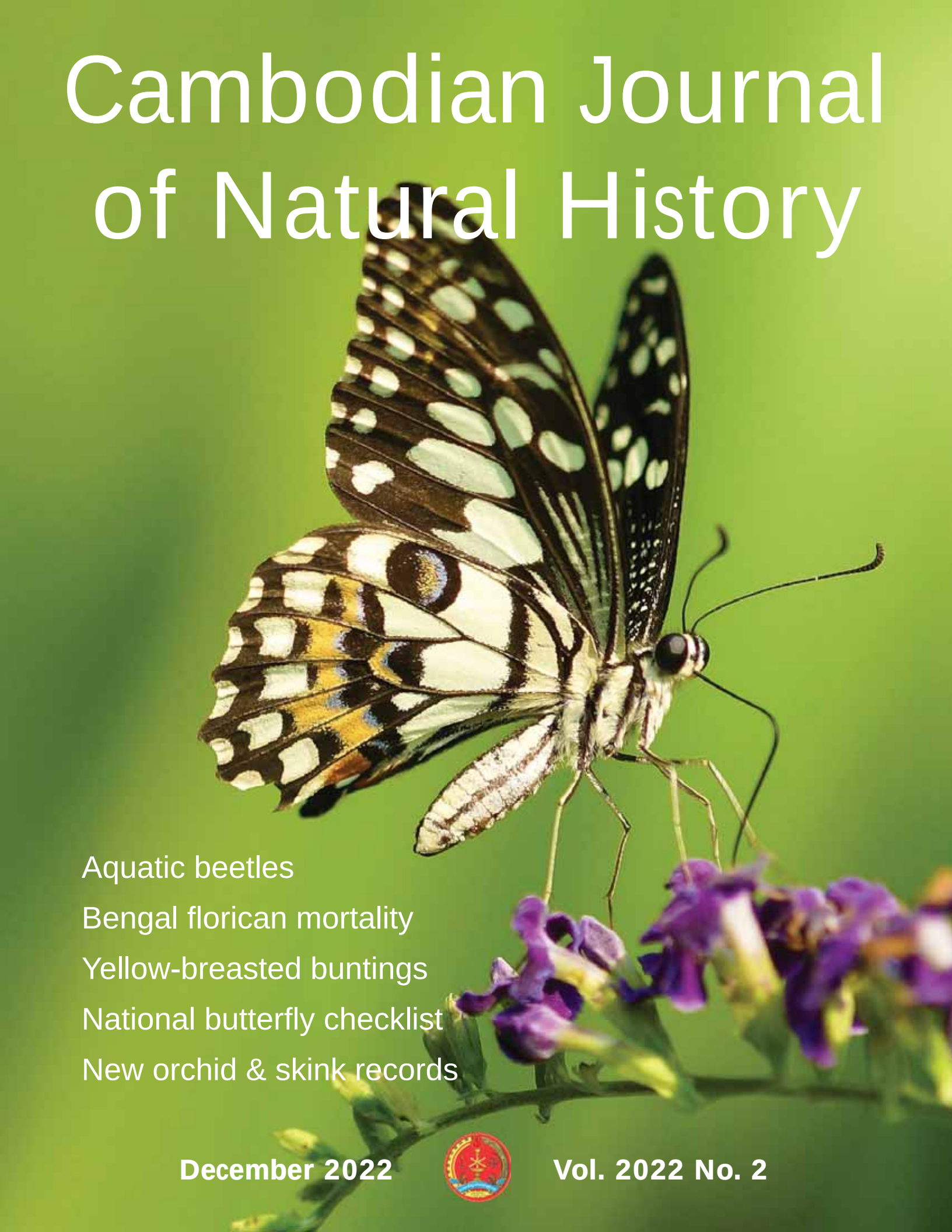
Cambodian Journal of Natural History



Aquatic beetles

Bengal florican mortality

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National butterfly checklist

New orchid & skink records

December 2022 **Vol. 2022 No. 2**

Cambodian Journal of Natural History

The *Cambodian Journal of Natural History* (ISSN 2226–969X) is an open access journal published by the Centre for Biodiversity Conservation, Royal University of Phnom Penh. The Centre for Biodiversity Conservation is a non-profit making unit dedicated to training Cambodian biologists and to the study and conservation of Cambodian biodiversity.

Cover image: *Papilio demoleus malayanus* Wallace, 1865, Siem Reap Province, April 2016 (photograph by Eddie Smith). An annotated checklist of butterfly species in Cambodia is provided by Chartier & Kosterin on pp. 99–126 of this volume.

News

Phnom Tamao Zoological Garden, Protected Forest and Botanical Garden established in Takeo, Cambodia, permanently protecting its forest and wildlife

In 1995, the Cambodian Ministry of Agriculture, Forestry and Fisheries (MAFF) established the Phnom Tamao Zoological Park and Wildlife Rescue Centre (PTWRC) in Takeo Province under the management of the Forestry Administration (FA) (MAFF, 2022). FA partnered with Wildlife Alliance (WA) in 2001, a collaboration which led to significant improvements to "the quality of animal care and staff capacity" and successful breeding of many threatened native species (MAFF & WA, 2019). In the decades since, hundreds of rehabilitated wild animals have been released into the forest surrounding the PTWRC (WA & FA, unpubl. data, 2022).

In early 2022, areas of forest surrounding the PTWRC were re-allocated for development, igniting much public debate and concern. European Space Agency Sentinel Satellite images taken on 29 July showed no forest clearance, but on 3 August when the satellite next passed, 130 ha had been deforested (Keat, 2022), as shown in widely circulated images. Ultimately, 500+ ha of forest was cleared (Flynn & Vutha, 2022).

Citing "a lot of requests to the Royal Government to keep the forest around Phnom Tamao zoo," the government wisely decided to conserve Phnom Tamao instead. On 7 August, Prime Minister H.E. Samdech Hun Sen declared in a popular Facebook post (with >230,000 likes) that all development permits for Phnom Tamao were cancelled, that companies involved in clearing must replant, and that the remaining forest should be protected (Hun, 2022). On 19 August, Cambodian King Norodom Sihamoni signed Royal Decree NS/RKT/0822/1008 creating the Phnom Tamao Zoological Garden, Protected Forest and Botanical Garden. According to this decree, the new protected area covers 2,025 ha which is divided into three zones: 1) Protected Forest for Wildlife Rehabilitation for "enrichment and conservation of wildlife and sustainable development of natural resources" (1,021 ha); 2) Phnom Tamao Luxury Tree Botanical Garden zone for "tree sapling care and botanical garden development" (530 ha); 3) Phnom Tamao Zoological Garden for "wildlife care, rescue, education, and tourism" (474 ha) (RGC, 2022).

Elisabeth D. GISH, NETH Vibol & Nick MARX, Wildlife Alliance, Phnom Penh, Cambodia. Email: gish@wildlifealliance.org

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Short Communication

First records of *Lygosoma haroldyoungi* (Taylor, 1962) from Cambodia with notes on its locomotion behaviour

Peter GEISSLER[1,*], Balázs FARKAS[2], SAMORN Vireak[3], NANTHAWICHIANRIT Nila[4], CHEA Samban[5] & NEANG Thy[3]

[1] Museum Natur und Mensch, Gerberau 32, D-79098 Freiburg, Germany.

[2] Bercsényi u. 21, H-2464 Gyúró, Hungary.

[3] Wild Earth Allies, 77a, Street Betong, Bayap Village, Sangkat Phnom Penh Thmei, Khan Sen Sok, Phnom Penh, Cambodia.

[4] Sambour village, Sambour commune, Siem Reap Province, Cambodia.

[5] Fauna in Focus, Sambour village, Sambour commune, Siem Reap Province, Cambodia.

* Corresponding author. Email pgeissler84@yahoo.de

Paper submitted 12 July 2022, revised manuscript accepted 14 October 2022.

Though *Lygosoma haroldyoungi* has been known to science for over 60 years (Taylor, 1962), the number of verified records and voucher specimens has remained very limited until now. This has led to a poor understanding of the actual distribution and general biology of the species and its primarily sub-fossorial life mode might be the major factor for that (Grossmann, 2012; Miller & Zug, 2016). Though the species is known to occur in a wide range of habitats, including dipterocarp forests and agricultural lands, any encounter with a *L. haroldyoungi* seems to be a rather unusual event, even for local people or farmers. One such rare finding of a "Naga with legs" in Laos was reported in an ethnozoological remark by Geissler *et al*. (2011). Currently the species is only known to occur in Thailand and Laos. The latest compilation of published distribution records (Taylor, 1962; Soderberg, 1967; Way, 1975; Nabhitabhata *et al*., 2004; Moravec & Böhme, 2008; Teynié & David, 2010; Orlov *et al*., 2010; Grossmann, 2012) was collated (Fig. 1) by Chuaynkern *et al*. (2013). Due to the proximity of some records to the borders of Myanmar and Cambodia, as well as the wide habitat range of *L. haroldyoungi*, its occurrence in both countries was suspected (Pauwels *et al*., 2008; Das, 2010; Miller & Zug, 2016). Subsequently, Miller & Zug (2016) found a partly digested *Lygosoma* in the stomach of a *Psammodynastes pulverulentus* from Kachin State in Myanmar, which they hesitantly referred to *L. haroldyoungi*. However, some differences in pholidosis and the poor state of preservation made the determination at species level preliminary.

In 2020 and 2022, a total of four specimens of *L. haroldyoungi* were found at two localities in central and northern Cambodia (Fig. 1). These represent the first country records of the species in Cambodia and extend its known range about 350 km towards the southeast. The first specimen was found on 22 July 2020 by an anonymous person in Siem Reap, Siem Reap Province. A photograph of this specimen (Fig. 2) was sent to Neang Thy for identification. The three other specimens were found by Nanthawichianrit Nila on 13 June 2022 near Alon Veng in Kulen Promtep Wildlife Sanctuary, Oddar Meanchey Province (Figs 2 & 3). Photographs and films (Figs 2 & 3) were subsequently posted in the group Natural Cambodia on Facebook for determination. Based on this material, we were able to identify all four specimens as *L. haroldyoungi* on account of their body shape and characteristic colour pattern. They match the holotype in the following diagnostic traits (Taylor, 1962; Grossmann, 2007; Geissler *et*

CITATION: Geissler, P., Farkas, B., Samorn V., Nanthawichianrit N., Chea S. & Neang T. (2022) First records of *Lygosoma haroldyoungi* (Taylor, 1962) from Cambodia with notes on its locomotion behaviour. *Cambodian Journal of Natural History*, **2022**, 74–77.

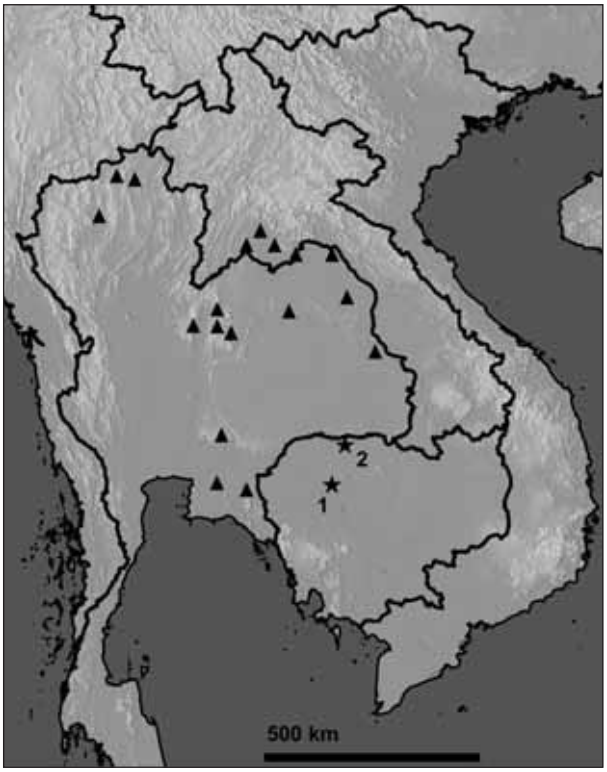

Fig. 1 Northern mainland Southeast Asia showing the known distribution records of *L. haroldyoungi*. Black triangles mark the published records in Thailand and Laos as compiled by Chuaynkern *et al*. (2013). Asterisk 1 marks the first Cambodian record from Siem Reap, Siem Reap Province. Asterisk 2 shows the second Cambodian record from Alon Veng within the Kulen Promtep Wildlife Sanctuary, Oddar Meanchey Province.

