J. Insect Biodivers. Syst. 10 (4), 725–735 https://jibs.modares.ac.ir

OPEN ACCESS

Tarbiat Modares University Press | **Short paper** | https://doi.org/10.61186/jibs.10.4.725 | **ISSN**: 2423-8112
Entomological Society of Iran | Faunistic | https://zoobank.org/urn:lsid:zoobank.org:D1838992-6733-439B-AF5E-09C4FBD942D9

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

Muhammad Izzelen Izzauddin Mamat
Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus. Terengganu, Malaysia.
✉ *izzelenizz96@gmail.com* https://orcid.org/0009-0005-9668-9918

Sander Bot
Kerklaan 30E, 9751 NN Haren, the Netherlands.
✉ *botsander@gmail.com* https://orcid.org/0000-0002-5504-4559

Muhammad Fatihah Syafiq
Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia, Terengganu, 21200 Kuala Nerus, Terengganu, Malaysia.
✉ *syafiqrahman1805@gmail.com* https://orcid.org/0000-0002-1185-3653

Chik Maslinda Omar
WWF-Malaysia, Setiu Wetlands Field Office, Lot 10575, Tanah Lot Kampung Pagar Besi, 21020 Kuala Nerus, Terengganu, Malaysia.
✉ *comar@wwf.org.my* https://orcid.org/0009-0007-0466-8541

Daria Mathew Abdullah
WWF-Malaysia, Setiu Wetlands Field Office, Lot 10575, Tanah Lot Kampung Pagar Besi, 21020 Kuala Nerus, Terengganu, Malaysia.
✉ *dmathew@wwf.org.my* https://orcid.org/0009-0000-3170-9803

Mohamed Nor Zalipah
Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus. Terengganu, Malaysia.
✉ *zalipah@umt.edu.my* https://orcid.org/0000-0003-3459-0910

Wahizatul Afzan Azmi
Faculty of Science and Marine Environment, Universiti Malaysia Terengganu, 21030 Kuala Nerus. Terengganu, Malaysia [1]; *Institute of Tropical Biodiversity and Sustainable Development, Universiti Malaysia, Terengganu, 21200 Kuala Nerus, Terengganu, Malaysia* [2].
✉ *wahizatul@umt.edu.my* https://orcid.org/0000-0003-2713-815X

Received:
18 March, 2024
Accepted:
30 June, 2024
Published:
21 July, 2024
Subject Editor:
Behnam Motamedinia

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

Citation: Mamat, M.I.I., Bot, S., Syafiq, M.F., Omar, C.M., Abdullah, D.M., Nor Zalipah, M. & Azmi, W.A. (2024) The metallic blue fly, *Axona chalcopyga* (Wiedemann, 1830) (Diptera: Syrphidae) in Gelam Forests, new to Malaysia. *Journal of Insect Biodiversity and Systematics*, 10 (4), 725–735.

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

Corresponding author: Wahizatul Afzan Azmi ✉ *wahizatul@umt.edu.my*
Copyright © 2024, Mamat et al. This is an open access article distributed under the terms of the Creative Commons NonCommercial Attribution License (CC BY NC 4.0), which permits Share - copy and redistribute the material in any medium or format, and Adapt - remix, transform, and build upon the material, under the Attribution-NonCommercial terms.

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), Actinoptergii (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), *Syzgium 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.

