The metallic blue fly, *Axona chalcopyga* (Wiedemann, 1830) (Diptera: Syrphidae) in Gelam Forests, new to Malaysia

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ABSTRACT. The ecological aspects, distribution, and possible conservation of a syrphid hoverfly, *Axona chalcopyga* (Wiedemann, 1839) is poorly known due to their rare records. Three female individuals of *A. chalcopyga* were discovered in the Gelam forests of Terengganu state, which is the first record in Peninsular Malaysia. Here, we provided a pictorial description of the female. We also noted the functional role of the hoverfly as a potential pollinator candidate for the Gelam trees by visiting its flowers.

Keywords: BRIS ecosystem, cajuput, flower-visiting, Gelam, hoverflies, pollinator

INTRODUCTION

Hoverflies, syrphid flies or flower flies, are the common name of the family Syrphidae (Diptera: Insecta), which encompasses an enormous number of species, approximately 6,300 species within more than 200 genera (Marshall, 2012; Skevington et al., 2019). Many hoverflies are yet to be identified; their identities are still awaiting discovery, and they are currently categorised as unidentified or unranked species within taxonomic ranks. *Axona* Walker, 1864 is a monotypic genus, that contains only a single...
species, *Axona chalcopyga* (Wiedemann, 1830), whose distribution ranges from Myanmar to Micronesia, South to Australia and East Asia (Morales, 2011; Thompson et al., 2017). Despite the little information available through publications, the occurrences of this species are considered valid or reliable. A total of eight occurrences were recorded from online platforms, including the Global Biodiversity Information Facility (GBIF) and Citizen Science (iNaturalist) of various regions and distinct timeframes, including Papua New Guinea (1885; 1921; 1922; 1967), Indonesia (1945), Solomon Islands (1945), Australia (1914), and Singapore (2017). To date, no study has unveiled the presence of this species in Malaysia. The prevailing research lacunae impedes our understanding of the crucial role of this species within a specific ecosystem. These critical gaps extend to areas including the distributional patterns and ecological roles of the *Axona*.

Hoverflies, often mistaken for bees or wasps, are beneficial insects that play a crucial role in pollination and pest control. With their agile flight and ability to hover in mid-air, hoverflies are efficient pollinators, making them valuable contributors to agroecosystems (Lucas et al., 2017; Doyle et al., 2020). Hoverflies are gaining more attention as a group of model insects considered important in ecological studies as pollinators after bees (Doyle et al., 2020; Rader et al., 2020; Miličić et al., 2021). Currently, Syrphidae are being reared commercially for pollination purposes in agroecosystems (Nicholas et al., 2018; Li et al., 2023). Surprisingly, hoverflies contribute approximately US$300 billion annually through pollination services (FAO, 2017). Another interesting aspect, hoverflies have evolved a good mimic of the appearance of bees, bumblebees, sawflies, and wasps (Marshall, 2012; Skevington et al., 2019). Additionally, due to their diverse larval feeding strategies, hoverflies play a pivotal role in providing ecological and environmental services as pollinators and decomposers. The life cycle of hoverflies is complex based on their feeding behaviour, and they provide varied functional roles in ecosystems; larval stages involve the decomposition of decaying organic matter (Rotheray, 2012; Wojciechowicz-Żytko & Jankowska, 2017), aphids pest control on crops (aphidophagous) (Dumbardon-Martial, 2016; Dunn et al., 2020) and in the adult stage, they contribute to the pollination mechanism of a diverse range of flowers (Woodcock et al., 2014; Moquet et al., 2018; Campoy et al., 2020; Li et al., 2023).

The Gelam forest in Terengganu is considered the largest Gelam forest in Malaysia (Omar et al., 2020). The term "Gelam" directly alludes to the *Melaleuca cajuputi* tree, which stands as the exclusive and dominant species within this biome. This unique ecosystem thrives in sandy terrain and hostile environments, mainly defined as Beach Ridges Interspersed with Swales (BRIS). The Gelam forest biomes harbour a significant number of the floral and faunal elements across various taxonomic groups, including Plantae (plants), Aves (birds), Mammalia (mammals), Insecta (insects), Actinopterygii (fishes), and Prokaryotes (microbes) (Mohd Salim & Mohamad, 2011). The forest is also vital for domesticated and wild insects (e.g. honeybees and stingless bees), which depend on resources for survival, especially for their floral rewards (pollen and nectar) (Ibrahim et al., 2012; Bramasta et al., 2023; Mamat et al., 2023). Despite its ecological importance, the Gelam forests face the relentless impact of anthropological and natural changes such as sand mining, deforestation, land clearance for rural developments, and the onslaught of fires during prolonged drought seasons (Mohd Salim et al., 2013, 2014). These significant factors pose marked risks to the forest's biodiversity and threaten the natural habitats of hoverflies (Rotheray, 2012). The hoverfly fauna of Malaysia remains understudied, and the distribution of *A. chalcopyga* is no exception. The male specimen of *A. chalcopyga* was briefly described by Morales (2011) and Thompson et al. (2017). Herein, we briefly describe the female morphology, current distribution, and a glimpse of the functional role of *A. chalcopyga* in Gelam forests from the east coast of Peninsular Malaysia. We provide photographs of the female specimen to add more details to the depiction of the species.