Fig. 2 Above: Specimen of *L. haroldyoungi* found during excavations on 22 July 2020 in Siem Reap, Siem Reap Province (© Anonymous). Below: Two specimens found on 13 June 2022 near Alon Veng in Kulen Promtep Wildlife Sanctuary, Oddar Meanchey Province (© Nila Nanthawichianrit).

al., 2011): body extremely elongated, snake-like; limbs short, pentadactyle (can be seen in the specimen in Fig. 2); dorsal surface of head dark brown, sharply bordered by the light dorsum colouration behind the parietals; ground colouration of dorsum light yellowish-brown (the specimen depicted in Fig. 2 shows a rather greyish-brown ground colouration); dorsum bearing dark brown or blackish crossbands which are narrowing towards the flanks, forming a reticulated pattern (in the specimen depicted in Fig. 2 the anterior crossbands are widely fused, forming an irregular paravertebral band on the anterior part of trunk); original parts of tail bearing dark brown crossbands, alternating with thin bands in grey, whitish or bluish colouration; regenerated parts of tail dark brown, scattered with irregular light spots. Interestingly, one specimen from Kulen Promtep Wildlife Sanctuary (the larger specimen depicted in Fig. 2) is bearing a completely original, not regenerated tail. All specimens known to science so far had partially regenerated tails (Grossmann, 2012). Though we do not have exact coordinates for the new localities, the highly disturbed microhabitats shown in Figs 2 & 3 as well as the circumstances of the observations support the assumption that *L. haroldyoungi* is able to survive in anthropogenically transformed habitats such as agricultural areas (Grossmann, 2012; Chuaynkern *et al*., 2013), and is by no means restricted to sub-montane forests, as stated by Chan-ard *et al*. (2015). One of the four reported Cambodian specimens was filmed in a sequence of about 30 seconds, providing a short insight into the various modes of locomotion employed by this skink (Fig. 3). Thus far, the locomotion of *L. haroldyoungi* was only observed in captivity and described by Grossmann (2012). He identified seven major ways of locomotion, of which four were observed in our filmed specimen. (1) Slow crawling: the skink moves in a sinuous movement, using all extremities for crawling; depending on the surface structure this

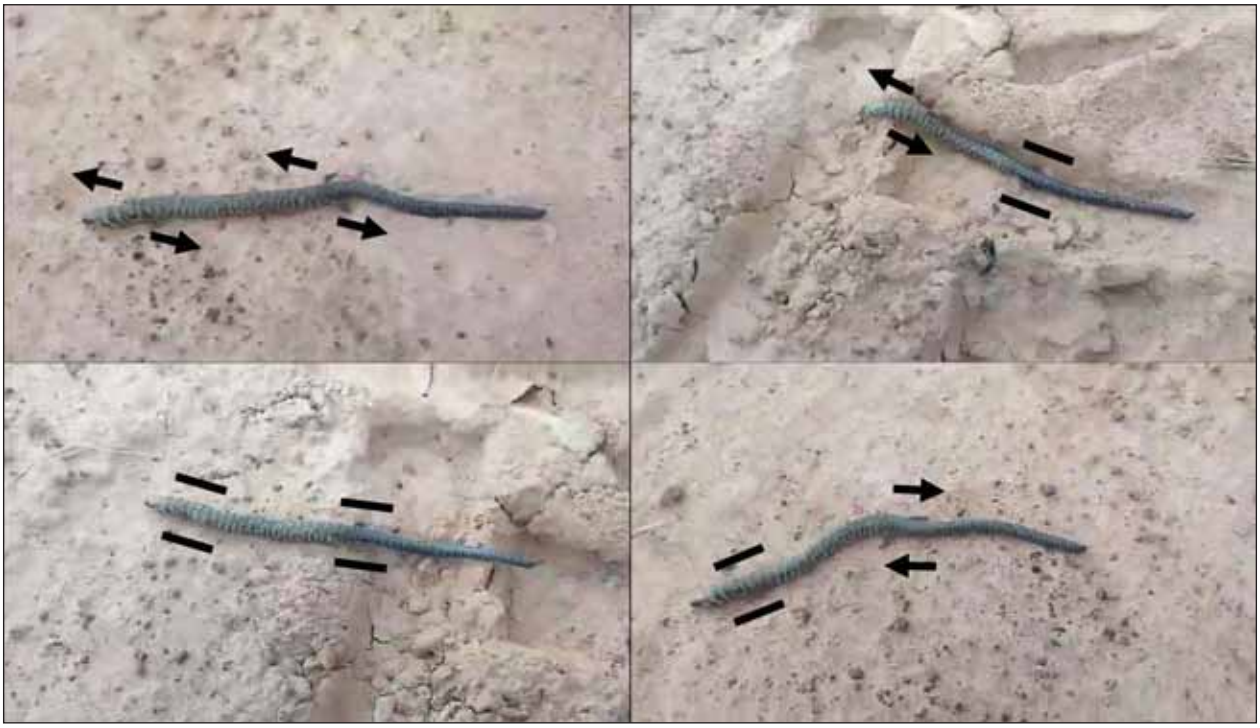

Fig. 3 Fixed images from a short film showing four different modes of locomotion (*sensu* Grossmann, 2012) observed in a fourth Cambodian specimen of *L. haroldyoungi,* found on 13 June 2022 near Alon Veng in Kulen Promtep Wildlife Sanctuary, Oddar Meanchey Province. Above-left: slow crawling; above-right: normal-speed crawling; below-left: speedy crawling; below-right: hindleg crawling. Arrows indicate the direction of move of each limb, while short lines indicate limbs adpressed to the body (© Nila Nanthawichianrit & Peter Geissler).

crawling also contains stages, in which the trunk is almost completely stretched out. (2) Normal-speed crawling: the sinuous movements are faster; forelegs are used for crawling while hindlegs are adpressed to the tail base; the skink actively uses the surface structure by pushing its body to the wheel imprint to thrust itself forward. (3) Speedy crawling: snake-like movement; all extremities adpressed to body and base of tail; the trunk may also be stretched out completely, while moving in this manner. (4) Hindleg crawling: forelegs are adpressed to trunk; hindlegs are used for crawling. The latter mode was also observed by Grossmann (2012), but only when his specimen was crawling through underground tunnels. All four modes are shown in Fig. 3.

The new records described above underline the value and importance of observations made by amateur naturalists and local people for a better understanding of biodiversity in Cambodia. Citizen science may not only contribute fundamental biological data for under-surveyed areas, but also represents a valuable starting point for wildlife conservation efforts.

Acknowledgements

We thank Piseth S. Sacca and an anonymous person from Siem Reap for providing valuable information and permission to use their photographs.

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Short Communication

Emerging evidence shows the global importance of the Boeung Prek Lapouv Protected Landscape, Cambodia for yellow-breasted buntings *Emberiza aureola*

LY Samphors[1], BUNNATH Zoe Sidana[1,*], YONG Ding Li[2], BOU Vorsak[1] & CHHEOUN Socheat[3]

[1] NatureLife Cambodia Organization-BirdLife in Cambodia, No. 32A, Street 494, Phsar Deurm Tkov, Chamkarmon, Phnom Penh, Cambodia.

[2] BirdLife International (Asia Division), Tanglin International Centre, Singapore.

[3] Department of Environment of Takeo Province, Snor Village, Rokaknong Commune, DounKeo Town, Takeo Province, Cambodia.

* Corresponding author. Email bunnath.zoesidana@gmail.com

Paper submitted 29 December 2021, revised manuscript accepted 14 October 2022.

The yellow-breasted bunting *Emberiza aureola* is a globally threatened migratory passerine that winters widely across southern China and continental Southeast Asia, west to northeast India, Nepal, and Bangladesh (Davaasuren *et al*., 2019; BirdLife International, 2021; Heim *et al*., 2021). The species used to be one of the commonest birds in Eurasia, being described by some authors as 'superabundant' (e.g., Kamp *et al*., 2015), and has a wide Palaearctic breeding distribution stretching from Fennoscandia to eastern Russia and Japan (Dementiev & Gladkov, 1951–1954; McClure, 1974; Beerman *et al*., 2021; BirdLife International, 2021). However, the global population of yellow-breasted bunting has suffered a major decline due to unsustainable levels of hunting for human consumption, and potential habitat loss and degradation (McClure & Chaiyaphun, 1971; Kamp *et al*., 2015; Heim *et al*., 2021). An estimated two million individuals were taken for food and merit release in Thailand in one year alone in the 1970s (McClure, 1974), and comparably large numbers from Cambodia in the 2000s (Gilbert *et al*., 2012). Large numbers are also reported to be trapped for consumption in China (Chan, 2004) and large seizures of the species remain regular (Heim *et al*., 2021).

Since the 1990s, global populations of yellow-breasted buntings have declined by almost 90% while the breeding range has contracted eastward (Kamp *et al*., 2015), with declines reported from Russia, Japan, and Korea (Tamada *et al*., 2014, 2017) and at stopover localities in South Korea (Choi *et al*., 2020; Park *et al*., 2020; Heim *et al*., 2021). The species was uplisted to Critically Endangered in 2017 (BirdLife International, 2021). Despite a good understanding of the extent of its breeding range, the wintering distribution of the species remains poorly defined and new sites are continually being discovered, including in Thailand, Myanmar and Cambodia (Chan & Li, 2017; BANCA, 2019), as well as eastern India (Viswanathan, unpubl.data, 2021).

In Cambodia, yellow-breasted buntings occur as a regular winter visitors and have been recorded from November to May (Thomas & Poole, 2003; Goes, 2013; Chan & Li, 2017; CBGA, 2019; SVCT, 2021), although the species may arrive earlier based on observations from Laos and Vietnam (Duckworth, unpubl. data, 2022). Several parts of Cambodia are known to include wintering sites for yellow-breasted buntings, especially in the Tonle Sap floodplain and in the Eastern Plains along the lower Mekong floodplains (Thomas & Poole, 2003; Goes, 2013), and these may form important wintering sites for the species in Southeast Asia given the large numbers counted, and the presence of relatively intact floodplain wetlands. Where found, the species typically occurs in flocks from tens to several

CITATION: Ly S., Bunnath Z.S., Yong D.L., Bou V. & Chheoun S. (2022) Emerging evidence shows the global importance of the Boeung Prek Lapouv Protected Landscape, Cambodia for yellow-breasted buntings *Emberiza aureola*. *Cambodian Journal of Natural History*, **2022**, 78–83.

hundred individuals in recent years, although larger congregations were documented in the past in Lao PDR (Duckworth, unpubl. data, 2022). For example, an estimated 250 individuals were recorded in Kratie Marsh in 2016–2017 (BICP, 2019), 300 individuals were observed at the Stoung-Chikreng Bengal Florican Conservation Area and 300 were found at Bakan Grassland in 2019 (BICP, 2019). Counts exceeding a thousand were also reported from Krous Krom and Prey Veng during the early 2000s (Thomas & Poole, 2003; Goes, 2013). In southeast Cambodia on the lower Mekong floodplains, the species had only been recorded sporadically in the wetlands of the Boeung Prek Lapouv Protected Landscape (BPL; 10°43′N, 105°01′E; Fig. 1), which was based on incidental observations of small groups of 4–13 individuals in 2015 and 2016 (BICP, unpubl. data, 2020), with none thereafter. To date, there have been no targeted surveys of the species at this site despite apparently suitable wintering habitats in the form of reedbeds, grassland and associated scrubby vegetation. As with other parts of Southeast Asia and southern China (Lekagul & Round, 1991; Viney *et al*., 1996; Round, 2008), the known wintering habitat of the species in Cambodia largely occurs in cultivated areas such as rice fields and natural grasslands, and the species is known to use scrubby margins of paddy fields for foraging, and dense reedbeds, grassland and associated scrub for roosting (Lekagul & Round, 1991; Round, 2008; BirdLife International, 2021).