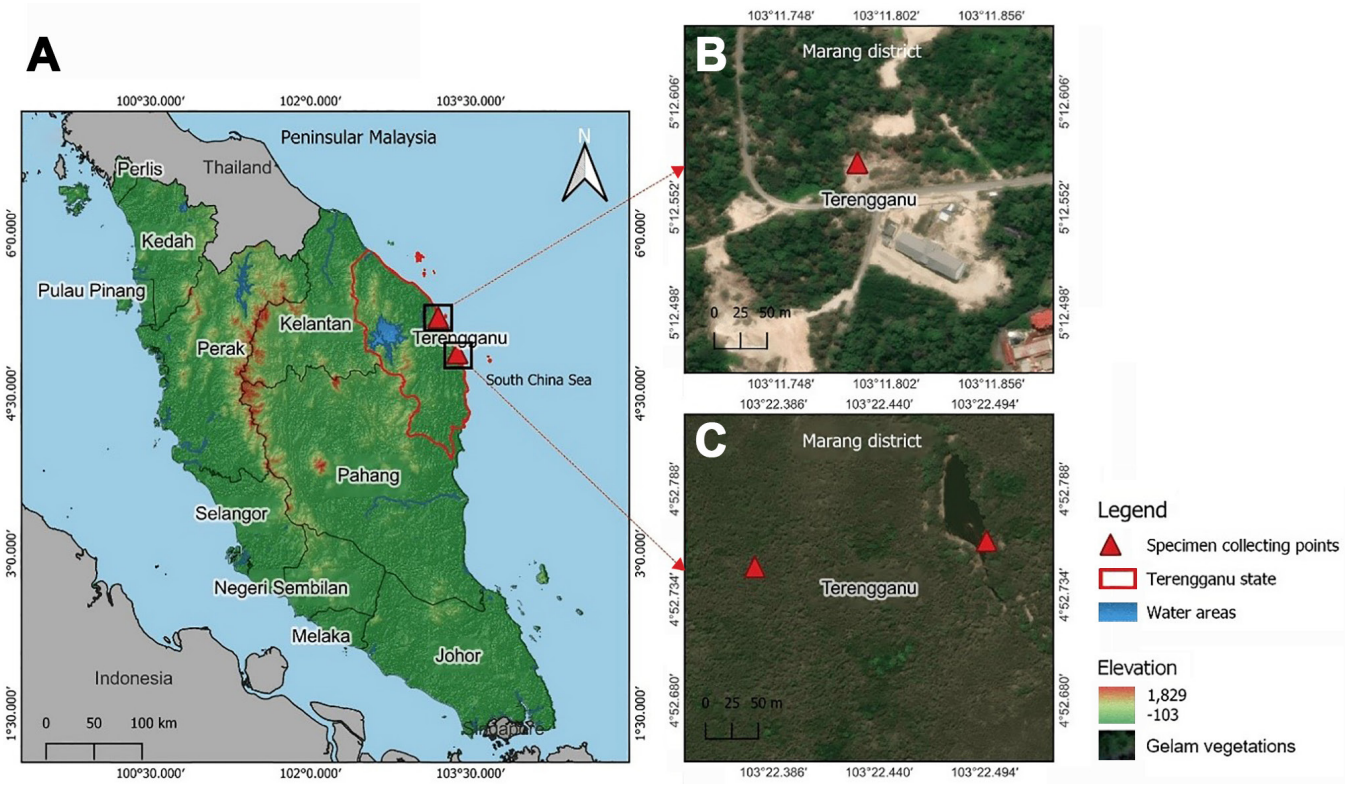

Figure 1. Map of collecting points of specimens from Gelam forests in Terengganu of Peninsular Malaysia. **A.** Peninsular Malaysia; **B.** Bukit Mawi, Kampung Kijing; **C.** Jambu Bongkok Forest Reserve (JBFR).