**MATERIAL AND METHODS**

**Study Sites.** The study was conducted in Gelam forests from the east coast of Peninsular Malaysia (Fig. 1). The specimens were caught in Jambu Bongkok Forest Reserve (JBFR), Marang, Kuala Dungun
(04°52′44.9″N, 103°22′22.6″E), (04°52′45.7″N, 103°22′29.7″E) and fragmented Gelam forests in Bukit Mawi Kampung Kijing (05°12′34.5″N, 103°11′47.3″E). The specimen collecting points were made for new locality records using QGIS 3.26.3. The Gelam forests at this site cover approximately 15 hectares in Terengganu (Omar et al., 2020). The forest in Bukit Mawi, Kampung Kijing, is fragmented and facing urban development activities such as land use change, residential areas, deforestation, and open burning (Fig. 1B). On the other hand, JBFR is a reserved forest with fewer anthropogenic activities. The forest is associated with the BRIS ecosystem and is covered dominantly by Melaleuca cajuputi (Gelam) and other trivial plant species, including Acacia mangium (Akasia lebar), Acacia auriculiformis (Akasia kuning), Fagraea fragrans (Tembusu padang), Ficus deltoidei (Mas cotek), Garcinia hombroinia (Beruas), Syzygium incarnatum (Kelat Gelam) Syzygium gratum (Gelam tikus), Syzygium grande (Kelat jambu laut), several carnivorous plants (eg. Nepenthes spp., Drosera sp. and Utricularia spp.) and ferns, orchids, and aquatic plants.

Collecting specimens, preservation and identification. Specimens of Axona chalcopyga were collected in three selected Gelam forests in 2022 (on May 23) and 2023 (on May 25 and August 24). The specimens were found in various Gelam forest environments including dry and swampy areas (Fig. 2). The flies were captured using a sweep net and placed in killing jars added with a drop of ethyl acetate. Later, the specimens were preserved and dried in an incubator at 37°C for 5 days. The specimens were then deposited at the Insectarium of Universiti Malaysia Terengganu (UMT) for further examination and identification. The specimens were identified under a Zeiss® Microscope Stemi 2000-C and captured by a camera Canon® 3000D equipped with a 60 mm macro lens and custom-made diffuser. Morphological descriptions were recorded following terminology by Van Steenis et al. (2023). Additional photographs were uploaded on an online platform; the Figshare web repository.

Figure 1. Map of collecting points of specimens from Gelam forests in Terengganu of Peninsular Malaysia. A. Peninsular Malaysia; B. Bukit Mawi, Kampung Kijing; C. Jambu Bongkok Forest Reserve (JBFR).

Journal of Insect Biodiversity and Systematics 2024 • 10 (4)
RESULTS

A total of three individuals of female *A. chalcopyga* were captured, which is the first record of this hoverfly in Malaysia. The taxonomical descriptions, distribution and photographs of the female are discussed below (Figs 3–5). *Axona chalcopyga* was observed hovering and landing on Gelam (*Melaleuca cajuputi*) flowers probably to forage for floral rewards such as pollen grains and flower nectar (Fig. 5).

**Taxonomic hierarchy**

Class *Insecta* Linnaeus, 1759  
Order *Diptera* Linnaeus, 1758  
Superfamily *Syrphoidea* Latreille, 1802  
Family *Syrphidae* Latreille, 1802  
Subfamily *Eristalinae* Newman, 1834  
Genus *Axona* Walker, 1864  
*Axona chalcopyga* (Wiedemann 1830) (Figs 3–5)  
*Eristalis chalcopyga* Wiedemann, 1830; *Eristalis maxima* Doleschall, 1857; *Axona volucelloides* Walker, 1864; *Eristalis volucelloides* Walker, 1864; *Eristalis kershawi* Ferguson, 1926.
Figure 3. Axona chalcopyga (Wiedemann, 1830), female, general habitus and wing. A. Dorsal view; B. Ventral view; C. Lateral view; D. Left wing.
Material examined. MALAYSIA – 1♀, Terengganu, Gelam forests, Terengganu districts, Peninsular Malaysia; 25-VI-2022, 4°52'44.9"N, 103°22'22.6"E; 1♀, 25-V-2023, 4°52'45.7"N 103°22'29.7"E; 1♀, 24-VIII-2023, 5°12'34.5"N, 103°11'47.3"E; leg.: M.I.I. Mamat, M.A.H. Ahmad Wizam. Sweep net, UMT.