The extensive floodplain grasslands in BPL provide habitat for several bird species dependent on seasonal freshwater wetlands and the site is one of few remaining areas of natural grassland in the upper Mekong Delta that support large numbers of the sarus crane *A. antigone sharpii* annually during their non-breeding season, alongside other waterbird species such as the greater adjutant *Leptotilos dubius* and lesser adjutant *L. javanicus* (Yav, 2014; Seng *et al*., 2015; Tran *et al*., 2020). The wetlands also provide habitat for several threatened and near-threatened migratory birds during the northern winter months (Sep–Mar) including yellow-breasted bunting and black-tailed godwit *Limosa limosa* (BICP, unpubl. data, 2020), and support high levels of biodiversity. Here, we report the results of fieldwork in BPL in 2020–2021 and present new records of wintering yellow-breasted bunting at the site which covers ca. 8,035 ha and was established as a protected area under the category of 'Protected Landscape' by the Royal Government of Cambodia in 2016.

Given the tendency of yellow-breasted buntings to flock in their wintering grounds, counts at roosting sites are preferred for surveying the species rather than standardised transects, and these have been conducted

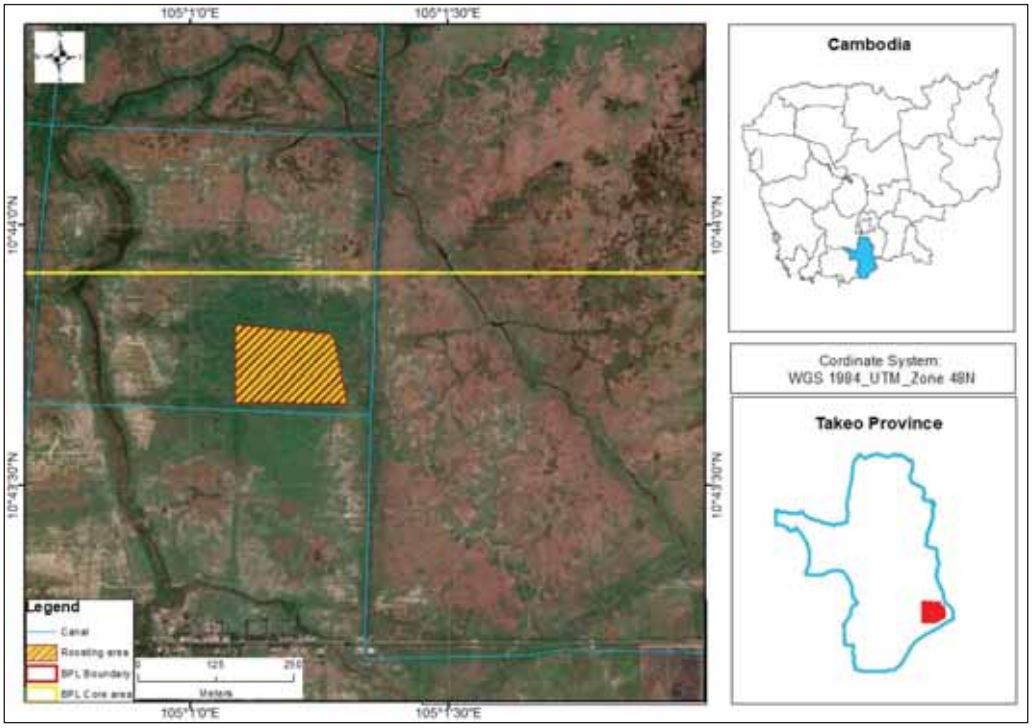

Fig. 1 Roosting area of yellow-breasted buntings in the Boeung Prek Lapouv Protected Landscape.

Fig. 2 Area of dense grasses and reeds identified as one of the main roosting sites of the yellow-breasted bunting in the Boeung Prek Lapouv Protected Landscape.

Fig. 3 Adult male yellow-breasted bunting in the Boeung Prek Lapouv Protected Landscape.

Fig. 4 Group of yellow-breasted buntings in dense grasses at the roosting site in the Boeung Prek Lapouv Protected Landscape.

in other parts of its range (e.g., Nepal, see Bhusal *et al*., 2020). We identified the roosting site for our surveys (Fig. 1) based on incidental observations of the species during regular fieldwork targeting sarus cranes. The crane surveys comprise point counts and transect surveys and are typically carried out by a team of five rangers and NatureLife staff based in BPL. One known area of BPL covered with dense reedbeds and other grasses where the buntings were observed in the past was surveyed for sarus cranes from November to December 2020 during our regular crane census. These surveys first recorded the buntings on 30 December 2020 during fieldwork along 1 km transects that traverse the roost area. Thereafter, we formed two survey teams and gathered at the roost site (Fig. 2) where we counted the birds as they returned to roost. One team counted the flocks of buntings that flew in to roost whereas the second team counted the birds present in the roost (in tall grass, reeds and sedges). We separately used a camera to collect photographs (Figs 3 & 4) to verify our identifications and numbers of birds present in the flocks of buntings. We then carried out monthly checks of this roost area to better understand the movement of birds within the landscape and determine if the buntings changed their roosting sites, as well as to check for disturbance or hunting activity. Additionally, we also checked similar areas of grass and scrub and areas near the BPL ranger station, although none contained any buntings.

Yellow-breasted buntings have been regularly observed by the rangers and monitoring team members since November 2021 through point surveys at the site where the species was seen the previous winter. While conducting the crane census, the first record of a roosting group involved 20 individuals on 30 December 2020, and the species was sporadically observed on a few more occasions. Subsequently, we monitored the roosting site once each week to see if there were changes in the number of buntings using it, and to assess the quality of the roosting habitat. We found that the counts of roosting buntings increased daily during the first quarter of 2021, reached a maximum count of ca. 2,780 individuals on 21 March 2021 (Table 1) and declined thereafter. Towards the end of April 2021, only one to four individuals were recorded during incidental visits to the roost, and no further visits were made to check the site.

We consistently detected yellow-breasted buntings in the BPL from December 2020 to April 2021 but did not

Table 1 Estimated counts of yellow-breasted buntings in Boeung Prek Lapouv Protected Landscape based on monthly visits from 30 December 2020 to 29 April 2021.

Date	Counter Location	Estimated Count	Habitat Type	No. of Counters
30 December 2020	Canal 86	20	Roosting (Tall grass)	3
30 January 2021	Canal 86	500	Roosting (Tall grass)	3
31 January 2021	Canal 86 / 03	4	Roosting (Tall grass)	2
05 February 2021	Canal 87 / 03	800	Roosting (Tall grass)	2
05 March 2021	Canal 86	1,200	Roosting (Tall grass)	5
21 March 2021	Canal 86	2,870	Roosting (Tall grass)	4
19 April 2021	Canal 86	100	Roosting (Tall grass)	2
27 April 2021	In front of HQ	4	Sighting (50 m from rice field)	3
29 April 2021	In front of HQ	1	Sighting (50 m from rice field)	2

find any individuals thereafter (Table 1). We are unsure what drives the large increases in buntings from January to March but it could be that birds are displaced from surrounding areas (including areas of farmland) due to disturbance, potentially in combination with birds congregating prior to migration (from March onwards). Our surveys recorded a maximum count of 2,780 individuals in March 2021, the highest count of the species from Cambodia in recent years (higher counts were reported by Goes (2013) from other sites), which possibly involved congregations of birds prior to spring migration. Our findings suggest that BPL is potentially important as a wintering site for yellow-breasted buntings and that it is particularly important as a site where the species aggregates in high densities when the landscape is at its driest during the wintering period. Further surveys should aim to establish the presence of the species more widely within BPL throughout the period when it is present, as well as in adjacent areas of farmland, to better understand its wintering ecology and spatial requirements.

The Palaearctic-breeding yellow-breasted bunting is known to use various stopover sites in eastern China and the Yangtze Valley before continuing on its migration to wintering sites in southern China and Southeast Asia (Heim *et al*., 2020; BirdLife International, 2021). There is limited documentation for the species in Cambodia, although high counts of several thousand individuals were reported at Krous Krom by Goes (2013) and survey work targeting the species since 2012 has been conducted by agencies such as the Ministry of Environment's Department of Freshwater and Wetland Conservation (Ministry of Environment, unpubl. data, 2019). Hence, our results provide insights that contribute to a better understanding of the status, distribution and wintering ecology of the species in Cambodia.

As one of few remaining areas of relatively undisturbed, seasonally inundated grasslands in the Lower Mekong floodplain in Cambodia, BPL has high priority for biodiversity conservation, especially for bird species dependent on grasslands, reedbeds and associated wetland vegetation, even though much of its landscapes remain little surveyed for wintering passerines. The wetlands also support the livelihoods of local communities through their diverse ecosystem services (Van Zalinge *et al*., 2013). For instance, BPL yields wetland resources such as fish, edible plants, firewood, grass (for grazing) and water that support 19 village communities in and around the protected landscape and are estimated to be worth a total net value of USD 2,168,019 per year (Ly *et al*., 2017). There is a need for further work to better assess the diversity of migratory bird communities in BPL, especially wintering passerines (e.g., reed warblers, grasshopper warblers, chats) which are poorly studied in mainland Southeast Asia (e.g. Yamaura *et al*., 2017), and to better understand the importance of the wetlands for species associated with open country such as the yellow-breasted buntings, so as to guide their management.

Our study provides the first baseline information on the status of the yellow-breasted bunting in the BPL. The next step for our work on the species is to conduct regular counts in the winter months of 2022–2023 to monitor population trends, find new roosts elsewhere in BPL, and better assess the size of the wintering population in the landscape. Protecting the core habitat of the buntings from disturbance and fires (i.e. stands of *Saccharum spontaneum* and the reed *Phragmites vallatoria*) and maintaining areas of adjacent scrubby, dry paddy

fields that are not intensively cropped is important and should be considered in the future management of the landscape for this and other wintering passerine species such as warblers, wagtails and chats.

There is limited information on the wintering ecology of yellow-breasted buntings in Cambodia, with very few records since 2002 (Goes, 2013; BICP, 2019). Most records from Southeast Asia stem from incidental observations. Counts at sites with large aggregations in Thailand, at Nong Pla Lai and Bueng Kalo for example, as well as in Vietnam (Nguyen, unpubl. data, 2022; North Thailand Birding, 2020) typically do not exceed several hundred individuals. Our maximum count of 2,780 individuals in March 2021 is the highest count of the species in this poorly-surveyed site to date and suggests how little the species is known in Cambodia. Our observations show that the wetlands of BPL may form an important aggregation (and major wintering) site for yellow-breasted buntings late in the dry season prior to their northbound migrations, and may represent one of the largest known congregations of the species in mainland Southeast Asia at present. Conservation of the habitats used by the buntings will require efforts to better manage the remaining areas of floodplain wetlands, alongside efforts to scale-up law enforcement, whilst working with local farmers to promote sustainable agriculture practices.

Acknowledgements

The authors are very grateful to Will Duckworth and Yu Yat-tung for helping to improve our manuscript. We also thank Nguyen Quang Hao and Ashwin Viswanathan for recent information on the species from Vietnam and India, and are indebted to Lim Varth (vice-director of BPL) and other members of the survey team including the rangers and monitoring team in BPL for supporting our work.