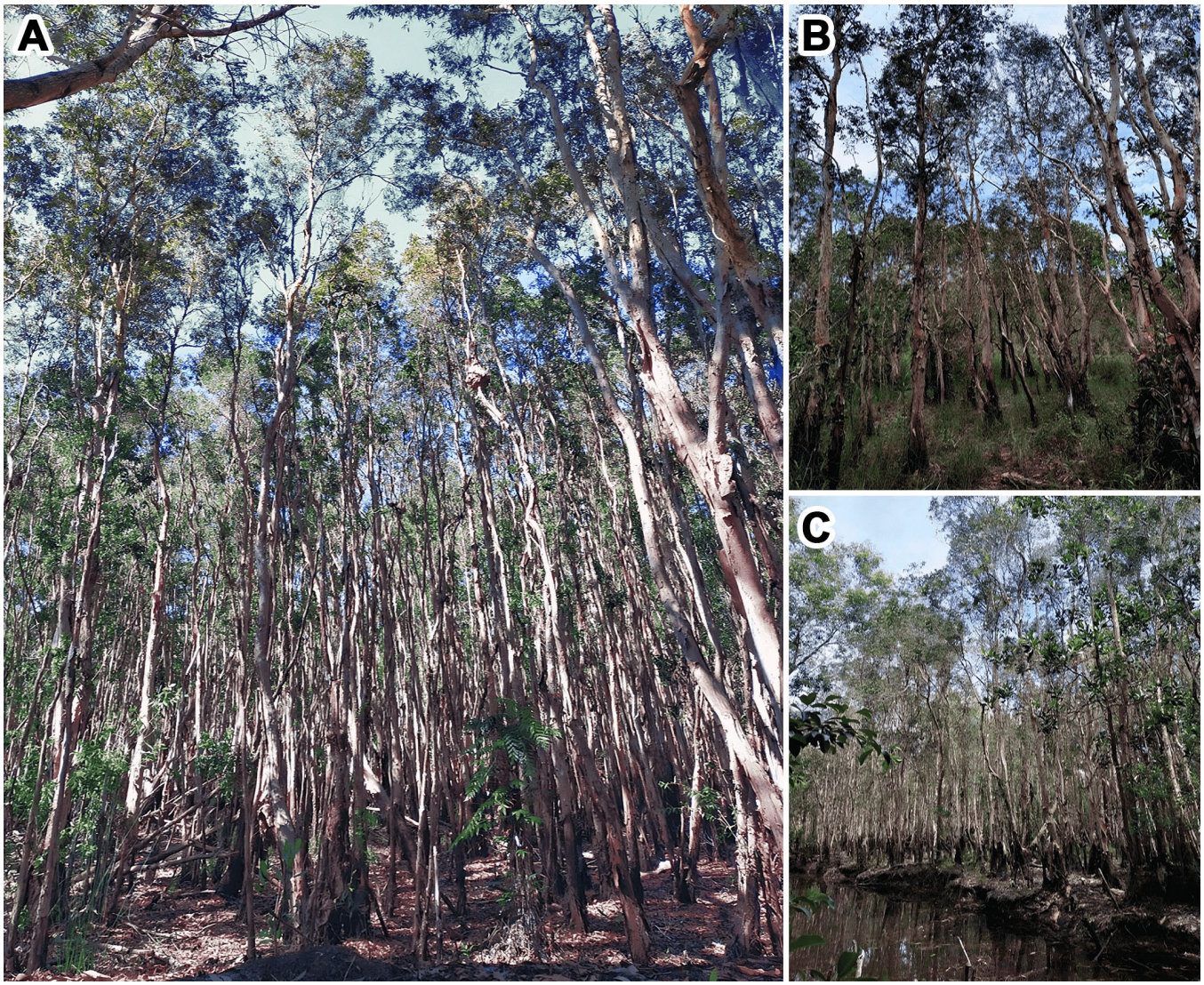

Figure 2. The Gelam forest from Terengganu, Malaysia. **A–B.** Gelam forest dry; **C.** Gelam forest swamp.

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.