Morphology. Body length: 20–23 mm (Figs 3, 5), Wing (Fig. 3D) length: 18 mm. Habitus: Large, strongly metallic fly, vivid blue reflections, blue head to abdomen and half-dark brown wings (Fig. 3A–C). Axona chalcopyga is a distinctive fly that is easily recognized by its impressive size and metallic blue whole body. Their large size typically measures 20–22 mm in body length. Adorning their unique yellow markings concentrated at the tips of the abdomen, which further enhances their visual appeal. Head: Eye black, frons blue with very short pile, parafacial with short silver pile, facial tubercle well developed, face at level of antennae narrower than an eye. Postpedicel predominantly black-grey, shorter than high, arista longer than the antenna, ocellar triangle black, slightly elevated and bare, occiput shiny blue with white hairs. Compound eyes separated (Fig. 4A–C). Thorax: Dark blue metallic, scutum shiny blue and seemingly bare, scutellum with very short pile. Proepimeron shiny blue. Legs metallic blue, pulvillus yellow (Fig. 4D–E). Wing: Strongly dark brown and black infuscated except posterior margin which is hyaline (Fig. 3D). Abdomen: Oval-shaped with 5 visible segments, entirely shiny; terga 1–3 vivid blue except posterior margin of tergum 3 orange, terga 4–5 orange with short sparse dark brown pile at the tip of abdomen; in dorsal view, wider than scutum at the maximum scutum width (Fig. 4F).

Ecology. Specimens have been collected within fragmented and intact Gelam forests, the biome highly dominated by Gelam trees (Melaleuca cajuputi).

Distribution. Australia, Indonesia, Malaysia (New record), Papua New Guinea, Solomon Islands and Singapore.

Remarks. Previous records from Singapore indicate A. chalcopyga visiting the big sage (Lantana camara) flower. Our observation in Malaysia documented its association with the Gelam (Melaleuca cajuputi) flower.

Figure 4. Axona chalcopyga (Wiedemann, 1830), female. A–C. Head. A. Frontal view; B. Lateral view; C. Dorsal view; D. Thorax, dorsal view; E. Scutellum, dorsal view; F. Abdomen, dorsal view.
DISCUSSION

Over the course of a year-long exploration in Gelam forests, we successfully captured three specimens of *A. chalcopyga* visiting *M. cajuputi* flowers. Gelam forest is a unique ecosystem with oligotrophic soil, low water retention, nutrient deficiency, high temperatures, and low humidity (Toriman et al. 2009; Arifin et al. 2016, 2017). Hitherto, the closest geographical distribution record of *A. chalcopyga* to Peninsular Malaysia was in Singapore, located in the south of the region. Due to its limited records, knowledge about this species is understudied across multiple dimensions, including distributional patterns, ecological roles, and its conservation status remains enigmatic. The occurrence of this species was also recorded from four sites in Papua New Guinea (GBIF, 2022), although no description of these habitats was available. This emphasised the gap in ecological knowledge for supporting the existence of *A. chalcopyga* in the tropical region.

This hoverfly exhibits a good mimicry of carpenter bees (*Xylocopa* spp. – Hymenoptera, Apidae) at first glance, aligning with a similar report wherein hoverfly species mimic wasps or bees (Ball & Morris, 2015). This mimicry phenomenon reflects the adaptive strategies of this hoverfly, enabling it to resemble other insects for various purposes. Additionally, the present study has shed light on the ecological role of *A. chalcopyga* as a flower-visiting insect in its natural habitat. This feeding behaviour inferred that the adult female sought nutritional properties (protein) from pollen, mainly for egg production. At the same time, nectar is a primary carbohydrate source for their short-term energy needs during peak activities such as flight, migration, mating, swarming, and oviposition (Haslett, 1989a, 1989b; Woodcock et al., 2014). These findings immediately uncover a new understanding of behavioural traits and interpretation of feeding in adult female *Axona*. This furthermore suggests that *A. chalcopyga* relies on *M. cajuputi* as one of their vital food sources in the Gelam forest habitat. Likewise, this feeding behaviour indicated that *A. chalcopyga* is a pollinator candidate for the Gelam trees. Urbanisation and development are among the major factors contributing to the degradation of
the Gelam forests in which landscapes being modified and other impediments may significantly affect the natural habitat of these hoverflies, which may be susceptible to the consequences of habitat fragmentation and land-use alterations (Samways, 1993). Moreover, poor forest practices further accelerate the risk of this species becoming threatened and endangered (Rotheray, 2012). Understanding the life cycle aspect and functional role of *A. chalcopyga* could impose key implications for the conservation and management dynamics of Gelam forest ecosystems in Terengganu.