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Short Communication

A new power transmission line causes significant mortality in the largest remaining population of Critically Endangered Bengal floricans *Houbaropsis bengalensis* in Cambodia

Simon P. MAHOOD[1,*], SUM Phearun[1], HONG Chamnan[2], SON Virak[2], Gneb GNUEN[1], LY Reang[1] & Robert TIZARD[1]

[1] Wildlife Conservation Society, Cambodia Program, No. 21, Street 21, Sangkat Tonle Bassac, Phnom Penh, Cambodia, 120101.

[2] Department of Freshwater Wetlands Conservation, General Department of Administration for Nature Conservation and Protection, Ministry of Environment, No. 48, Samdech Preah Sihanouk Boulevard, Sangkat Tonle Bassac, Phnom Penh, Cambodia, 120101.

* Corresponding author. Email smahood@wcs.org

Paper submitted 28 April 2022, revised manuscript accepted 21 November 2022.

Over the last decade Cambodia has witnessed a rapid expansion of its power transmission line network. This has been driven by rapid economic development and increasing energy demands for manufacturing and residential areas. Power transmission and distribution lines have been found to kill birds in all countries where their impacts have been studied (e.g., Jenkins *et al*., 2010). For instance, in the United States, it has been estimated that between 8 million and 57 million birds are killed by power lines annually (Loss *et al*., 2014). Typically, birds are killed not by electrocution, but because they fly into the wires at high speed, causing trauma and broken bones (Loss *et al*., 2014). Bird species differ in their susceptibility to collisions with power lines in predictable ways. The risk of collisions is higher for species whose eyes are aligned such that they have a narrow field of view when looking forwards, because they cannot see the power lines when they are flying directly towards them until they are very close to the lines (Martin & Shaw, 2010). The risk of collision is higher in fast-flying birds with heavy bodies because they cannot manoeuvre easily to avoid the lines, which is a particular problem if they do not see the power line until they are very close (Bevanger, 1998). Bustards, a family of 26 Eastern Hemisphere bird species, possess a combination of physical characteristics that makes them the most vulnerable group to power line collisions (Martin & Shaw, 2010). Elevated mortality due to collisions with power lines has caused population level declines in some bustard species (Shaw *et al*., 2017).

Bustards are represented in Cambodia by one species, the Bengal florican *Houbaropsis bengalensis* (Goes, 2013). This species is Critically Endangered, with a global population of less than 500 individuals (BirdLife International, 2022). The global population of the Southeast Asian subspecies *H. b. blandini* is now restricted to the Tonle Sap floodplain, where displaying males have declined from 416 (95% CI: 333–502) in 2007 to 216 (95% CI: 156–275) in 2012 and 104 (95% CI: 89–117) in 2018 (Gray *et al*., 2009; Packman *et al*., 2013; Mahood *et al*., 2019). These declines have been caused by the almost complete conversion of grassland in the Tonle Sap floodplain to irrigated dry-season rice (Mahood *et al*., 2020), an agricultural land-use that is incompatible with the breeding ecology of Bengal floricans (Ibbett *et al*., 2019), and to a lesser extent small-scale hunting. Since 2018, Bengal floricans are thought to breed only in four sites in the Tonle Sap Floodplain, with the Stoung-Chikreang sector of the Northern Tonle Sap Protected Landscape (NTSPL) accounting for half

CITATION: Mahood, S.P., Sum P., Hong C., Son V., Gnuen, G., Ly R. & Tizard, R. (2022) A new power transmission line causes significant mortality in the largest remaining population of Critically Endangered Bengal floricans *Houbaropsis bengalensis* in Cambodia. *Cambodian Journal of Natural History*, **2022**, 84–89.

of all remaining birds, and the only stable population (Mahood *et al*., 2019).

In 2019, a new threat to Cambodia's Bengal floricans emerged in the form of a 350 km power transmission line that was constructed from Kampong Cham to Battambang, along the northern edge of the Tonle Sap floodplain. A five-kilometre stretch of the power line runs through the northeast part of the Stoung-Chikreang sector of the NTSPL, which was completed in June 2019. Before the power line was constructed, it was predicted that this would likely cause elevated Bengal florican mortality, as well as mortality of other bird species (Mahood *et al*., 2016). These predictions were based on satellite telemetry data from 15 Bengal floricans that were satellite-tagged by the University of East Anglia in 2010 (Packman, 2011). These data showed that almost all of Cambodia's Bengal floricans must migrate over the power line twice each year when they move from their breeding to their non-breeding grounds, whilst those in the Stoung-Chikreang sector of the NTSPL were likely to cross it more frequently and would therefore be at greatest risk (Mahood *et al*., 2016).

To determine whether the power line causes Bengal florican mortality, we conducted weekly searches for carcasses underneath the stretch of the line that passes through the Stoung-Chikreang sector of the NTSPL. These began as soon as the power line was installed (June 2019) and have continued to the time of writing. The surveys are conducted by a team of four or five community members who have worked for the Wildlife Conservation Society Bengal florican project for many years and are familiar with the bird species of the area. Survey methodology follows standard protocols for assessing mortality of birds associated with power lines (e.g., Burnside *et al*., 2015). During each survey, the team arrange themselves approximately 15 m apart in a row under the power line at 13°00′50.8″N, 104°28′41.9″E and slowly walk for 4.5 km to 13°00′47.2″N, 104°28′54.6″E. During the survey they look carefully at the ground to search for bird carcasses.

The following data were recorded for each survey: site name, observer name, time start, time end and date of survey. These data are recorded whether or not any carcasses are found on the survey. For each carcass found, the following data were recorded: date, time found, name of finder, GPS location, location name, English name of species (where known), Khmer name of species, estimated cause of death, and distance from the carcass to the power line. A new survey sheet is used for each survey irrespective of whether any carcasses are found. All carcasses found were photographed so that species identifications could be verified. Carcasses found were not removed but based on photographs of these it is not thought that any carcasses remained from one week to the next. A total of 111 power line surveys were undertaken between 23 June 2019 and 22 February 2022. These were typically conducted weekly, but no surveys were undertaken in March 2020 due to constraints caused by COVID-19 precautions, and no surveys were conducted from late October to mid-December 2020 because the survey area was under deep water.

A total of 140 bird carcasses constituting at least 30 species were recorded during the surveys (Annex 1). This should be considered a minimum estimate of the number of birds killed by the power line since it was installed. Of significant concern, mortalities included six Bengal floricans (Table 1). Carcasses of two globally Near Threatened species were also recorded comprising seven spot-billed pelicans *Pelecanus philippensis* and four painted storks *Mycteria leucocephala*. The most commonly recorded species included birds that are common in the local area, and species that are scarcer but more susceptible to power line collisions. It was not possible to definitively identify all species killed by the power transmission line, specifically accurate identification of all small birds of the order Passeriformes was not possible, so many of these

Table 1 Bengal florican carcasses recorded during surveys conducted between June 2019 and February 2022.

Date	Sex	Location Name	Coordinates
19 September 2019	F	Tom Neab Kork Touch	13°00'36.1"N, 104°29'50.8"E
5 February 2020	M	Tom Neab Kon Thnal	13°00'50.0"N, 104°29'03.7"E
12 August 2020	M	Tom Neab Kork Touch	13°00'23.4"N, 104°30'12.7"E
12 August 2020	M	Tom Neab Kork Touch	13°00'23.2"N, 104°30'12.2"E
2 March 2021	F	Tom Neab Kon Thnal	13°00'39.0"N, 104°29'21.8"E
25 August 2021	M	Tom Neab Kork	13°00'23.6"N, 104°30'12.9"E

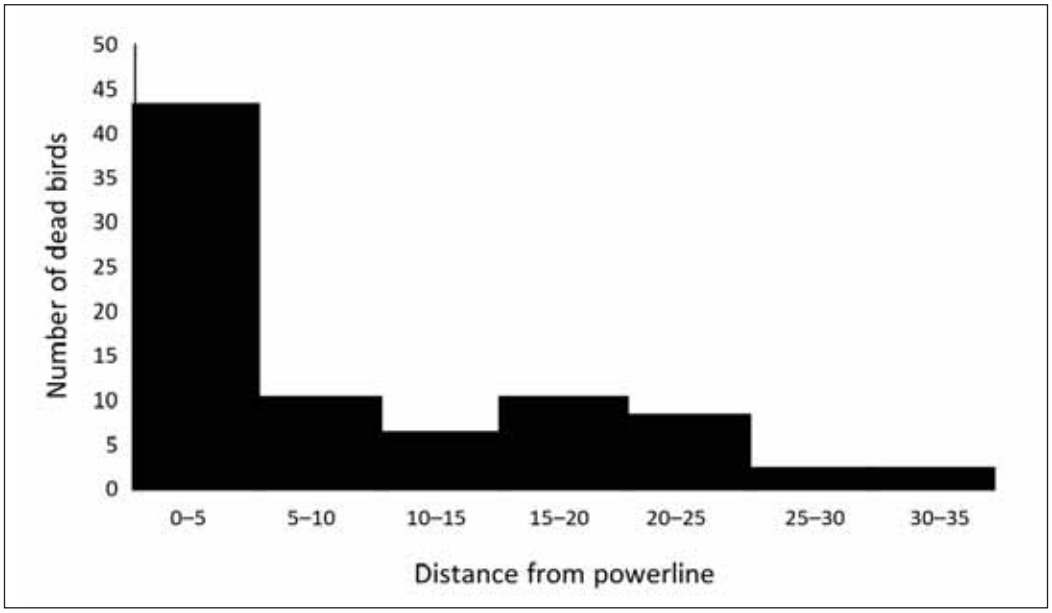

Fig. 1 Histogram showing distance (metres) of bird carcasses relative to the power line. Only species of a mass greater than 500g are included.

were recorded as Passerine sp. It is possible that some carcasses of birds that were killed by the power line were scavenged by free-ranging domestic dogs before the survey team conducted the weekly surveys. In addition, the survey team may not have found all the carcasses that were present at the time of the surveys.

It may be postulated that finding a bird carcass under a power line does not itself mean that the bird was killed by the power line. We tested this assumption by analysing the distance that carcasses were found from the power line. More birds were found closer to the power line than further from it, indicating a strong positive influence of the power line on the distribution of bird carcasses in the landscape (Fig. 1). However, owing to our search method we were unable to account for crippling bias, whereby estimates of power line mortalities are under-estimated because birds collide with a power line and continue flying in an injured state, dying tens or hundreds of meters from it. Estimates of crippling mortality vary by species, location and type of power line, but can be up to 80% (Rioux *et al*., 2013).

Despite being one of the rarest species in the study area, six Bengal floricans collided with the power transmission line and were killed. Of these, two were females and four were males (Table 1). All were adult (aged from photographs). Excluding "Passerine sp.", which covers many unidentified small bird species, Bengal floricans were the 7th most abundant bird species in our power line casualty statistics. Many other species that are far more abundant in the study area than Bengal floricans, such as herons and egrets, suffered less mortality, or no mortality at all. This finding is consistent with other studies that have found that bustards are particularly vulnerable to collisions with power lines (e.g., Uddin *et al*., 2021; Shaw *et al*., 2017). The study area is in the most important part of Cambodia for Bengal floricans. Within this area, the power line cuts through a protected area of grassland that supports 44 (95% CI: 25–63) male Bengal floricans (and an unknown number of females), which equal 42% of Cambodia's Bengal florican population (Mahood *et al*., 2019). The additional loss of six adult Bengal floricans from this population over less than three years is unlikely to be trivial. Bengal floricans reproduce slowly, laying one (or occasionally two) eggs each year (Collar, 2019), so they cannot sustain high levels of adult mortality. Cambodia's Bengal florican population is already undergoing a rapid decline (55% over the 2012–2018 period, prior to power line construction), which even the level of mortality recorded during our survey is likely to worsen.