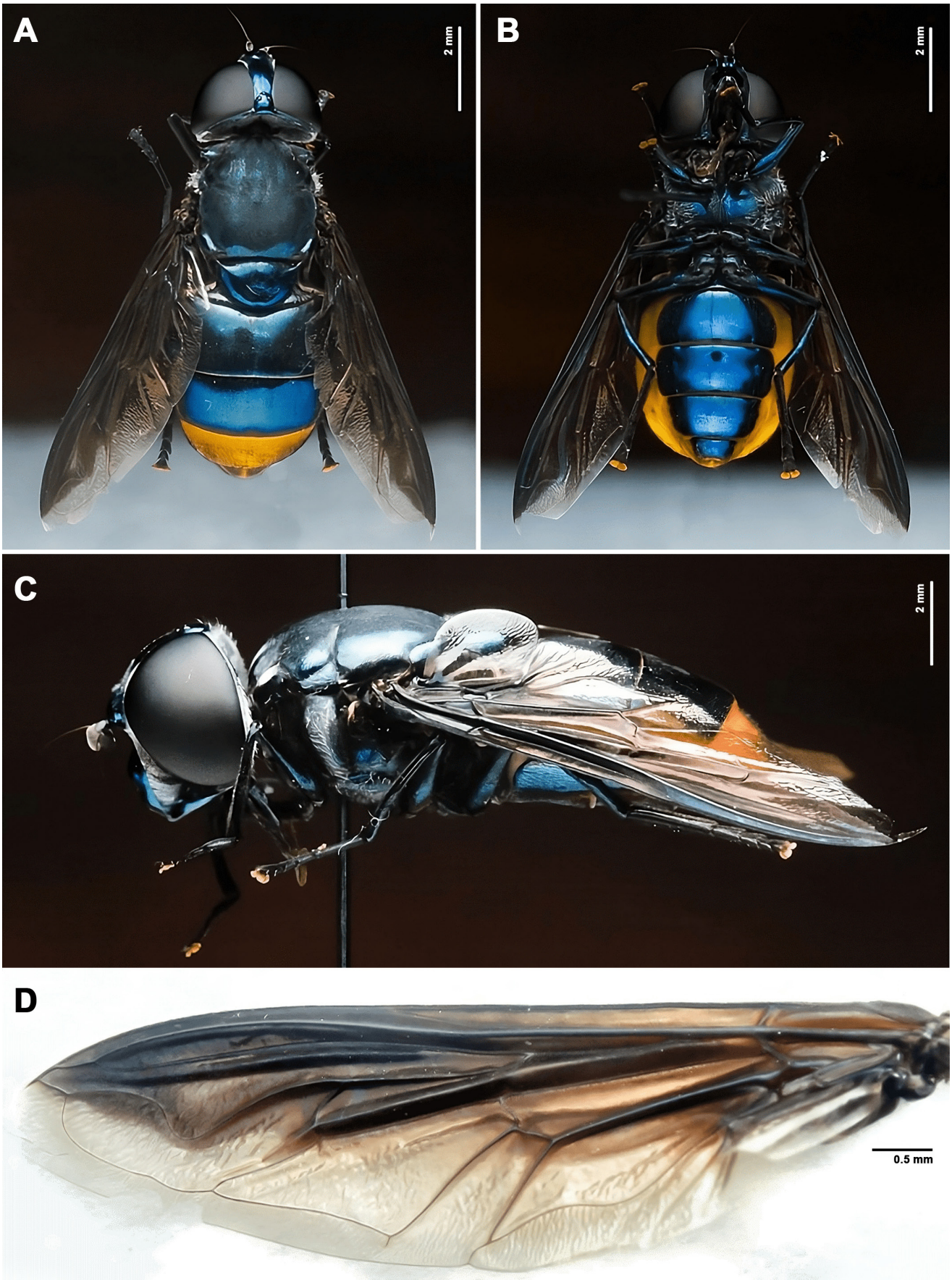

Figure 3. *Axona chalcopyga* (Wiedemann, 1830), female, general habitus and wing. **A.** Dorsal view; **B.** Ventral view; **C.** Lateral view; **D.** Left wing.

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.

