal part is dark brown with gold stripe at both sides. Ventral part is yellow to ash white with dark spots and white line at the center. Setae were present at the anal end (0.1 cm). Forewing measured 2.5 cm. Costal margin is straight coated with dark brown up to the pointed apex. Outer margin slightly undulant and convex. Five light to heavy colored lines from inner margin to the apex. Orbicular spot present on its dorsal part while ventral part is light to heavy orange with dark bands and black spots. Postmedial band and outer margin is coated

with gray. Golden yellow near the base, above inner margin. Hindwing ranged from 1.4 cm to 1.5 cm. Dorsal part is with pink medial path, golden yellow near the base of costal margin, outer margin and inner margin coated with dark brown in color. Ventral part is light to heavy orange color with dark spots, outer margin slightly undulant.

DISTRIBUTION. *Hippotion rosetta* is uncommon or local in Philippines and widely distributed in Bongao, Cebu, Jolo, Leyte, Luzon, Marinduque, Mindanao, Negros, Palawan, Panay, Sanga-Sanga, Siquijor, Sibutuc and Tawi-Tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Hippotion celerio (Linnaeus, 1758) Fig. 12

MATERIAL EXAMINED. Musuan, Bukidnon (7°52'57" N,125°3'49''E), 2 males.

DESCRIPTION. This species is commonly known as taro hawkmoth. The head was dominantly covered with brown and white line anterior its eyes on its dorsal part while ventral part is covered with white.The antennae ranged from 0.4 to 0.5 cm, proboscis (3.6 cm) and compound black eyes (0.4–0.5 cm). Dorsal part of its thorax is covered with brown color and ash white on its center part while ventral part is dominantly white: prothorax (0.5 cm–0.6 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen ranged from 2.1 to 2.3 cm and its dorsal part is brown with golden stripes on both sides and on its center while ventral part is dominantly white with black dots. Forewing ranged from 3.1 to 3.3 cm and its dorsal part is dominantly dark coloration with several white lines. Black dot is present near discal cell. Costal margin is straight with pointed apex. Ventral part dominantly colored gray near the base and light orange with dark spots on post median part. Light yellow above inner margin near the base. Hindwing ranged from 2.0 to 2.1 cm and its dorsal part has discal cell with yellow and pink coloration, black bands on basal and submedian part. Outer margin consists of white fringe while ventral part is dominantly pale orange black spots.

DISTRIBUTION. *Hippotion celerio* is common and widely distributed throughout the Philippines like in Balabac, Bohol, Calamian, Cebu, Dumaguete, Jolo, Leyte, Luzon, Marinduque, Mindoro, Mindanao, Negros, Palawan, Panay, Polilo, Panaon, Samar and Tawi-Tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Marumba amboinicus luzoni (Clark, 1935) Fig. 13

MATERIAL EXAMINED. Vintar, Valencia City-2 (7°56'36" N,125°10'33'' E) and Bacusanon, Pangantucan, Bukidnon-11 (7°52'34" N, 124°42'28" E), 13 males.

DESCRIPTION. This species has no common name. The head dominantly covered with light brown and black line at dorsal part. Antennae ranged from 1.0 to 1.5 cm, with no presence of proboscis and compound black eyes (0.4 cm). Dorsal part of thorax is light brown with black line at the center with heavy brown color on ventral side: prothorax (0.2–0.4 cm), mesothorax (0.2–0.3 cm) and metathorax (0.2 cm). Abdomen ranged from 2.4 to .8 cm. Dorsal part is similar with the dorsal part of thorax but with thinner black horizontal line at the center. Ventral part is heavy brown color with white vertical lines present on each segment of the abdomen. Setae were present at the anal end (0.2 cm). Forewing ranged from 4.7 to 5.5 cm. Dorsal part is dominantly light brown with several black transverse lines and a maroon spot located near the tornus called subreniform spot. Outer margin is undulant while costal margin is straight. Ventral part is darker color on postmedial part near the apex with light brown shade near the base and inner margin. Hindwing ranged from 3.0 to 3.4 cm. Dorsal part is dominantly dark brown with maroon spots near the tornus, costal margin is straight with outer margin slightly undulant and convex. Ventral part is lighter brown with darker transverse lines and much darker color near the anal angle.