All of the detected power line mortalities of Bengal floricans occurred in February–March or August–September. Outside of these periods, Bengal floricans are either holding display territories and nesting to the south of the power line (March–August) or on the non-breeding grounds located north of the power line (October–January). The lack of detected mortality during the breeding season is surprising, because the power line

is extremely close to a known lek. We did not quantify the impacts of the power line on Bengal florican mortality outside of the study area. However, since all Bengal floricans are likely to cross the power line during their migration periods, it is plausible that additional Bengal florican mortalities occurred elsewhere along the line.

There was very limited mitigation of impacts to birds during development of the Kampong Cham to Battambang power transmission line. The most effective mitigation option would have been to re-route the power line in areas where it would otherwise closely approach the sites where Bengal floricans breed (such as the study area). Bird flight deflectors, disks or spirals that make it easier for the birds to see the power line, could have been fitted to the wires prior to erection of the power line to reduce the number of birds that would be killed (Barrientos *et al*., 2011). However, they were only attached to the pylons, which are of little threat to flying birds, not to the wires. Because birds typically collide with the earth wire, bird flight deflectors are usually attached only to this wire. It is low cost and technically simple to do this prior to installation of power lines. It is still possible to attach bird flight deflectors to a power line after construction is completed, but this is considerably costlier and logistically difficult. These mitigation measures are standard in many countries in areas where power lines cross areas used by globally threatened species that are susceptible to power line mortalities, such as bustards. Although they reduce mortality of most bird species, long-term data sets and a recent meta-analysis concluded that bird flight deflectors do not reduce mortality of bustards (Shaw *et al*., 2021; Silva *et al*., 2022). Future construction of power lines should ideally be avoided completely in areas with populations of Bengal floricans. Where it is unavoidable that power lines pass close to areas that support Bengal floricans, there is a need to improve habitat management and reduce hunting to offset residual power line mortality, in addition to fitting bird flight deflectors to reduce mortalities of other species.

Acknowledgements

This study was conducted as part of a wider program of work on Bengal florican conservation in the Tonle Sap Landscape under a Memorandum of Understanding between the Ministry of Environment, Cambodia, and Wildlife Conservation Society. Our work was funded by grants from Margaret A. Cargill Philanthropies, Agence française de développement, and the European Union. We are grateful to community members for data collection, namely Meas Than, Soun Kanil, Chan Saery, Khy Thai, In Khin, Lim Socheat, Torn Ro, Met Mot, Lorn Phal, Loun Kimhan, Eng Vy, Hean Ket, Born Chi, Vy Vut, Ti Neang and Ly Sinan.

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Annex 1 Total carcasses found during surveys conducted between 23 June 2019 and 22 February 2022

IUCN Status: CR=Critically Endangered, NT=Near Threatened, LC=Least Concern.

English name	Scientific Name	No. of Carcasses	IUCN Status
Blue-breasted quail	*Coturnix chinensis*	1	LC
Lesser whistling-duck	*Dendrocygna javanica*	1	LC
Knob-billed duck	*Sarkidiornis melanotos*	7	LC
Cotton pygmy-goose	*Nettapus coromandelianus*	1	LC
Indian spot-billed duck	*Anas poecilorhyncha*	1	LC
Painted stork	*Mycteria leucocephala*	4	NT
Asian openbill	*Anastomus oscitans*	1	LC
Black-crowned night-heron	*Nycticorax nycticorax*	6	LC
Pond-heron sp.	*Ardeola* sp.	4	LC
Eastern cattle egret	*Bubulcus coromandus*	2	LC
Grey heron	*Ardea cinerea*	7	LC
Egret sp.	*Ardea/Mesophyx/Egretta* sp.	17	LC
Spot-billed pelican	*Pelecanus philippensis*	7	NT
Little cormorant	*Phalacrocorax niger*	1	LC
Black-shouldered kite	*Elanus caeruleus*	3	LC
Bengal florican	*Houbaropsis bengalensis*	6	CR
Ruddy-breasted crake	*Porzana fusca*	1	LC
Watercock	*Gallicrex cinerea*	3	LC
Buttonquail sp.	*Turnix* sp.	3	LC
Red-wattled lapwing	*Vanellus indicus*	1	LC

Annex 1 Cont'd

English name	Scientific Name	No. of Carcasses	IUCN Status
Little ringed-plover	*Charadrius dubius*	1	LC
Snipe sp.	*Gallinago* sp.	9	LC
Oriental pratincole	*Glareola maldivarum*	14	LC
Feral pigeon	*Columba livia*	1	LC
Spotted dove	*Steptopelia chinensis*	1	LC
Zebra dove	*Geopelia striata*	1	LC
Pied kingfisher	*Ceryle rudis*	1	LC
Little green bee-eater	*Merops orientalis*	1	LC
Black drongo	*Dicrurus macrocercus*	1	LC
Passerine sp.	Passerine sp.	33	-

Diversity, distribution and habitat associations of aquatic beetles (Order Coleoptera) in Chambok, southwest Cambodia

DOEURK Bros[1,2,3,*], CHHORN Soksan[1,2,4], SIN Sopha[1,2], PHAUK Sophany[2] & SOR Ratha[4,5]

[1] Centre for Biodiversity Conservation, Royal University of Phnom, Russian Confederation Blvd, Phnom Penh 12156, Cambodia.

[2] Cambodian Entomology Initiatives, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Russian Confederation Blvd, Phnom Penh 12156, Cambodia.

[3] Malaria Molecular Epidemiology Unit, Institut Pasteur du Cambodge, 5 Monivong Boulevard, P.O. Box 983, Phnom Penh 12201, Cambodia

[4] Wonders of the Mekong Project, c/o Inland Fisheries Research and Development Institute, 186 Preah Norodom Boulevard, P.O. Box 582, Phnom Penh 12300, Cambodia.

[5] International Relations, Research and Collaborations & Graduate School, Chea Sim University of Kamchaymear, 157 Preah Norodom Boulevard, Khan Chamkarmon, Phnom Penh 12300, Cambodia.

* Corresponding author. Email dourkbros@gmail.com

Paper submitted 23 October 2021, revised manuscript accepted 13 July 2022.

មូលន័យសង្ខេប

យើងបានធ្វើការអង្កេតទៅលើនានាភាព របាយ និងទំនាក់ទំនងជាមួយទីជម្រករបស់សត្វល្អិតទឹកស្លាបរឹង នៅឃុំចំបក់ ខេត្តកំពង់ស្ពឺ ភាគនិរតីនៃប្រទេសកម្ពុជា។ សំណាកសិក្សាត្រូវបានប្រមូលចាប់ពីខែសីហា ដល់ខែកញ្ញា ឆ្នាំ២០១៨ នៅទីតាំងចំនួន១០កន្លែង នៅក្នុងឃុំនេះ។ ជាលទ្ធផល យើងប្រមូលបានសត្វល្អិតស្លាបរឹងចំនួន ១៥២ក្បាល ត្រូវនឹង៩អំបូរ ១០ពូក និង២២ប្រភេទ។ អំបូរ Scirtidae ត្រូវបានចាប់ក្នុងបរិមាណច្រើនជាងគេចេញពីទីតាំងទាំង១០កន្លែង ដែលអាចបង្ហាញបានថា អំបូរនេះមាននានាភាពច្រើន និងរស់នៅតាមទឹកន្លែងផ្សេងៗគ្នា។ Elmidae ជាអំបូរដែលចាប់បានច្រើនលំដាប់ទី២ ហើយបន្ទាប់មកគឺអំបូរ Dryopidae, Hydrophilidae, Limnichidae, Hydraenidae, Dytiscidae, Gyrinidae និងអំបូរ Chrysomelidae។ ការវិភាគតាម Non-metric multidimensional scaling analysis បានបង្ហាញថា អំបូរខ្លះអាស្រ័យលើទីជម្រកផ្សេងៗគ្នា។ ឧទាហរណ៍ អំបូរ Scirtidae មានទំនាក់ទំនងជាវិជ្ជមានជាមួយគម្របព្រៃឈើ ប៉ុន្តែវាមានទំនាក់ទំនងជាអវិជ្ជមានជាមួយនឹងការប្រើប្រាស់ដីកសិកម្ម។ ផ្ទុយមកវិញ អំបូរ Limnichidae មានទំនាក់ទំនងជាវិជ្ជមានជាមួយរយៈកម្ពស់ និងកម្រិតហ្សរច្រោះ នៅពេលដែលអំបូរ Dytiscidae មានទំនាក់ទំនងជាវិជ្ជមានជាមួយនឹងបរិមាណថ្មគួចៗក្នុងទីជម្រកនៅតាមដងអូរ ប៉ុន្តែវាមានទំនាក់ទំនងជាអវិជ្ជមានជាមួយនឹងជម្រៅទឹកនិងបរិមាណថ្មធំៗក្នុងទីជម្រក។ លទ្ធផលនៃការសិក្សានេះបង្ហាញថា វត្តមាននៃកូនញាស់និងសត្វពេញវ័យរបស់អំបូរទាំងនេះ ប្រែប្រួលទៅតាមប្រភេទទីជម្រកតូចៗជាក់លាក់ (microhabitats) ដែលជាកត្តាគាំទ្រឱ្យមានបណ្តុំប្រភេទខុសៗគ្នានៃពូកសត្វល្អិតទឹកស្លាបរឹង។ លទ្ធផលទាំងនេះអាចផ្តល់ជាមូលដ្ឋានដ៏មានប្រយោជន៍សម្រាប់ការសិក្សាស្រាវជ្រាវអំពីសត្វល្អិតទឹកស្លាបរឹងនៅតំបន់ផ្សេងៗនៃប្រទេសកម្ពុជា និងនៅពេលអនាគត។ តែទោះយ៉ាងណាក្តី យើងស្នើឱ្យមានការសិក្សាជាបន្តទៀត ដើម្បីបញ្ចាក់បន្ថែមនិងពង្រីកលទ្ធផលនៃការស្រាវជ្រាវរបស់យើង។

CITATION: Doeurk B., Chhorn S., Sin S., Phauk S. & Sor R. (2022) Diversity, distribution and habitat associations of aquatic beetles (Order Coleoptera) in Chambok, southwest Cambodia. *Cambodian Journal of Natural History*, **2022**, 90–98.

Abstract

We investigated the diversity, distribution and habitat associations of aquatic beetles in Chambok Commune of Kampong Speu Province, southwest Cambodia. Sampling at ten locations within the commune in August–September 2018 resulted in the collection of 152 individuals representing 22 morphospecies, ten genera and nine families. Scirtidae was the most abundant family across the ten sampling sites, which may reflect its greater diversity and wider distribution as a group. Elmidae was the second most common family, followed by Dryopidae, Hydrophilidae, Limnichidae, Hydraenidae, Dytiscidae, Gyrinidae and Chrysomelidae. Non-metric multidimensional scaling analysis revealed that some families differed in their habitat associations. For example, Scirtidae was positively associated with forest and canopy cover, but negatively associated with agricultural land use. In contrast, Limnichidae was positively correlated with altitude and erosion levels, whereas Dytiscidae was positively associated with stream substrates characterised by small stones, but negatively associated with water depth and substrates characterised by large stones. Our results suggest that the occurrence of larvae and adults of these families varies in response to different types of microhabitats which consequently support different species assemblages of aquatic beetles. While further investigations are desirable to confirm and extend these findings, our study nonetheless provides a useful baseline for future research efforts on aquatic beetles in Cambodia.

Keywords Beetles, habitat characteristics, Shannon Index, species diversity, non-metric multidimensional scaling.