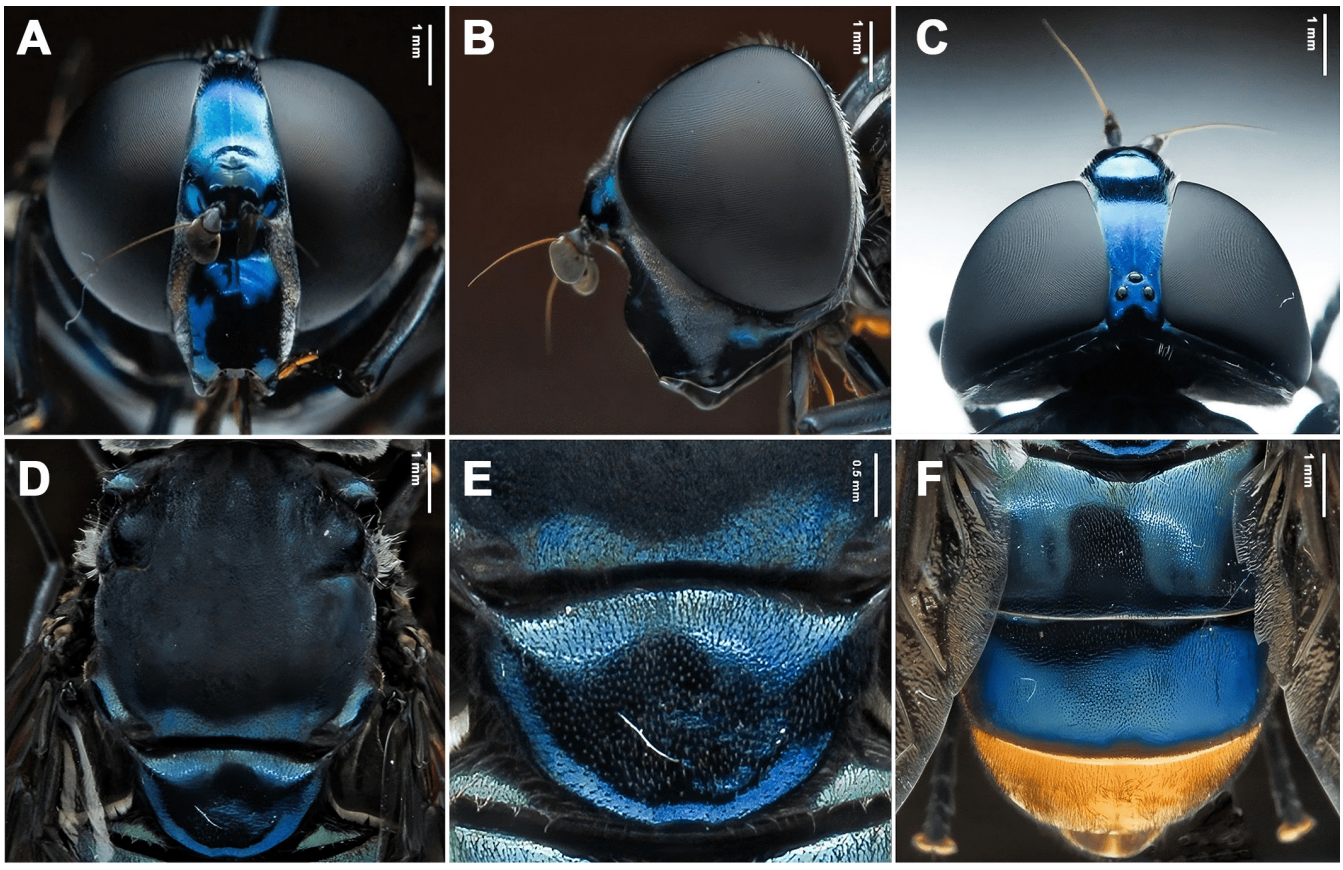

Figure 4. *Axona chalcopyga* (Wiedemann, 1830), female. **A–C.** Head. **A.** Frontal view; **B.** Lateral view; **C.** Dorsal view; **D.** Thorax, dorsal view; E. Scutellum, dorsal view; **F.** Abdomen, dorsal view.

Figure 5. *Axona chalcopyga* (Wiedemann, 1830), female. Visiting the flowers of Gelam (*Melaleuca cajuputi*) on 24 August 2023 (Photograph by M.I.I. Mamat).

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.