DISTRIBUTION. *Marumba amboinicus luzoni* is common to the Philippines and widely distributed in Balabac, Bohol, Cebu, Dinagat, Jolo, Leyte, Luzon, Marinduque, Mindoro, Mindanao, Negros, Panay, Samar, Sibuyan and Siquijor (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

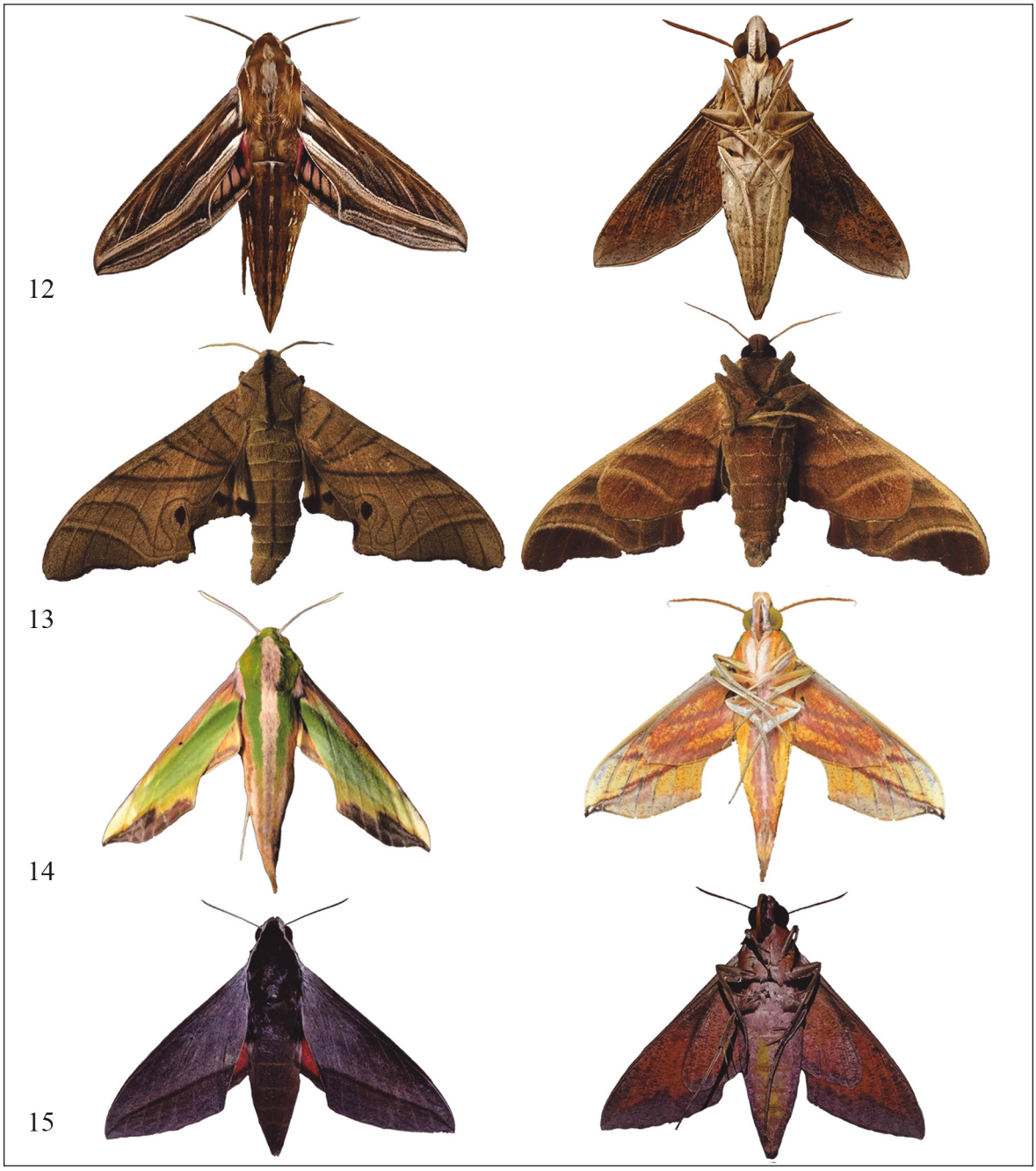

Figure 12. *Hippotion celerio*, male, dorsal and ventral view, Figure 13. *Marumba amboinicus luzoni*, male, dorsal and ventral view. Figure 14. *Pergesa actea*, female, dorsal and ventral view. Figure 15. *Theretra alecto*, female, dorsal and ventral view.

Pergesa actea (Cramer, 1779) Fig. 14

MATERIAL EXAMINED. Vintar, Valecia City-3 (7°56'36" N,125°10'33'' E) and Bacusanon, Pangantucan, Bukidnon-1 (7°52'34" N, 124°42'28" E), 3 males, 1 female.