Introduction

Beetles (order Coleoptera) are the largest insect order with approximately 400,000 species currently described and are estimated to comprise ≈1.1 million species worldwide (Oberprieler *et al*., 2007). However, less than 2% of these are adapted to aquatic life (Jäch & Balke, 2008). Aquatic and riparian beetles dwell in various habitats including wetland, lakes, streams and terrestrial habitats associated with water (Balke *et al*., 2014). They are regarded as aquatic beetles because either the larvae or adults (or both) occur in water (Bouchard, 2004). The larvae of aquatic beetles are characterised by a sclerotized head capsule, three pairs of legs and frequent presence of swimming hairs around the body (Bouchard, 2004). The adults are characterised by a strongly-sclerotized body with the forewings hardened into elytra, which serve to protect the more delicate hind wings, as well as the dorsal surface of the last two thoracic segments (pterothorax) and abdomen (Jäch & Balke, 2008). The size of the latter ranges from 1 mm to 3 cm depending on the family and species and the size of larvae can exceed that of adults (Balke *et al*., 2014).

Aquatic beetles can be found in various freshwater habitats including rivers, creeks, springs, lakes, ditches, puddles, lithotelmata, phytotelmata, seepages and groundwater (Freitag, 2015), although they are most diverse in lentic habitats such as marshes and pond margins (Bouchard, 2004). Their occurrence typically varies in response to microhabitat characteristics including particulate organic matter, algae, zooplankton and abiotic factors (i.e., temperature, substrate composition and altitudinal ranges) (Braun *et al*., 2018). For instance, they are greatly influenced by water quality and occur at low abundance when primary habitats are removed (Jäch & Balke, 2008). As a consequence, some aquatic beetles have been used as indicators for ecological diversity and habitat characteristics (Shailendra *et al*., 2013).

Aquatic beetles are among the most common aquatic insects on the planet, and are only exceeded by true flies (Order Diptera) in the number of taxa (though only as larvae). Over 13,000 species of aquatic beetles are presently recognised (Short, 2018) and many new species are described each year. From 2006 and 2010 for instance, nearly 200 species and five genera of Hydrophilidae were described, although as almost a dozen genera were synonymized during the same period, the number of valid genera actually decreased (Short & Fikáček, 2013). Thirty-nine species of aquatic Polyphaga have been reported in Cambodia to date (Hansen, 1998; Short & Hebauer, 2006; Short & Fikáček, 2011; Freitag *et al*., 2018).

Few studies have been conducted on aquatic beetles in Cambodia to our knowledge. Existing reports include records of 21 taxa from southwest Cambodia (Freitag *et al*., 2018), four aquatic beetle families in urban ponds in Phnom Penh (Chhy *et al*., 2019) and nine coleopteran taxa from the lower Mekong Basin region in Cambodia (Sor *et al*., 2017). The aim of our study was to investigate the diversity, distribution and habitat associations of aquatic beetles in a freshwater stream in southwest Cambodia and more broadly to improve understanding of aquatic beetle biodiversity and ecology in the country.

Table 1 Locations, elevations and dates of sampling in Chambok commune.

Site	Longitude	Latitude	Elevation (m)
S1	11°21'25.1"N	104°06'10.8"E	425 [1]
S2	11°21'27.7"N	104°06'14.3"E	394 [1]
S3	11°21'31.3"N	104°06'12.3"E	391 [1]
S4	11°21'53.4"N	104°06'12.4"E	293 [2]
S5	11°21'59.0"N	104°06'17.3"E	241 [2]
S6	11°22'03.9"N	104°06'26.7"E	197 [2]
S7	11°22'07.1"N	104°06'35.6"E	150 [3]
S8	11°22'14.0"N	104°06'42.7"E	133 [3]
S9	11°22'24.6"N	104°06'44.8"E	117 [3]
S10	11°22'30.7"N	104°06'49.9"E	116 [3]

Notes: Sampled with hand nets on 13[1], 14[2] and 15[3] August 2018. Artificial substrate traps were retrieved from sites on 11 September 2018.

Methods

Study site

We sampled aquatic beetles in August and September 2018 along a freshwater stream in a community-based ecotourism site located in Chambok Commune, Phnom Sruoch District, Kampong Speu Province. The study stream originates from a freshwater reservoir in the upper part of Kirirom National Park, a few kilometres from the Kirirom Hillside Resort. Ten sites (S01–S10) were sampled along the stream in several habitat types at different elevations (Table 1, Fig. 1). The distance between the upper and lowermost sampling sites (S01 & S10) was approximately three kilometres.

Field sampling

Two methods were employed for sampling aquatic beetles, hand nets and artificial substrate traps. Each sampling site was sampled with three replicates situated in different parts (left, right & middle) of the stream, resulting in a total of 30 samples. Hand nets with a mesh size 0.1 mm were employed for ≈30 minutes at each site to sample aquatic beetles along the stream-shore in different microhabitats including bottom gravel, rock surfaces, submerged root packs, submerged woods and other bottom substrates. After rinsing each net sample with water, aquatic beetles were extracted using soft forceps and transferred to labelled vials containing 95% ethanol. The substrate of our artificial traps comprised rocks and naturally occurring substrate in the area and were deployed at each site for ≈30 days. As with our hand net samples, aquatic beetles in each trap were extracted with soft forceps and transferred into labelled vials containing 95% ethanol.

The adult specimens were identified in the laboratory to morphospecies and larvae were identified to family level based on Balke *et al*. (2014), MRC (2006) and an unpublished identification key for freshwater macroinvertebrates in Southeast Asia. These identifications were subsequently reviewed in part by a specialist on Southeast Asian aquatic beetles (Dr Hendrik Freitag, Ateneo de Manila University, Philippines).

We used a multi-parameter meter with GPS (Hanna Instruments, Rhode Island, USA) to record the altitude and water temperature of each sampling site. Several habitat characteristics, including stream width, water depth, erosion and substrate composition (large stones [>250 mm], medium stones [64–250 mm], small stones [2–64 mm], sand & silt/clay) were also recorded (Annex 1). Erosion measurements were based on the loss of the soil mass of bank channels over time. Three categories were recognised, with a value of zero (0) indicating no erosion, a value of one (1) indicating <30% erosion and value of two (2) indicating >30% erosion (Raven *et al*., 1998; Parsons *et al*., 2002). Additionally, percentage land cover (i.e. forest, agriculture, residential areas, orchards, bamboo & shade/canopy) was recorded in the vicinity of each sampling site following the Australian River Assessment System (Parsons *et al*., 2002) and River Habitat Survey protocols (Raven *et al*., 1998).

Statistical analyses

We employed taxonomic richness, taxonomic abundance and the Shannon diversity (*H*) index to characterize the diversity of aquatic beetles at our study sites using the 'vegan' package of Oksanen *et al*. (2015). Simple linear regressions were initially performed to test the relationship between environmental variables and aquatic beetle families. Significantly related variables were retained in subsequent analysis. Non-metric multidimensional scaling (NMDS) was employed to visualize the associations between these variables and aquatic beetle families and stress scores were used to determine the reliability of NMDS results (Clarke, 1993). Correlation coefficients were employed to assess the statistical power of our results and p values < 0.05 were considered significant. All analyses were performed in R v.4.0.3 (R Core Team, 2020).

Fig. 1 Sampling sites (S1–S10) along study stream in Chambok Commune, Kampong Speu Province, southwest Cambodia.

Table 2 Abundance and occurrence of aquatic beetle morphospecies at sampling sites in Chambok Commune.

No	Family / Morphospecies	Abundance	Occurrence (%)	Sampling Sites
Hydrophilidae				
1	*Pelthydrus* sp.	1	10	S09
2	*Pelthydrus* sp.1	2	20	S06, S09
3	*Pelthydrus vitalisi*	3	20	S09, S10
4	*Agraphydrus* sp.	1	10	S07
5	Hydrophilidae larvae	3	20	S05, S10
Hydaenidae				
6	*Hydraena* sp.1	2	10	S10
7	*Hydraena* sp.2	1	10	S10
8	*Hydraena* sp.3	3	20	S09, S10
9	*Hydraena* sp.4	3	30	S07, S09, S10
Elmidae				
10	*Grouvellinus* sp.2	1	10	S01
11	Elmidae larvae	12	60	S01, S04–S06, S08, S09
Dryopidae				
12	*Elmomorphus* sp.	11	50	S02, S03, S05, S08, S10
Dytiscidae				
13	*Neptosternus hydaticoides*	1	10	S10
14	Dytiscidae larvae	6	20	S03, S09
Gyrinidae				
15	*Patrus* sp.1	3	10	S06
Limnichidae				
16	Limnichidae sp.	4	30	S01, S03, S05
17	*Caccothryptus* sp.	2	20	S02-S03
18	*Throscinus* sp.	2	10	S03
19	*Byrrhinus* sp.	1	10	S03
Scirtidae				
20	Scirtidae larvae	87	100	S01–S10
21	Scirtidae adults	2	20	S03, S04
Chrysomelidae				
22	Chrysomelidae larvae	1	10	S06

Results

We recorded 152 individuals belonging to 22 morphospecies, ten genera and nine families in Chambok (Table 2). Among these, Scirtidae was the most common family and found at all ten sites with a total of 89 individuals (Figs. 2 & 3). This was followed in decreasing order by Elmidae (six sites, 13 individuals), Dryopidae (five sites, 11 individuals), Hydrophilidae (five sites, ten individuals), Limnichidae (four sites, nine individuals), Hydraenidae (three sites, nine individuals) and Dytiscidae (three sites, seven individuals) (Figs. 2 & 3). Gyrinidae and Chrysomelidae were the least common families and occurred at only one site with three and one individuals, respectively. Across our sampling sites, the taxonomic richness of aquatic beetles ranged from one to ten taxa (5 ± 2.7), whereas abundance ranged from five to 36 individuals (15.2 ± 9.9) and Shannon diversity values from 0 to 1.5 (1.1 ± 0.5).

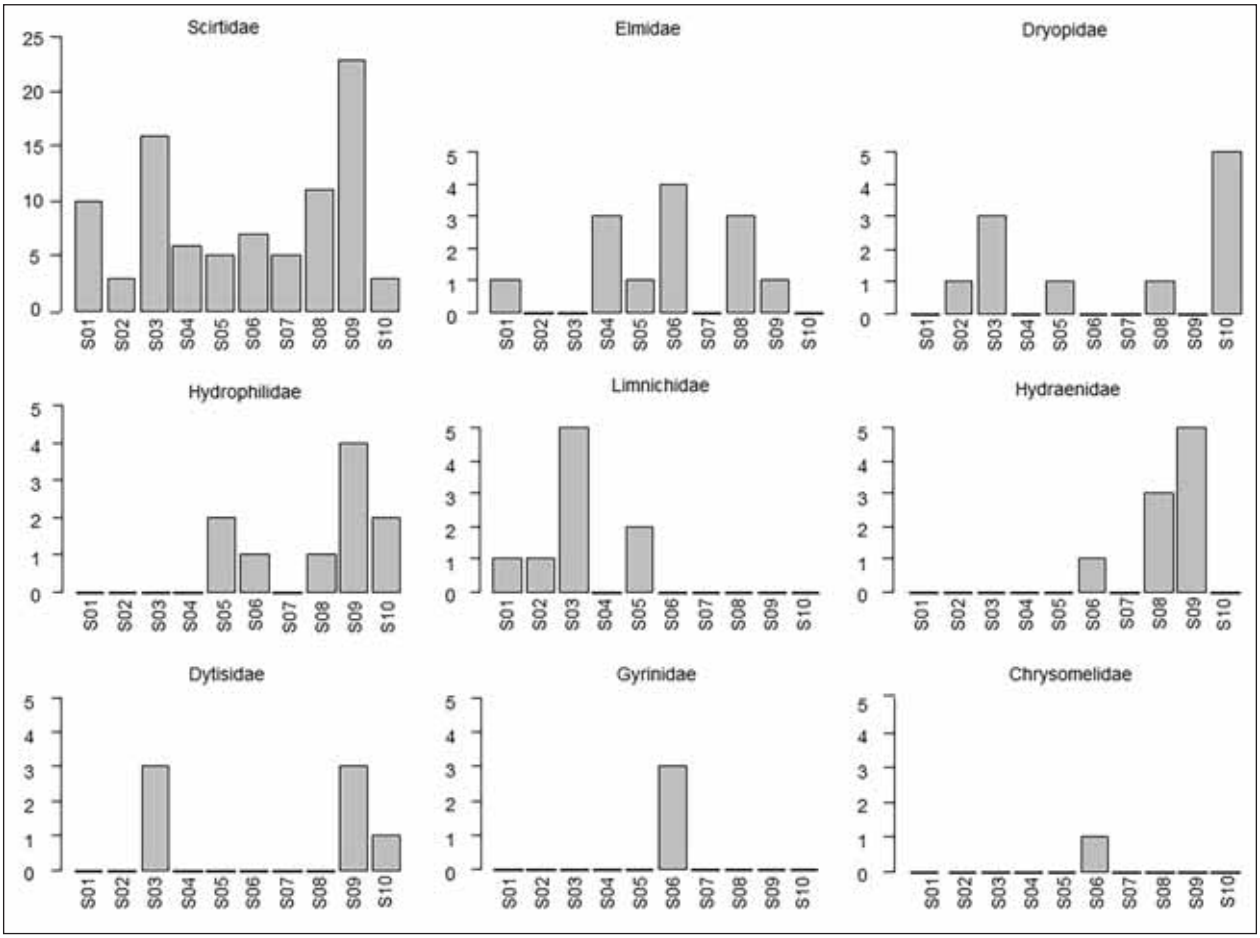

Fig. 2 Abundance of aquatic beetle families by sampling site in Chambok Commune.