REFERENCES

Arifin, Y.F., Hamidah, S. & Arifin, Y.F. (2016) Ecological analysis of Gelam (*Melaleuca cajuputi*) on peatland in South Kalimantan. *Journal of Tropical Silviculture*, 7 (3), 77–79. https://doi.org/10.29244/j-siltrop.7.3.S77-S79

Arifin, Y.F., Hamidah, S. & Arifin, Y.F. (2017) Site analysis and conservation of Gelam (*Melaleuca cajuputi*) on peat swamp forest in South Kalimantan, Indonesia. *Journal of Biological Science*, 3 (3), 23–31. https://doi.org/10.53555/bs.v3i3.1579

Ball, S. & Morris, R. (2015) *Britain's Hoverflies: A field guide*. 2nd edition. Princeton University Press, UK. 312 p.

Bramasta, D., Qayim, I., Djuita, N.R., Raffiudin, R., Putra, R.E., Soesilohadi, R.H. & Purnobasuki, H. (2023) Melissopalynology and vegetation analysis surrounding Sunggau of giant honey bee *Apis dorsata* in Belitung Regency. *HAYATI Journal of Biosciences*, 30 (6), 1167–1174. https://doi.org/10.4308/hjb.30.6.1167-1174

Campoy, A., Pérez-Bañón, C., Aznar,D., and Rojo. (2020) Description of the Preimaginal Stages of the Golden Native Dronefly from Australia, *Eristalinus punctulatus* (Macquart, 1847) (Diptera: Syrphidae). *Austral Entomology*, 59 (4), 784–793. https://doi.org/10.1111/aen.12497

Doyle, T. Hawkes W.L.S., Massy, R., Powney, G.D., Menz, M.H.M. & Wotton, K.R. (2020) Pollination by hoverfies in the Anthropocene. *Proceedings of the Royal Society B, Biological Sciences*, 27 (287), 20200508. https://doi.org/10.1098/rspb.2020.0508

Dumbardon-Martial E. (2016) Pollen feeding in the larva of *Toxomerus pulchellus* (Diptera, Syrphidae). *Bulletin de la Société entomologique de France*, 121 (4), 413–420. https://doi.org/10.3406/bsef.2016.2778

Dunn, L., Lequerica M., Reid, C.R. & Latty, T. (2020) Dual ecosystem services of syrphid flies (Diptera: Syrphidae). Pollinators and biological control agents. *Pest Management Science*, 76 (6), 1973–1979. https://doi.org/10.1002/ps.5807

FAO (2017) Food and Agriculture Organisation of the United Nations - FAOSTAT. Available from: http://www.fao.org/faostat/en/#data. [Accessed 20th January 2024].

GBIF (2022) *Axona chalcopyga* (Wiedemann, 1830). Checklist dataset. Available from: https://www.gbif.org/occurrence/search?taxon_key=5070605 [Accessed 25th July 2023]

Haslett, J.R. (1989a) Adult feeding by holometabolous insects: pollen and nectar as complementary nutrient sources for *Rhingia campestris* (Diptera: Syrphidae). *Oecologia*, 81 (3), 361–363. https://doi.org/10.1007/BF00377084

Haslett, J.R. (1989b) Interpreting patterns of resource utilization: randomness and selectivity in pollen feeding by adult hover flies. *Oecologia*, 78 (4), 433–442. https://doi.org/10.1007/BF00378732

Ibrahim, I.F., Balasundram, S.K, Abdullah, N.A.P., Alias, M.S. & Mardan, M. (2012) Morphological characterization of pollen collected by *Apis dorsata* from a tropical rainforest. *International Journal of Botany*, 8 (3), 96–106. https://doi.org/10.3923/ijb.2012.96.106

Li, H., Wyckhuys, K.A. & Wu, K. (2023) Hoverflies provide pollination and biological pest control in greenhouse-grown horticultural crops. *Frontiers in Plant Science*, 14, 1118388. https://doi.org/10.3389/fpls.2023.1118388

Lucas, A., Bull, J.C., De Vere, N., Neyland, P.J. & Forman, D.W. (2017) Flower resource and land management drives hoverfly communities and bee abundance in seminatural and agricultural grasslands. *Ecology and Evolution*, 7 (19), 8073–8086. https://doi.org/10.1002/ece3.3303

Mamat, M.I.I., Khamis, S., Fuaad, M.F.L., Mohamed, N.Z., Omar, C.M., Abdullah, D.M. & Azmi, W.A. (2023) Pollen sources foraged by domesticated stingless bee (*Heterotrigona Itama*) reared in Gelam Forests of Terengganu, Malaysia. *Serangga,* 28 (2), 120–138.