In the present study, we unveil the East Coast of Peninsular Malaysia as a new geographical record for the occurrence of *A. chalcopyga*, as well as details of its habitat, and the cryptic behaviour of its adult female individuals, which indicate a mutualistic relationship with *M. cajuputi* trees. This metallic blue hoverfly is considered a rare species inhabiting the Gelam forests, highlighting the significance of Gelam forest biomes in Terengganu. Our findings expand the understanding of the biodiversity and ecology of the Gelam forests. The findings of this study also offer valuable insights and compelling evidence on the ecological role of *A. chalcopyga* as a pollinator. A more in-depth study on *A. chalcopyga* is recommended to comprehensively understand its life cycle, behaviour, and ecological roles, particularly in the Gelam forest. Finally, the present study identified a need for more research on hoverfly species in Malaysia, to enrich the knowledge for conservation practices towards the biotopes and BRIS ecosystem.

**AUTHOR’S CONTRIBUTION**

The authors confirm their contribution to the paper as follows: Conceptualisation: MIIM, WAA, NZM. Investigation MIIM & SB. Funding acquisition CMO, DMA. Methodology: MIIM, SB, MFS. Writing—original draft: MIIM. Writing—review and editing MIIM, SB, NZM, WAA. Supervision: NZM, WAA. The authors read and approved the final version of the manuscript.

**FUNDING**

This research received support from Universiti Malaysia Terengganu and WWF-Malaysia through a Private Partnership Research Grant (PPRG) (UMT/PPRG2022/VOT 55378).

**AVAILABILITY OF DATA AND MATERIAL**

The specimens listed in this study are deposited at the Insectarium of Universiti Malaysia Terengganu (UMT) and are available from the curator, upon request.

**ETHICS APPROVAL AND CONSENT TO PARTICIPATE**

This study only included plants and arthropod material, and all required ethical guidelines for the treatment and use of animals were strictly adhered to in accordance with international, national, and institutional regulations. No human participants were involved in any studies conducted by the authors for this article.

**CONSENT FOR PUBLICATION**

Not applicable.

**CONFLICT OF INTERESTS**

The authors declare that there is no conflict of interest regarding the publication of this paper.

**ACKNOWLEDGMENTS**

The research received financial support from the Private Partnership Research Grant (PPRG) (Vot. 55378), provided by Universiti Malaysia Terengganu (UMT) and the World Wildlife Fund Malaysia (WWF-Malaysia). Special thanks to Mr. Jeroen van Steenis (Syrphidae Foundation, the Netherlands) for his constructive comments on our manuscript; Dr. Ximo Mengual and Mr. Michael Knapp for their assistance in specimen identification. We also thank Mr. Idham Abd Aziz and Mr. Muhammad Adam Haziq Ahmad Wizam for their contributions to field sampling and specimen collection.
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Axona chalcopyga new to Malaysia


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| تاریخ دریافت: 28 اسفند 1402 | تاریخ پذیرش: 10 تیر 1403 | تاریخ انتشار: 31 تیر 1403 |

چکیده: اطلاعات موجود از ویژگی‌های اکولوژیک، دانه انتشار و امکان اجرای برنامه‌های حفاظتی از مگس آبی جواهرنشان، (1830) مالزی در جنگل‌های گلام ایالت ترنگانو کشی شده که اولین گزارش از حضور این حشره در شبه‌جزیره مالزی محصول می‌شود. توصیف خصوصیات مفلوپولیک به همراه تصاویر حشره در این مقاله ارائه شد.

بعلایون، نشان دهنده این مگس به عنوان عامل بالقوه گردیده‌اند درختان گلام ناشی از فعالیت آن رو گل‌ها این گیاه مورد توجه قرار گرفت.

واژگان کلیدی: زیست‌بوم، BRIS، درخت کچوپوتو، بادیکتندی گل‌ها، گلام، مگس‌های گل‌گرد، آکوپی‌ها