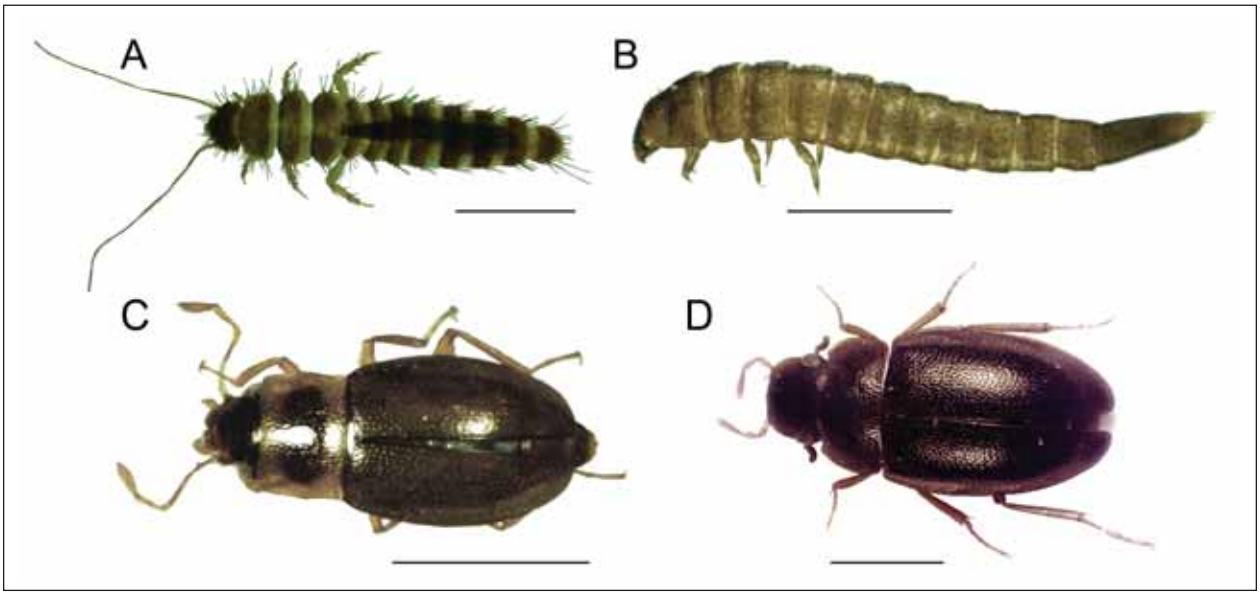

Fig. 3 Selected aquatic beetle families recorded during the study: A) Scirtidae larva, B) Elmidae larva, C) Adult *Hydraena* (Hydraenidae), D) Adult *Pelthydrus* (Hydrophilidae). Scale bars = 1 mm.

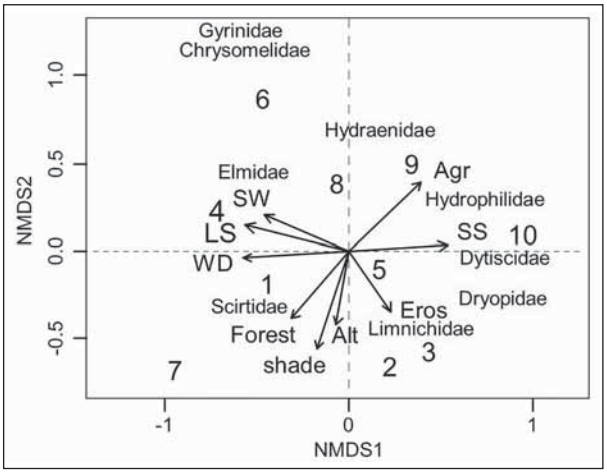

Fig. 4 Non-metric multidimensional scaling plot illustrating the association between sampling sites (1–10), aquatic beetle families and environment variables (WD=water depth, Alt: =altitude, Eros=erosion, SS=small stones, Agr=agriculture, LS=large stones, SW=stream width).

Habitat association of aquatic beetle families

Our linear regressions indicated nine environment variables were significantly correlated with aquatic beetle family ordination scores ($p < 0.05$), namely altitude, water depth, stream width, erosion levels, forest cover, agricultural land use and shade and the quantity of large and small stones in stream substrates. The result of our NMDS (stress score = 0.08) depicts these relationships (Fig. 4). Scirtidae was positively associated with forest cover and shade, but negatively with agricultural land use. Limnichidae was positively associated with altitude and erosion levels, whereas Dytiscidae was positively associated with small stone substrates, but negatively associated with large stone substrates and water depth. Hydrophilidae was positively associated with agricultural land use and negatively associated with forest cover, whereas Elmidae was positively associated with stream width, water depth and large stone substrates. The remaining families (Gyrinidae, Chrysomelidae & Hydraenidae) were not clearly associated with any of the environmental variables we sampled.

Discussion

Existing literature on invertebrates in Chambok Commune includes a species list of 21 aquatic beetle taxa (Freitag *et al*., 2018), one study on mayflies (Ephemeroptera) (Chhorn *et al*., 2020) and a study of insectivorous bat diets which included coleopteran fragments (Sin *et al*., 2020). We recorded 22 morphospecies of aquatic beetles, a figure similar to that of Freitag *et al*. (2018), although lower than numbers documented by some studies elsewhere in Southeast Asia (e.g., Freitag & Zettel, 2013). As a whole however, few studies have investigated the diversity, distribution and environmental associations of aquatic insects in Cambodia to date.

We found that some beetle families were much more broadly distributed (e.g., Scirtidae & Elmidae) than others (e.g., Gyrinidae & Chrysomelidae). This may be explained by their differing life histories. For instance, Scirtidae larvae mostly occur in water, whereas the adults occur in terrestrial ecosystems (similar to Odonata, Ephemeroptera, Plecoptera & Trichoptera). In contrast, both life stages (larvae & adults) of Dytiscidae, Hydrophilidae and Elmidae can usually be found in water (Jäch & Balke, 2008). Since Coleoptera is a large order, ecological adaptations within the group are more diverse compared to other orders (Balke *et al*., 2014).

The habitat associations of aquatic beetles vary between families (Slipinski *et al*., 2011). Scirtidae, the most common family in our study, was negatively associated with the presence of agricultural land but positively related to forest cover and shaded areas, particularly at upstream sites (S01–S03). Given that Scirtidae occur on all continents and includes ≈1,400 species (Slipinski *et al*., 2011), its abundance at Chambok is unsurprising. Scirtidae larvae typically live in water and sometimes in wet soil whereas the adults emerge to surrounding forests (Lawrence, 2005; Yoshitomi & Sato, 2005). Streams characterised by low flow velocities and high proportions of aquatic plants have also been found to harbour high abundances of the group (Gooderham & Tsyrlin, 2002; Lawrence & Ślipiński, 2011).

We found that Hydrophilidae was positively correlated to high proportions of agricultural land use. Members of this family can be found in marsh vegetation-associated wetlands, side puddles of lakes and decaying organic plant matters in irrigated rice paddy fields (Freitag, 2015; Marsh *et al*., 2016). In contrast, Elmidae occurred at high abundance in wider stream areas characterised by deeper water and a greater quantity of large stones on the substrate. Members of this family are known as riffle beetles and typically occur in the rocky habitat of a fast-flowing streams and rivers. The larvae of the family also prefer microhabitats among stones and a high percentage of moss or plant roots (Elliott, 2008).

We also found that Dytiscidae, commonly referred as predaceous dying beetles, was positively associated with substrates characterised by accumulations of small stones. This was exemplified by our downstream sampling site (S10) which had a slow current. Previous

reports indicate that this family occurs in most types of freshwater habitats including lakes, rivers, small stagnant water bodies, groundwater, streams and seepages (Jäch & Balke, 2008; Yee, 2014).

In conclusion, our study suggests that aquatic beetle communities in Chambok Commune are dominated by members of the Scirtidae and to a much lesser extent, the Elmidae and Dryopidae, whereas the presence of families such as Gyrinidae and Chrysomelidae is comparatively marginal. They also suggest that the occurrence of larvae and adults of these families varies in response to different types of stream microhabitats which consequently support different species assemblages. While further sampling is desirable to confirm and extend these findings, our study nonetheless provides a useful baseline for future research efforts on aquatic beetles in Cambodia.

Acknowledgements

Our research was partially supported by the Cambodian Entomology Initiatives of the Biology Department, Faculty of Science, Royal University of Phnom Penh (STEMRUPP-2018). The last author was also supported by the Wonders of the Mekong Project (USAID). We are grateful to Dr Hendrik Freitag for verifying some of our taxonomic identifications. We are also grateful to the head of the Chambok Community-Based Ecotourism Site, Mr. Toch Morn, who advised our field sampling.

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Annex 1 Environmental characteristics of sampling sites

Variable	S01	S02	S03	S04	S05	S06	S07	S08	S09	S10
Elevation (m)	425	394	391	2 93	241	197	150	133	117	116
Water Temperature (°C)	23.71	23.77	23.70	23.69	24.07	24.23	24.42	24.42	24.24	24.19
Water depth (m)	0.37	0.47	0.24	0.44	0.42	0.40	0.45	0.46	0.29	0.24
Stream width (m)	6.60	5.60	10.70	20.50	9.80	13.50	8.80	6.20	6.60	8.00
Erosion level	1	2	1	1	1	0	2	2	2	2
Large stones (>250 mm) (%)	60	50	45	65	45	48	55	65	55	35
Medium stones (64–250 mm) (%)	15	25	15	25	15	20	20	10	25	25
Small stones (2–64 mm) (%)	10	15	10	5	20	15	7	10	7	25
Sand (<2mm) (%)	10	8	10	3	10	10	5	10	3	10
Silt / clay (%)	5	2	20	2	10	7	13	5	10	5
Forest (%)	70	100	80	80	60	70	60	20	20	10
Agriculture (%)	0	0	0	0	0	0	0	45	50	40
Residential areas (%)	0	0	0	0	0	0	0	0	0	0
Orchards (%)	0	0	0	0	0	0	0	0	0	0
Bamboo (%)	30	0	20	20	40	30	40	35	30	50
Shade / canopy (%)	75	80	95	75	95	70	92	40	40	60

An annotated checklist of the butterflies (Lepidoptera: Papilionoidea) of Cambodia

Gerard CHARTIER[1,*] & Oleg E. KOSTERIN[2]

[1] No. 467, Boeung Toteung Tngai, Daeum Kor, Chrouy Changva, Phnom Penh, Cambodia, 121001.