Marshall, S.A. (2012) *Flies: The Natural History and Diversity of Diptera*. Firefly Books, New York. USA. 616 pp.

Miličić, M., Popov, S., Jurca, T., Cardoso, P., Janković M., Ačanski, J. & Vujić, A. (2021) Functional groups of hoverflies in Southeast Europe across different vegetation types. *Entomological Science,* 24 (3), 235–246. https://doi.org/10.1111/ens.12477

Mohd Salim, J. & Mohamad, F. (2011) *A Biological Assessment of Jambu Bongkok Forest Reserve, Terengganu and Nearby Ecosystem*. Penerbit Universiti Malaysia Terengganu. Malaysia, Terengganu. 84 p.

Mohd Salim, J., Husni, U., Hanani, N., Junaidi, A., Lammu, R. & Salam, M. (2013) Natural vegetation of BRIS soil ecosystem on coastal dune of Terengganu. In: Editor, E. (ed) *Seminar Kebangsaan Pemuliharaan Hutan Pesisir Pantai Negara*, 11–13 June 2013. Universiti Malaysia Terengganu, Kuala Lumpur, 10 (2), 3695–8727. https://doi.org/10.13140/2.1.3695.8727

Mohd Salim, J., Nur Faiezah, A.G., Siti Kehirah, A., Siti Mariam, M.N. & Razali, M.S. (2014) Woody plants on

`dune landscape of Terengganu, Peninsular Malaysia. *Journal of Tropical Forest Science,* 26 (2), 267–274.

Moquet, L., Laurent, E., Bacchetta, R. & Jacquemart, A.L. (2017) Conservation of hoverflies (Diptera, Syrphidae) Requires Complementary Resources at the Landscape and Local Scales. *Insect Conservation and Diversity*, 11 (1), 72–87. https://doi.org/10.1111/icad.12245

Morales, M.N. (2011) *Filogenia da tribo Eristalini (Diptera, Syrphidae, Eristalinae) Inferida por Caracteres Morfologicos*. PhD Dissertation, Federal University of Paraná. 90 p.

Nicholas, S., Thyselius, M., Holden, M. & Nordström, K. (2018) Rearing and long-term maintenance of *Eristalis tenax* hoverflies for research studies. *Journal of Visualized Experiments,* 135, e57711. https://doi.org/10.3791/5771

Omar, H., Misman, M.A. & Yaakub, S.Y. (2020) Vegetation Indices for Identifying Melaleuca forest from Multispectral Satellite Sensors. *10th IGRSM International Conference and Exhibition on Geospatial & Remote Sensing*, 20–21 October 2020, Kuala Lumpur, Malaysia, p. 540.

Rader, R., Cunningham, S.A., Howlett, B.G. & Inouye, D.W. (2020) Non-bee insects as visitors and pollinators of crops: biology, ecology and management. *Annual Review of Entomology,* 65 (2020), 391–407. https://doi.org/10.1146/annurev-ento-011019-025055.

Rotheray, E.L. (2012) *The Ecology and Conservation of Endangered Saproxylic Hoverflies (Diptera, Syrphidae) in Scotland*. PhD Dissertation, The University of Stirling, Scotland. 289 p.

Samways, M.J. (1993) Insects in biodiversity conservation: some perspectives and directives. *Biodiversity and Conservation,* 2, 258–282. https://doi.org/10.1007/BF00056672

Skevington, J.H., Locke, M.M., Young, A.D., Moran, K., Crins, W.J. & Marshall, S.A. (2019) *Field guide to the flower flies (hover flies) of northeastern North America*. Princeton University Press. New Jersey, USA. 512 p.

