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The re-discovery in Sumatra of a rarely seen moth, *Heterosphecia tawonoides*, and its identification using citizen science platform iNaturalist

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ABSTRACT

Traditional methods of species identification involve the collection and killing of specimens. The associated costs and expertise required are prohibitory. In this paper we describe the first documented record of *Heterosphecia tawonoides* in its natural habitat in Sumatra since 1887, reporting its identification using photographs uploaded to the citizen science platform iNaturalist. Our findings add valuable information to the small body of work on this species and demonstrate the importance of having freely available high-quality tools such as iNaturalist without which this important record would not have been reported and the observation of this rarely seen moth species in Sumatra would have remained unknown.

ABSTRAK

Metode identifikasi spesies tradisional melibatkan pengumpulan dan pembunuhan spesimen. Biaya terkait dan keahlian yang dibutuhkan adalah berupa larangan. Dalam artikel ini kami menjelaskan catatan pertama yang terdokumentasikan dari *Heterosphecia tawonoides* di habitat alaminya di Sumatera sejak 1887, melaporkan identifikasinya menggunakan foto yang diunggah ke platform ilmiah iNaturalist. Temuan kami menambah informasi berharga untuk sejumlah kecil pekerjaan pada spesies ini dan menunjukkan pentingnya memiliki alat berkualitas tinggi yang tersedia secara gratis seperti iNaturalist, tanpanya catatan penting ini tidak akan dilaporkan dan pengamatan spesies ngengat yang jarang terlihat ini di Sumatera akan tetap tidak diketahui.

Keywords: *biodiversity, citizen science, iNaturalist, rediscovery, species identificationt*

INTRODUCTION

Biodiversity is in crisis with estimates that over 1 million plant and animal species are threatened with extinction (Estrada et al., 2017). Accurate biological species identification is essential and can be used to inform the management and conservation of biodiversity (Austen et al., 2016; Hope et al., 2018; Kürzel et al., 2022). Traditionally species have been identified by describing morphological traits from biological specimens collected in the field. Such 'voucher specimens' are a verifiable representative of a species, often used to describe new species and usually deposited in a curated collection typically of a museum or institution (Ajmal Ali et al., 2014; Turney et al., 2015). The necessity of killing specimens to study them is being called into question and is often subject to controversy (Minteer et al., 2014; Waeber et al., 2017). There are limitations associated with traditional species level identification methods: identification of insects is expensive, time consuming, requires expert knowledge, including of behavioural phenotypes and can be problematic due to the vast number of species (Valan et al., 2019).

Alternative methods of identification are available and include techniques such as DNA sequencing of biopsy or other samples, computer vision/machine learning and behavioural observations (Ajmal Ali et al., 2014; Perring et al 1993; Ronque et al 2016; Spiesman et al., 2021). Such methods might appear supplementary, as voucher specimen collection still seems to be the reference method and museum collections have been recently described as making innumerable contributions to science and society that save governments and taxpayers millions of dollars (Bakker et al., 2020; Suarez & Tsutsui, 2004; Turney et al., 2015).

Citizen science is increasingly used to contribute to scientific research and species identification with databases such as iNaturalist (www.inaturalist.org) and eBird (www.ebird.org) contributing massive amounts of biodiversity data that could not be sourced in any other way (Koch et al., 2022; Sun et al., 2021). iNaturalist, a joint initiative of the California Academy of Sciences and the National Geographic Society, is a freely available, online open access platform that allows users to upload biodiversity photographs, using machine learning methods to automatically suggest an identification which is then verified by community members (iNaturalist 2023 a). Importantly, submissions are curated using open

source software and submitted under a Creative Commons license allowing reuse of data (iNaturalist b, c 2022). As of 20th February 2023 iNaturalist has 127,247,966 observations, 415,739 species, 289,590 identifiers and 2,521,464 observers (iNaturalist 2022 d). The designation 'research grade' to an observation requires a photo, date, coordinates and agreement from the community on the taxon which results in high quality datasets (iNaturalist e 2022). As of 12th November 2022 the Global Biodiversity Information Facility website (www.GBIF.org) lists the iNaturalist dataset as having 53,049,459 research grade occurrences and 2,966 citations (GBIF 2022 a).

Clearwing moths (Lepidoptera: Sessidae) are known for their Batesian mimicry of Hymenoptera species and worldwide there are 160 genera with 1452 recognized species (Pühringer 2022). Tropical clearwing moths are rarely encountered in nature and little is known about their behaviour, distribution and ecology and photographic documentation is extremely uncommon (Gorbunov & Severtsov, 2015; M. Skowron Volponi, 2020). Heterosphecia is a genus of moths in the family Sesiidae found in Borneo, Sumatra and South India. There are eight known species with few records, and their conservation status is unknown (GBIF 2022 b; M. A. Skowron Volponi & Volponi, 2017). *Heterosphecia tawonoides* was first described in 2003 using a specimen collected from an unknown location in Sumatra in 1887 (Kallies, 2003). It was observed and filmed for the first time in its natural habitat in Malaysia 2013 exhibiting puddling behaviour and bee mimicry which are only possible to see on live specimens. (M. A. Skowron Volponi & Volponi, 2017).