DESCRIPTION. This species is commonly known as green pergesa hawkmoth. The head was dorsally covered with green color. Antennae measured 1.3 cm, with proboscis reaches up to 6.6–6.8 cm and compound yellowish eyes, 0.4 cm. Dorsal part of the thorax is covered with green on both sides and

lighter brown on between. Pilose hairs present near the base of forewing. While ventral part is covered with white at the center and orange on sides: prothorax (0.5 cm), mesothorax (0.2 cm) and metathorax (0.2–0.3 cm). Setae were present at the anal end (0.4 cm). Abdomen measured 2.5 cm. Dorsal part is similar to the dorsal part of the thorax in terms of color but became thinner and lighter as its approaches at the anal part. Light orange observed on both sides. While ventral part is covered with three different bands: light orange on both sides followed by darker color and white band on its center. Forewing ranged from 3.2 to 3.4 cm. Dorsal part is with costal margin is straight with pointed apex. Outer margin is convex, slightly undulate and coated with black. Inner margin with curve near the tornus. Light orange on basal part and discal space with orbicular black spot. Green antemedial band. Ventral part with postmedial band covered with light orange with small black spots, darker postmedial line. Discal cell is ash green and inner margin is partially coated with pale yellow. Hindwing ranged from 2.0 cm to 2.1 cm. Dorsal part is dominantly colored black on medial patch and orange at the bottom. Costal margin is straight, partially coated with bright yellow as well as in discal cell, outer margin is convex and coated black with white fringe. While ventral part is dominantly colored orange with dark transverse lines and small orange spots.

DISTRIBUTION. *Pergesa actea* is common to the Philippines and widely distributed in Balabac, Bohol, Bongao, Cebu, Dinagat, Dumaguete, Jolo, Leyte, Luzon, Marinduque, Masbate, Mindoro, Mindanao, Negros, Palawan, Panay, Samar and Siquijor (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Theretra alecto (Linnaeus, 1758) Fig. 15

MATERIAL EXAMINED. Vintar, Valencia City (7°56'36" N,125°10'33'' E), 1 female.

DESCRIPTION. This species is commonly known as levant hawkmoth. The head was dominantly dark in coloration with white lines anterior on its eyes. Antennae measured 1.5 cm, proboscis 5.2 cm and compound black eyes 0.4 cm. Dorsal part of its thorax is dominantly dark brown while ventral part is lighter: prothorax (0.7 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen measured 3.1 cm and its dorsal part is dominantly dark brown color with visible lines on each segment while ventral part is dominantly lighter color than dorsal part. Setae were present at anal end (0.1 cm). Forewing measured (3.2 cm) and its dorsal part is dominantly dark brown color, with darker line from its apex down to its inner margin, submarginal part with black spots. Costal margin is straight and golden brown in color, outer margin is slightly undulant. Ventral part is dominantly red orange with black spots on its anterior part. Yellow color above inner margin near the base. Submarginal part is dark brown. Hindwing measured (2.2 cm) and its dorsal part is dominantly colored red orange medial patch while anterior to inner margin near the base is black, posterior to costal margin near the base is yellow. Outer margin is slightly undulant with white and orange fringe. Submarginal part is dark brown. Ventral part is dominantly red orange (but much lighter compared to dorsal part) with black spots. Posterior to costal margin and outer margin is dark brown color.

DISTRIBUTION. *Theretra alecto* is widely distributed throughout the Philippines like in Balabac, Bohol, Bongao, Calamian, Cebu, Leyte, Luzon, Mindoro, Mindanao, Negros, Palawan, Panay, Samar, Sibuyan, Siquijor, Sibutuc and Tawi-Tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Uncommon (Hogenes & Treadaway, 1998).

Theretra clotho clotho (Drury, 1773) Fig. 16

MATERIAL EXAMINED. Vintar, Valencia City-1(7°56'36" N,125°10'33'' E) and Musuan, Bukidnon-2 (7°52'57" N,125°3'49''E), 2 males, 1 female.

DESCRIPTION. This species is commonly known as common hunter hawkmoth. The head was dominantly dark green with white lines anterior on its eyes. Antennae measured 1.6 cm, proboscis 2.7 cm and compound dark green eyes 0.5 cm. Dorsal part of its thorax is dominantly dark green with white line near the base while ventral part is dominantly dirty white coloration: prothorax (0.8 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen dorsal part is dominantly dark green while

ventral part is dominantly dirty white coloration. Setae were present at anal end (0.3 cm). Forewing ranged from 3.7 to4.0 cm and its dorsal part is dominantly light army green with black patches on post median part. Costal margin is straight and light brown in color with pointed apex while ventral part is dominantly light orange with black spots, anterior to inner margin near basal part is yellow, discal cell is much darker in color. Hindwing ranged from 1.9 to 2.1 cm and its dorsal part is dominantly black color, posterior to costal margin is yellow. Outer margin is undulant near the tornus with white fringe while ventral part is dominantly light orange with black spots.