Thompson, F.C., Mengual, X., Young, A.D. & Skevington, J.H. (2017) Flower flies (Diptera: Syrphidae) of Philippines, Solomon Islands, Wallacea and New Guinea. *Biodiversity, biogeography and nature conservation in Wallacea and New Guinea*, 3, 501–524.

Toriman, M.E., Mokhtar, M. & Abd Aziz, N.A. (2009) Analysis of the physical characteristics of Bris soil in coastal Kuala Kemaman, Terengganu. *Research Journal of Earth Sciences*, 1 (1), 1–6.

Van Steenis, J., Miranda, G.F., Tot, T., Mengual, X. & Skevington, J.H. (2023) Glossary of morphological terminology of adult Syrphidae (Diptera): An update and extension. *Journal Van Syrphidae*, 2 (4), 1–99.

Wojciechowicz-Żytko, E. & Jankowska, B. (2017) Herbs as a source of nutrition for flower-visiting hoverflies (Diptera, Syrphidae). *Folia Horticulturae*, 29 (2), 135–141. https://doi.org/10.1515/fhort-2017-0013

Woodcock, T.S., Larson, B.M., Kevan, P.G., Inouye, D.W. & Lunau, K. (2014) Flies and flowers II: floral attractants and rewards. *Journal of Pollination Ecology*, 12 (8), 63–94. https://doi.org/10.26786/1920-7603(2014)5

کشف مگس آبی جواهرنشان، *Axona chalcopyga* (Wiedemann, 1830) (Diptera: Syrphidae) در جنگل گلام، گزارش جدید برای مالزی

محمد ایزالن ایزاودین مامات[۱]، ساندر بات[۲]، محمد فتیحا شفیق[۳]، چیک ماسلیندا عمر[۴]، دریا متیو عبدالله[۴]، محمد نـور زالیپـا[۱]، واحیزاتول افزان عظمی[۱،۳*]

۱ دانشکده علوم و محیط دریایی، دانشگاه ترنگانو مالزی، ۲۱۰۳۰ کوالا نروس. ترنگانو، مالزی.
۲ کرکلان ۳۰، ۹۷۵۱ هارن، هلند.
۳ مؤسسه تنوع زیستی استوایی و توسعه پایدار، دانشگاه ترنگانو، کوالا نروس، ترنگانو، مالزی
۴ گروه حمایت مالی حیات وحش مالزی، دفتر تالاب‌های ساحلی ستیو، کوالا نروس، ترنگانو، مالزی.

* پست الکترونیک نویسنده مسئول مکـاتبه: *wahizatul@umt.edu.my*

| **تاریخ دریـافت:** ۲۸ اسفند ۱۴۰۲ | **تاریخ پذیرش:** ۱۰ تیر ۱۴۰۳ | **تاریخ انتشار:** ۳۱ تیر ۱۴۰۳ |

چکیـده: اطلاعات موجود از ویژگی‌های اکولوژیک، دامنهٔ انتشار و امکان اجرای برنامه‌های حفاظتی از مگس آبی‌جواهرنشان، *Axona chalcopyga* (Wiedemann, 1839)، به دلیل بررسی‌های اندک، بسیار محدود است. سه نمونهٔ ماده از مگس *A. chalcopyga* در جنگل‌های گلام ایالت ترنگانو کشف شد که اولین گزارش از حضور این حشره در شبه‌جزیرهٔ مالزی محسوب می‌شود. توصیف خصوصیات مرفولوژیک به همراه تصاویر حشره در این مقاله ارایه شد. به‌علاوه، نقش عملکردی این مگس به عنوان عامل بالقوه گرده‌افشانی درختان گلام ناشی از فعالیت آن رو گل‌های این گیاه مورد توجه قرار گرفت.

واژگـان کلیدی: زیست‌بوم BRIS، درخت کچوپوت، بازدیدکننده گل‌ها، گلام، مگس‌های گل، گرده‌افشان