In this paper we present the first documented record of *H. tawonoides* in its natural habitat in Sumatra since 1887, reporting its identification using iNaturalist.

METHODS

Observations of *H. tawonoides* were made near Bukit Lawang, North Sumatra on the 20th May 2015 and photographed using Canon EOS 2000d mounted with a 55-250 mm Canon lens. Observations were uploaded onto iNaturalist on 24th February 2022.

Study Area

Bukit Lawang is a tourist focused village located within the Langkat district of north Sumatra (03°32.770'N, 098°07.000'E) on the eastern edge of the Gunung Leuser National Park, adjacent to the Bohorok river. Orangutan are flagship species for conservation of their forest habitat and Bukit Lawang has a very long affiliation with orangutan tourism as well as its associated problems (Molyneaux et al., 2021; Walpole & Leader-Williams, 2002). Whilst Sumatra is a biodiversity hotspot and Bukit Lawang gives relatively easy access to a wide variety of habitats the tourism in this area is heavily reliant on orangutan and little attention is given to promoting awareness of any other species (Molyneaux 2022).

RESULT AND DISCUSSION

A single specimen of *H. tawonoides* was observed and photographed on the cement block path (Figure 1) of a remote house on the border of Gunung Leuser National Park close to the tourist village of Bukit Lawang. The path is next to an ornamental fish pool but over 100 m from the large, fast flowing Bohorok river. The surrounding habitat (Figure 2) is an overgrown mix of both primary and secondary forest and small scale rubber and palm oil plantations. 6 photographs (Figure 3 a-f) were taken between 13:30-13:35 on the 20th May 2015 and show the moth puddling on the edges of the cement block path.

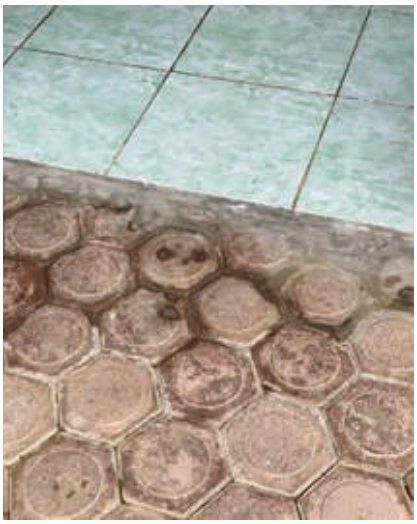

Figure 1. Cement block path of remote house near Bukit Lawang village.

Figure 2. Surrounding habitat of the remote house.

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The first 4 photographs (Figure 3 a-d) were uploaded onto iNaturalist on the 24th February 2022 (iNaturalist, 2022) and were submitted with a provisional identification of "genus Epicharis, apine bee". Over a period of several weeks community members suggested refinements of the identification arriving at the suggestion of *H. tawonoides* on 13th March 2022 which was confirmed by user @kallies (who first described the species in 2003) and by 5 other community members (Kallies, 2003; iNaturalist 2022 d). It is the first and currently the only recording of this species on iNaturalist and is a research grade observation. (see Table 1 Species identification sequence on iNaturalist). A comparison with the holotype (Kallies, 2003) and with descriptions of its observation in Malaysia (Skowron Volponi & Volponi, 2017) shows that our observation also has the novel morphological features only visible on a live specimen – blue wing sheen, blue and white hair like scales on all tibia, elongated white hair like scales on hind tibia. (see Table 2 Comparison of documented records of *H. tawonoides*).

Figure 3. a-f *H. tawonoides* observed and photographed on 20th May 2015 near Bukit Lawang village, North Sumatra, Indonesia.

Table 1. Species identification sequence on iNaturalist

Photographs uploaded on 24 /2 /2022	
24/02/2022	Genus Epicharis - a member of Apine Bees (**withdrawn**)
25/02/2022	Kupu-Kupu dan Ngengat - Order Lepidoptera
25/02/2022	Picture-winged Leaf Moths (**withdrawn**) - Superfamily Thyridoidea
27/02/2022	Clearwing Moths - Family Sesiidae
13/03/2022	Genus Heterosphecia -a member of Clearwing Moths -Family Sesiidae
Species identified and confirmed 13/3/2022	
Oriental Blue Clearwing *Heterosphecia tawonoides*	

Here we show that high quality photographic records can be used to identify a poorly known and rarely seen species of moth using iNaturalist in the field. Having access to a large network which included an 'expert enabled rapid identification of this species of moth that has not been recorded in Sumatra since 1887. Our findings represent the first ever record of observation of this species in its natural habitat in Sumatra and only the 3rd published record.