DISTRIBUTION. *Theretra clotho clotho* is common and widely distributed throughout the Philippines like in Balabac, Bohol, Bongao, Calamian, Cebu, Jolo, Leyte, Luzon, Mindoro, Mindanao, Negros, Palawan, Panay, Samar, Sibuyan, Siquijor,

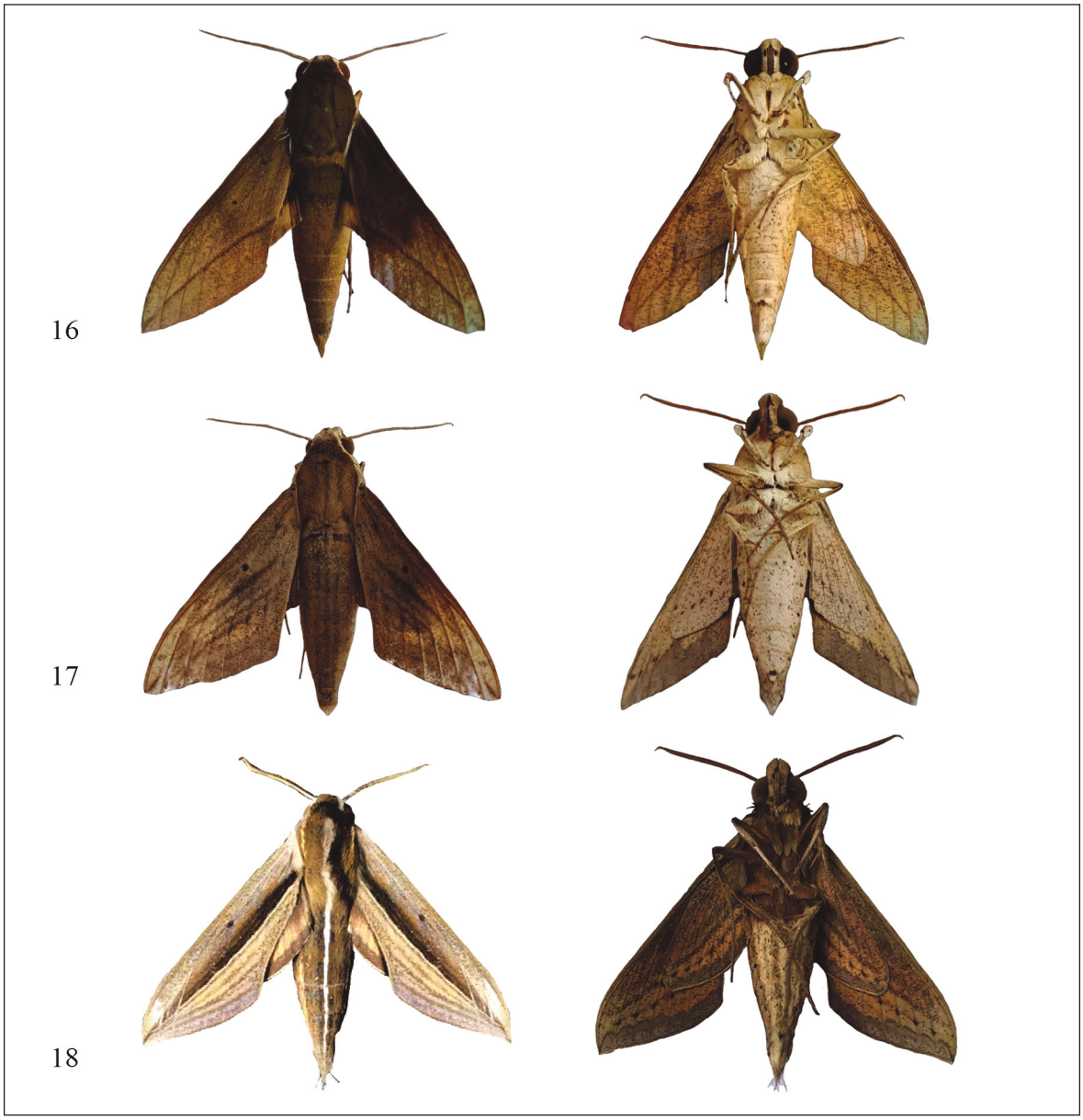

Figure 16. *Theretra clotho clotho*, female, dorsal and ventral view. Figure 17. *Theretra latreillii*, male, dorsal and ventral view. Figure 18. *Theretra silhetensis*, male, dorsal and ventral view.

Sibutuc, Tawi-Tawi and Mapun (Hogenes & Treadaway, 1998; Zwick & Treadaway, 2001).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

Theretra latreillii (Walker, 1826) Fig. 17

MATERIAL EXAMINED. Vintar, Valencia City (7°56'36" N,125°10'33'' E), 3 males.

DESCRIPTION. This subspecies is known as Lucas's hawkmoth. The head was dominantly covered dark green with black vortex on its dorsal part. Antennae measured 1.4 cm, proboscis 4.1 cm and compound dark green eyes 0.4 cm. Dorsal part of its thorax is dominantly covered with green color, white line on both sides near the base of its forewing while ventral is white with black spots: prothorax (0.6 cm), mesothorax (0.3 cm) and metathorax (0.3 cm). Abdomen ranged from 2.3 to 2.4 cm and its dorsal part consists of three vertical lines on its center while ventral part is dominantly white with dark spots. Forewing ranged from 3.2 to 3.4 cm and its dorsal part is dominantly light army green in color with black patch at basal part. Outer margin slightly undulate with black fringe. Six horizontal lines from inner margin to outer margin which varies in thickness while ventral part, anterior portion of its inner margin near the base is yellow, post basal part is black while post median part is light yellow with black spots. Hindwing ranged from 2.1 to 2.2 cm and its dorsal part is dominantly black on its medial patch, posterior to costal margin is yellow, fringe on its outer margin is white while ventral part is yellow orange with black spots and bands.

DISTRIBUTION. *Theretra latreillii* is widely distributed throughout the Philippines like in Balabac, Bohol, Bongao, Cebu, Jolo, Leyte, Luzon, Mindoro, Mindanao, Negros, Palawan, Siquijor, Sibutuc, Tawi-Tawi and Mapun (Hogenes & Treadaway, 1998; Zwick & Treadaway, 2001).

ECOLOGICAL STATUS. Uncommon (Hogenes & Treadaway, 1998).

Theretra silhetensis (Walker, 1856) Fig. 18

MATERIAL EXAMINED. Vintar, Valencia City-2 (7°56'36" N,125°10'33'' E), Musuan-1 (7°52'57" N,125°3'49"E) and Bacusanon, Pangantucan, Bukidnon-3 (7°52'34" N, 124°42'28" E), 3 males, 3 females.

DESCRIPTION. The head was dominantly colored black dorsally with white line above the eye. The antennae measured 0.9 cm, with proboscis reached up to 2.4 cm and dark compound eyes, 0.3 cm. Dorsal part of its thorax consists of two gold lines on both sides with white line at the center continuous to the abdomen, pilose hairs are also present. While the ventral part is covered with light brown with dark spots: prothorax (0.4 cm), mesothorax (0.2 cm) and metathorax (0.2 cm). Abdomen measured 1.7 cm. Dorsal part is dominantly covered with dark brown with white visible line at the center. Ventral part is dominantly colored light brown with black small spots. Setae were present at the anal end (0.3 cm). Forewing measured 2.3 cm. Dorsal part of its body had straight costal margin with pointed apex; outer margin is slightly convex with inner margin slightly undulant. Three dark lines present near the outer margin, with whiter transverse line at the center and above is a dark band with one black orbicular spot. Ventral part with outer margin is coated with dark brown, yellow above the inner margin near the base, six visible black spots present in each vein at postmedial area. Light orange color also observed with black spots, darker discal cell. Hindwing measured 1.5 cm. Dorsal part is black and light orange band at medial patch, outer margin coated with dark color and costal margin and discal cell yellow near the base. Ventral part is dominantly covered with light orange with black spots, two dark transverse line, outer margin coated with dark band.

DISTRIBUTION. *Theretra silhetensis* (Walker, 1856) is common to the Philippines and widely distributed in Balabac, Bohol, Cebu, Jolo, Leyte, Luzon, Mindoro, Mindanao, Negros, Palawan, Panay, Panaon, Samar, Sibuyan, Siquijor and Tawi tawi (Hogenes & Treadaway, 1998).

ECOLOGICAL STATUS. Common (Hogenes & Treadaway, 1998).

DISCUSSION

Less disturbed area in Bacusanon, Pangantucan, Bukidnon (Site 1) has the highest number of

collected individuals (51.85%). Different trees like tulips tree with blooming flowers, balabago, falcata and fruits like guava, star apple, jackfruit and marang and several kinds of angiosperm species were present in that area, which it could be a very good source of food for adult hawkmoths whose feed on nectars or rotten fruits. According to Choi (2008), the availability of food plant sources will be one of the important factors for the moth's successful growth and to be able to survive. Vintar, Valencia City (Site 2) has the second highest percentage (35.18%) of collected hawkmoth species. This area is also surrounded with many trees like gmelina, ipil-ipil, fruits like guava, santol and jackfruit were also present. This area is surrounded with houses and susceptible to human intervention. Since hawkmoths are mainly attracted to artificial light (Jonason et al., 2014), light trapping techniques are ineffective and inefficient when collecting this species due to the competition of lights present everywhere (McDermott & Mullens, 2017). Site 3 which is in Vintar, Valencia City has the lowest number of collected hawkmoth species (12.96%). They are prone to anthropogenic disturbance due to the presence of agricultural crops like rice and corn. According to Cecchi et al. (2001), anthropogenic disturbance may affect natural population living in a particular area. As stated in the report of Li et al. (2013), it could also influence variety of ecological attributes, species interactions as well as ecosystem function. Sometimes, farmers apply pesticides on their crops and, according to Kaur & Garg (2014), most of the pesticides may kill the organisms that are harmless or useful to the ecosystem and one of these are moth species.