The traditional method of obtaining voucher specimens for species identification is subject to controversy with two recent examples relating to a non-endangered goliath bird eating spider and a rarely seen moustached kingfisher. Both species were collected during large biodiversity surveys and the spider was one of 857 voucher specimens!

Both instances received a lot of negative criticism prompting the collectors to publish detailed accounts of their reasons for collecting the specimens. (Naskrecki 2014; Boroff 2015; Filardi 2015; Silber 2015). Scientists have long been polarized about the use of voucher specimens (Funk et al., 2018; Marshall & Evenhuis, 2015) The suggestion that alternative methods of identification should be used in relation to threatened or rediscovered species (Minteer et al., 2014) proved controversial and elicited strong response in support of voucher specimens (Krell & Wheeler, 2014; Rocha et al., 2014). Digital photography, geolocation, open access databases and widespread internet access are enabling wider engagement with the process of collecting and curating primary biodiversity data and pushing access beyond that of professional academic researchers. Species ARE nowadays being identified without voucher specimens and it is recommended that traditional taxonomic scientists engage with this ever expanding network and community (Marshall, 2018; Marshall & Evenhuis, 2015; Wilson et al., 2020).

Table 2. Comparison of documented records of *H.tawonoides*

	Kallies 2003 (holotype)	Volponi 2017	This paper
Date of publication / uploading	2003	2017	24-2-2022
Date of specimen / observation	1887	2013, 2016, 2017	20-5-2015
Country	Sumatra	Malaysia	Sumatra
Habitat	not detailed	primary lowland forest	cement path next to primary/secondary rainforest
Stored location of specimen	Natural history museum, Vienna	British museum of natural history and private collection	n/a
Observed behaviour	not detailed	Mud-puddling on sandy/pebble river bank	puddling on a cement block path
Id methods	not detailed	Photo, pinned for morphological analysis, dissection of male genitalia, DNA barcoding	Photo, iNaturalist
Novel morphological observations	not detailed	strong blue sheen on wings	Yes
		characterisitic tufts of hair like scales on all tibia longest on hind legs, alternate shiny blue and white colouration	Yes
		strongly elongated, creamy white hair like scales of hind tibia extend interiorly over folded wings and abdomen in natural resting position	Yes
		resemblance to bees	Yes

With our account we show that it has not been necessary to kill and remove the specimen to a museum or collection to identify it. Our observations show the moth exhibiting puddling behaviour and displaying novel morphological features which are consistent with those described in the only other documented record of this species in its natural habitat (Skowron Volponi & Volponi, 2017). Sessiids have been noted to visit river banks, streams, puddles and wet soil remaining after drying out of flowing water (Gorbunov & Severtsov, 2015; Skowron Volponi, 2020, 2022). A potentially significant difference is that in our observations the moth was puddling on an artificial cement block path far from natural flowing water (but close to a small artificial fish pool) whereas Volponi (2017) documents *H. tawonoides* puddling on a leaf on the riverbank of a lowland dipterocarp forest.

Thus we add valuable information to the small body of work on this species and genus. We demonstrate the importance of having an open access database and vast community network as without it this important record would not have been reported and the observation of this rarely seen moth species in Sumatra would have remained unknown.

CONCLUSION

The debate around specimen collection will doubtless continue with strong ethical and conservation concerns being expressed and alternatives proposed (Russo et al 2017). Citizen scientist platforms such as iNaturalist continue to generate vast amounts of increasingly important data with significant contributions, such as rediscovery of species and previously undocumented behaviours, the value of which taxonomic science cannot ignore. (Callaghan et al 2022, Fraisl et al 2022). Citizen science plays a crucial part in species identification and the documentation of biodiversity (Koo et al., 2022; Mueller et al., 2019; Wilson et al., 2020).

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Implications for conservation

Information about the distribution of Lepidoptera in Indonesia and particularly Sumatra is limited (Iqbal et al., 2022). Whilst long term field studies and surveys for clearwing moths in this area may be desirable the funds and expertise to carry them out are scarce. Our rediscovery and documenting of a rarely seen moth species, *H. tawonoides*, using noninvasive, easily accessible and affordable yet high quality methods could be used to highlight the importance and conservation of its forest edge habitat. It could be used as an alternative flagship species, to promote biodiversity awareness in Bukit Lawang, an area that relies heavily on tourism focused around orangutan (Molyneaux 2022). We strongly encourage travelers, visitors, residents, scientists and naturalists to take photos of the wildlife they see and upload their observations to iNaturalist in order that biodiversity can be documented and the information accessible to all.

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