During sampling period, heavy to moderate rainfall, thick fogs, warm temperature and strong winds were observed along the way. Due to this, there were days that only few species of moths were collected. According to Holyoak et al. (1997), numbers of moth caught in light traps were influenced by daily weather variation and light traps could also be affected by the presence of fogs and winds. High rainfall influences the presence of adult moth species. Due to wet wings, they cannot be able to fly to where light is present, however, increased rainfall may also have advantage in terms of its effect on vegetation, a larval food resource, and survivorship of early life cycle stages in continuously breeding species (Intachat et al., 2001). Local conditions such as wind speed, temperature, humidity and the amount of time that the trap is operated also affect the trap efficiency (Southwood & Henderson, 2000; Rafi et al., 2014). Temperature is one of the most important factors to consider in collecting hawkmoths species (Jonason et al., 2014; Pittaway & Kitching, 2020). During sampling period, temperature ranges from 17 °C to 28 °C. The study of Choi (2008) & Jonason et al. (2014) confirms that hawkmoths are active during warmer nights. However, we managed to collect hawkmoth species even with cold temperatures. According to the report of Primo et al. (2013), the changes between the dry and rainy seasons create impact on cycles of leaf availability of host plant to the larvae of hawkmoths which consequently determines the seasonal occurrence of adults. Moths are indicators of a healthy environment due to its well understood taxonomy, fast response to environmental changes and easy sampling method (Hilty & Merenlender, 2000). Without them, the ecological services that they provide are affected as well as other groups that mainly depends on them, obviously creating imbalance in our ecosystem (Mohagan et al., 2018).

Determination of ecological status of hawkmoths based on Hogenes and Treadaway (1998) revealed the following: eleven (11) common, three (3) uncommon, one (1) rare and three (3) species were endemic to the Philippines.

CONCLUSIONS

The collected hawkmoths species were described based on the presence of skull in the head and the a) general color of their eyes, thorax, abdomen and wings and the b) length of the eyes, antennae, proboscis, prothorax, mesothorax, metathorax, abdomen, setae, shape of the forewings and hindwings. These morphological characteristics became the basis of their identification. Out of 15 species, 3 species collected are endemic to the Philippines namely: *Ambulyx bakeri, Ambulyx wilemani* and *Ambulyx johnsoni*. Temperature, location, types of vegetation and weather conditions could affect the presence of night flying insects like hawkmoths.

ACKNOWLEDGEMENTS

To Central Mindanao University president, Dr. Jesus Antonio G. Derije, Barangay Captain of Vintar, Valencia City; Honarable Frankie F. Agbayani, Barangay Captain of Bacusanon; Honorable Rodelio Magbanua Lucero, the author is thankful for allowing us conduct our study. To Sir Dave Mohagan of Central Mindanao University Museum for facilitating the identification of hawkmoths species. The author is also grateful to the Department of Science and Technology - Science Education Institute (DOST-SEI) as the primary support of this research. This paper would have not been possible without them. Thank you very much.

REFERENCES

Akkuzu E., Ayberk H. & Inac S., 2007. Hawk moths (Lepidoptera: Sphingidae) of Turkey and their zoogeographical distribution. Journal of Environmental Biology, 28: 723–30.

Cecchi B.L., Pannacciulli F., Bulleri F., Moschella P.S., Airoldi L., Relini G. & Cinelli F.,2001. Predicting the consequences of anthropogenic disturbance: large-scale effects of loss of canopy algae on rocky shores. Marine Ecology Progress Series, 214: 137–150.

Cho S., Epstein S.W., Mitter K., Hamilton C.A., Plotkin D., Mitter C. & Kawahara A.Y., 2016. Preserving and vouchering butterflies and moths for large-scale museum-based molecular research. PeerJ . Doi 10.7717/peerj.2160

Choi S.W., 2008. Effects of Weather Factors on the Abundance and Diversity of Moths in a Temperate Deciduous Mixed Forest of Korea. Zoological Science, 25: 53–58. doi:10.2108/zsj.25.53

De Camargo A.J.A., de Camargo N.F., Corrêa D.C.V., de Camargo W.R.F., Vieira E.M., Marini-Filho O. & Amorim F.W., 2016. Diversity patterns and chronobiology of hawkmoths (Lepidoptera, Sphingidae) in the Brazilian Amazon rainforest. Journal of Insect Conservation, 20: 629–641. https://doi.org/10.1007/s10841-016-

Devi J.S. & Ramaraju K., 2015. Studies on the Survey and Life History of Hawk Moths (Lepidoptera: Sphingidae) from Coimbatore, Tamil Nadu. Trends in Biosciences. 8(1). ISSN 0974-8431, 13–16, 2015

Fontanilla I.K.C., Torres A.F., Cañasa A.D.G., Yap S. & Ong P.S., 2014. State of animal DNA barcoding in the Philippines: A review of COI sequencing of Philippine native fauna. Philippine Science Letters, 7: 104–137. Retrieved from https://www.researchgate.net/publication/273064221

Forewood J.R., 1980. Observation on the Life Cycle of Spurge Hawkmoth.Transactions of the Nebraska Academy of Sciences 7: 31–34.

Hilty J. & Merenlender A. 2000. Faunal indicator taxa selection for monitoring ecosystem health. Biological Conservation, 92: 185–197

Hogenes W. & Treadaway C.G., 1998. The Sphingidae (Lepidoptera) of the Philippines. Entomologischer Verein Apollo e.v. Frankfurt am main, 17: 17–132. Retrieved from www.zoobodat.at

Holyoak M., Jarosik V. & Novac I., 1997. Weather induced changes in moth activity bias measurement of long-term population dynamics from light trap samples. Entomologia Experimentalis et Applicata, 83: 329–335.

Intachat J., Holloway J.D. & Staines H., 2001. Effects of weather and phenology on the abundance and diversity of geometroid moths in a natural Malaysian tropical rain forest. Journal of Tropical Ecology, 17: 411–429. https://doi.org/10.1017/s0266467401001286

Johnson S.D., Moré M., Amorim F.W., Haber W.A., Frankie G.W., Stanley D.A., Cocucci A.A. & Raguso R.A., 2016. The long and the short of it: a global analysis of hawkmoth pollination niches and interaction networks. Functional Ecology, 31, 101–115. https://doi.org/10.1111/1365-2435.12753

Jonason D., Franzen M. & Ranius T., 2014. Surveying Moths Using Light Traps: Effects of Weather and Time of the Year. PLoS ONE, 9(3). doi:10.1371/journal.pone.0092453

Kaur H. & Garg H., 2014. Pesticides: Environmental Impacts and Management Strategies. Pesticides - Toxic Aspects. doi:10.5772/57399

Kawahara, A. Y., Mignault, A. A., Regier, J. C., Kitching, I. J., & Mitter, C. 2009. Phylogeny and Biogeography of Hawkmoths (Lepidoptera: Sphingidae): Evidence from Five Nuclear Genes. PLoS ONE, 4(5). https://doi.org/10.1371/journal.pone.0005716

Kelber A., Balkenius A. & Warrant E.J., 2003. Colour Vision in Diurnal and Nocturnal Hawkmoths. Integrative and Comparative Biology, 43, 571–579. https://doi.org/10.1093/icb/43.4.571

Kodandaramaiah, U. 2011. The evolutionary significance of butterfly eyespots. Behavioral Ecology, 22: 1264–1271. https://doi.org/10.1093/beheco/arr123

Lara-Pérez L.A., Campos-Domínguez J., Díaz Fleischer F., Adame-García J. & Andrade Torres A., 2017. Species richness and abundance of Saturniidae (Lepidoptera) in a tropical semi-deciduous forest of Veracruz, Mexico and the influence of climatic variables. Revista Mexicana de Biodiversidad, 88: 173–182. https://doi.org/10.1016/j.rmb.2016.10.020

Li W., Tan R., Wang J., Du F. & Yang Y., 2013. Effects of anthropogenic disturbance on richness-dependent stability in Napahai plateau wetland. Chinese Science Bulletin, 58: 4120–4125. https://doi.org/10.1007/s11434-013-5954-4

McDermott E.G., & Mullens B.A., 2017. The Dark Side of Light Traps. Journal of Medical Entomology, 55: 251–261.

Messenger C., 1997. The Sphinx Moths (Lepidoptera: Sphingidae) of Nebraska. Transactions of the Nebraska Academy of Sciences and Affiliated Sciences, 24: 89–141. Retrieved from http://digitalcommons.un/.edu/tnas/72

Miller W.E., 1997. Diversity and Evolution of Tongue Length in Hawkmoths (Sphingidae). Journal of the Lepidopterists Society, 5: 9–31.

Mohagan D.L., Solis E. Ruel F.G., Colong, Laraga S.H., Doblas G.Z., Paraguas K.G.S., Mohagan D.P., Moagan A.B. & Tomas B., 2018. Hawkmoths (Heterocera: Sphingidae) diversity and Status on selected vegetation types of a protected natural forest (Mt. Hamiguitan Wildlife Sanctuary, San Isidro, Davao Oriental) and Ecotourist Area (Busay Garden Marilog District, Davao City) Philippines. International Journal of Current Research in Life Sciences, 7: 2684– 2690.

Pittaway A.R. & Kitching I.J., 2020. Sphingidae of the Eastern Palaearctic (including Siberia, the Russian Far East, Mongolia, China, Taiwan, the Korean Peninsula and Japan). http://tpittaway.tripod.com/china/china.htm.

Primo L.M., Duarte J.A. & Machado I.C., 2013. Hawkmoth fauna (Sphingidae, Lepidoptera) in a semi-deciduous rain forest remnant: composition temporal fluctuations, and new records for northeastern Brazil. Annals of the Brazilian Academy of Sciences, 85: 1177–1188.

Rafi M.A., Sultan A., Kitching I.J., Pittaway A.R., Markhasiov M., Khan M.R. & Naz F., 2014. The Hawkmoth Fauna of Pakistan (Lepidoptera: Sphingidae). Zootaxa, 3794: 393–418. http://dx.doi.org/10.11646/zootaxa.3794.3.4

Rougerie R., Kitching I.J., Haxaire J., Miller S.E., Hausman A. & Hebert P.D.N., 2014. Australian Sphingidae -DNA Barcodes Challenge Current Species Boundaries and Distributions. PLoS ONE, 9(7). https://doi.org/10.1371/journal.pone.0101108

Sebua C.M.D. & Nuñeza O.M., 2020. Species Diversity of Lepidoptera in Western Mindanao State University. Experimental Forest Area, Zamboanga City, Philippines. Entomology and Applied Science Letters, 7: 33–43.

Singh D., & Kaur N., 2017. DNA barcoding of Some Indian species of hawkmoths based on COI gene (Lepidoptera: Sphingidae). Journal of Entomology and Zoology Studies, 5: 35–40.

Southwood T.R.E. & Henderson P.A., 2000. Ecological Methods, Blackwell Science Ltd, Oxford.

Suelo M.S., Dela Cruz R.Y.D., Luceño A.J. & Mohagan, A.B., 2020. Morphological Description and Ecological Status of Hawkmoths (Lepidoptera: Sphingidae) in Three Vegetation Types of Mt. Kitanglad, Lirongan, Lantapan, Bukidnon, Philippines. Biological Forum- AN International Journal, 12: 18–28.

Stöckl A.L. & Kelber A., 2019. Fuelling on the wing: sensory ecology of hawkmoth foraging. Journal of Comparative Physiology A. https://doi.org/10.1007/s00359-019-01328-2

Yen S.H., Kitching I.J. & Tzen C.S., 2003. A New Subspecies of Hawkmoth from Lanyu, Taiwan, with a Revisedand Annotated Checklist of the Taiwanese Sphingidae (Lepidoptera). Zoological Studies, 42: 292–306.

van Nieukerken E.J., Kaila L., Kitching I.J., Kristensen N.P., Lees D.C., Minet J., Mitter C., Mutanen M., Regier J.C., Simonsen T.J., Wahlberg N., Yen S.-H., Zahiri R., Adamski D., Baixeras J., Bartsch D., Bengtsson B.Å., Brown J.W., Bucheli S.R., Davis D.R., De Prins J., De Prins W., Epstein M.E., Gentili-Poole P., Gielis C., Hättenschwiler P., Hausmann A., Holloway J.D., Kallies A., Karsholt O., Kawahara A.Y., Koster J.C., Kozlov M.V., Lafontaine J.D., Lamas G., Landry J.-F., Lee S., Nuss M., Park K.-T., Penz C., Rota J., Schintlmeister A., Schmidt B.C., Sohn J.-C., Solis M.A., Tarmann G.M., Warren A.D., Weller S., Yakovlev R.V., Zolotuhin V.V. & Zwick A., 2011. Order Lepidoptera Linnaeus, 1758. In: Zhang Z.-Q. (Ed.), Animal biodiversity: An outline of higher-level classification and survey of taxonomic richness. Zootaxa, 3148: 212–221. http://www.mapress.com/zootaxa/2011/f/zt03148p221.pdf

Zwick A. & Treadaway C.G., 2001. Notes on the hawkmoths of the Philippines (Lepidoptera:Sphingidae). Nachrichten des Entomologischen Vereins Apollo, N. F. 22: 177–181.