[2] Institute of Cytology & Genetics, Russian Academy of Sciences (Siberian Branch), Academician Lavrent'yev Avenue, 10, Novosibirsk, Novosibirsk Oblast, Russia, 630090.

* Corresponding author. Email gee@geenature.com

Paper submitted 24 April 2022, revised manuscript accepted 1 October 2022.

មូលន័យសង្ខេប

យើងបានផ្តល់ជូននូវបញ្ជីឈ្មោះសត្វមេអំបៅសរុបចំនួន ៥១២ប្រភេទ ដែលត្រូវបានគេអះអាងថ្មីៗនេះថាមានវត្តមាននៅក្នុងប្រទេសកម្ពុជា។ បញ្ជីឈ្មោះសត្វមេអំបៅទាំងនេះត្រូវបានចងក្រងឡើងដោយប្រមូលព័ត៌មានពីឯកសារអត្ថបទវិទ្យាសាស្ត្រ ពីសំណាកមានលេខកូដសម្គាល់ និងពីប្រភពអនឡាញ ដែលរួមបញ្ចូលទាំងទិន្នន័យវិទ្យាសាស្ត្រ និងរូបថតភស្តុតាងរបស់យើងផ្ទាល់។ សត្វមេអំបៅចំនួន៩០ប្រភេទ និងពូកចំនួន០៣បន្ថែម ត្រូវបានកត់ត្រាជាលើកដំបូងសម្រាប់ប្រទេសកម្ពុជា ហើយក្នុងនោះដែររូបថតភស្តុតាងក៏ត្រូវបានផ្តល់ជូនសម្រាប់ប្រភេទនិងពូកនៃសត្វមេអំបៅដែលទើបនឹងត្រូវបានកត់ត្រាថ្មីៗ។

Abstract

We present an annotated checklist of 512 butterfly species currently confirmed in the territory of Cambodia. The checklist was compiled from literature information, voucher specimens and online resources, including citizen science data and our own photographic evidence. Ninety species and three additional genera are recorded for the first time for Cambodia and photographic evidence is provided for all newly reported species and genera.

Keywords butterflies, Cambodia, checklist, fauna, Indochina, Lepidoptera, Papilionoidea.

Introduction

Butterflies are conspicuous and beautiful insects which attract much attention from scientists and the public and so are usually the best studied insects in any area. They are also considered to be useful indicators of habitat quality (Fleishman & Murphy, 2009). Despite this and partly due to the country's troubled history during much of the 20th century, few dedicated investigations were undertaken on Cambodian butterflies until recently. Prior to the 1970s, relatively few publications documented butterflies in the country (Boullet & Le Cerf, 1912; Fruhstorfer, 1913, 1914; Dubois & Vitalis, 1914, 1919, 1921, 1924; Cowan, 1967), whereas more recently, there were two expeditions by Onodera (2007, 2008, 2009) and studies in Phnom Samkos Wildlife Sanctuary in 2006 and 2010 (Monastyrskii *et al*., 2011). Other literature devoted to butterflies of Cambodia is scarce and includes a popular photographic album of the butterflies of southwest Cambodia by Woodfield & Murton (2006), which was the result of prolonged work by Frontier UK/Cambodia, a report on the genus *Hidari* Distant, 1886 (Chartier, 2019) and three communications reporting photographic records of butterflies made during odonatological surveys undertaken by Kosterin (2019a, 2019b, 2020).

The most comprehensive source of information on Indochinese butterflies is currently the website ('A Check

CITATION: Chartier, G. & Kosterin, O.E. (2022) An annotated checklist of the butterflies (Lepidoptera: Papilionoidea) of Cambodia. *Cambodian Journal of Natural History*, **2022**, 99–126.

List of Butterflies of Indo-China, chiefly from Thailand, Laos and Vietnam') maintained by Inayoshi (2022). However, as follows from its title, Cambodia is not of primary concern and because the frequency of updates varies greatly between species, some papers on Cambodian butterflies have yet to be included, while others have only been partly adopted (e.g., Monastyrskii *et al*., 2011). Additionally, records of butterflies made by the first author between 2010 and 2020 in the foothills of the Cardamom Mountains near Tatai village in Koh Kong Province have yet to be published. No checklist of butterflies in Cambodia is yet available. This information gap motivated us to compile a checklist based on the latest information available, so as to encourage further research. This is particularly important given the continued loss and degradation of natural forest habitats in Cambodia. At a minimum, further study based on voucher specimens is needed to verify observational records we have omitted due to these being of genera which cannot be reliably identified from photographic records alone.

Methods

In the absence of systematic research efforts on butterflies in Cambodia, our checklist was compiled from as many information sources as possible. The quality and reliability of these varied, with the most reliable being scientific publications based on voucher specimens. Most records of butterflies in Cambodia are referenced for each Indochinese country by Inayoshi (2022), which was our main source for literature and distribution information.

Records based on photographic evidence alone were regarded as less reliable although still useful. This approach avoids the need for voucher specimens and allows most species to be reliably identified, with the notable exception of taxa in genera such as *Jamides* Hübner, [1819], *Nacaduba* Moore, [1881], *Melanitis* Fabricius, 1807, *Mycalesis* Hübner, [1819], *Ypthima* Hübner, [1819], *Potanthus* Scudder, 1872 and *Telicota* Scudder, 1872, among others. Species were identified from photographs using a variety of keys (Evans, 1927, 1949, 1957; Corbet, 1941; Eliot, 1990; Seki *et al*., 1991; Corbet & Pendlebury, 1992) and with assistance from Tek Lin Seow. Photographic records of butterflies in Cambodia have rapidly accumulated in recent years through online citizen science platforms such as iNaturalist (2022) and also appear on more mainstream platforms such as Facebook. The latter is not as convenient for accumulating scientific data as it does not allow full context searches. For this reason, we encouraged the authors of interesting photographic records (the most prolific of whom was E. Smith) to also contribute these to iNaturalist. Nevertheless, some photographic records only remain available on personal sites or Facebook pages e.g., Jump (2022). All observations of butterflies available on the aforementioned platforms were reviewed by us. Photographs of all species reported for Cambodia for the first time were used with the permission of their owners or according to the creative commons licenses (CC BY NC or CC BY) under which these are deposited in iNaturalist (2022).

We carefully reviewed the publications of Kosterin (2019a, 2019b, 2020) for errors and these were addressed in the present study. First, Kosterin (2020) re-identified three species from Kosterin (2019a) as follows: *Arhopala aedias meritatas* Corbet, 1941 as *A. camdana* Corbet, 1841; *Nacaduba* cf. *berenice aphya* (Fruhstorfer, 1916) ('cf.' was used by Kosterin to indicate provisional identifications) as *Ionolyce helicon merguiana* (Moore, 1882) and *Notocrypta clavata theba* (Evans, 1949) as *N. paralysos asawa* Fruhstorfer, 1911. Second, *Pelopidas* cf. *mathias* (Fabricius, 1798) from Kosterin (2019b) was re-identified as *Borbo cinnara* (Wallace, 1866). Third, Kosterin (2019b) expressed doubts regarding the identification of *Arhopala elopura* Druce, 1774 from Kep Province in Kosterin (2019a: Fig. 22) but nonetheless provided a photograph of the species from Mondulkiri Province (Kosterin 2019b: Fig. 11).

Further corrections were kindly provided by Yutaka Inayoshi who made the following revisions to Kosterin (2019a): *A. elopura* was regarded as *A. aida* Nicéville, 1889, *Lasippa tiga siaka* (Moore, 1881) as *L. camboja* (Moore, 1879), *Euploea phaenareta drucei* Moore, 1883 as *E. phaenareta catselnaui* C. & R. Felder, 1865 and *Pyroneura* sp. as *P. margherita miriam* (Evans, 1941). Nine species were also rejected as not being reliably identifiable from photographs (*Poritia* cf. *erycinoides elisei* Evans, 1925, *Miletus* cf. *chinensis learchus* C. & R. Felder, 1862, *Arhopala avatha* Nicéville, *Nacaduba* cf. *pavana vajuva* Fruhstorfer, 1916, *N.* cf. *sanaya naevia* Toxopeus, 1929, *N*. cf. *subperusia lysa* Fruhstorfer, 1916, *Halpe* cf. *hauxwelli* Evans, 1937, *Halpe zola zola* Evans, 1937 and *Pelopidas* cf. *subochraceus barneyi* (Evans, 1937)), whereas the provisional identification of *Allotinus unicolor rekkia* Riley & Godfrey, 1921 was confirmed.

The following revisions were made to Kosterin (2019b): *Poritia* cf. *hewitsoni tavoyana* Doherty, 1889 was regarded as *P. erycinoides elisei*, whereas the provisional identification of *Virachola kessuma* (Horsfield, 1829) was confirmed. Three species were also rejected as not being reliably identifiable from photographs: *Aeromachus* cf.

pygmaeus (Fabricius, 1775), *Pelopidas* cf. *mathias mathias*, and *Rapala* cf. *dieneces* (Hewitson, [1878]).

For Kosterin (2020), three species were rejected (*Rapala* cf. *dieneces*, *Arhopala aurelia* Nicéville, 1889 and *Ideopsis similis persimilis* (Moore, 1879)), *Prosotas aluta* ssp. was regarded as *Prosotas aluta coelestis* (Wood-Mason & Niceville, [1887]), and *Poritia hewitsoni tavoyana* was confirmed.

All photographs included in this study were reviewed by Yutaka Inayoshi, Adam Cotton and three anonymous reviewers. All species and subspecies that were deemed as not identifiable with certainty from photographs were omitted from the checklist, with exceptions for three genera: *Thauria* sp., *Dacalana* sp. and *Baoris* sp.

Results

The primary result of our review is presented in Annex 1 which lists 512 butterfly species currently reported for Cambodia (Table 1). Two of these species have records of two subspecies within the country: *Atrophaneura varuna* (White, 1842), ssp. *astorion* (Westwood, 1842) and ssp. *zaleucus* (Hewitson, [1865]), and *Capila phanaeus* (Hewitson, 1867), ssp. *decoloris* Inoué & Kawazoé 1964 and ssp. *falta* Evans, 1949.

Of the 512 species listed in Annex 1, 90 species (one with two subspecies) are reported for the first time for Cambodia (Table 1). In addition, three genera for which we are unable to determine specific identifications are included because the generic identification is certain: *Thauria* Moore, 1894, *Dacalana* Moore, 1884 and *Baoris* Moore, 1881. All of the newly reported species and genera are depicted in Figs 1–9.

Table 1 Summary counts of butterfly species in Cambodia by family and subfamily.

Family/Subfamily	No. of Species Documented	Newly Reported Species
Papilionidae	32	2
Pieridae	34	
Pierinae	20	
Coliadinae	14	
Nymphalidae	179	15
Danainae	28	
Satyrinae	51	4
Charaxinae	9	2
Heliconiinae	15	2
Limenitinae	48	5
Cyrestinae	5	
Pseudergolinae	1	
Biblidinae	3	
Apaturinae	2	
Nymphalinae	15	1
Lybitheinae	2	1
Riodinidae	11	3
Lycaenidae	161	25
Poritinae	3	1
Miletinae	8	3
Curetinae	3	
Polyommatinae	58	7
Lycaeninae	1	
Aphnaeinae	3	
Theclinae	85	14
Hesperiidae	95	45
Coeliadinae	15	8
Pyrginae	19	8
Hesperiinae	61	29
Total	512	90

Discussion

The 512 butterfly species we document for Cambodia is less than half the 1,291 species reported for neighbouring Thailand by Ek-Amnuay (2012). This can be attributed to Cambodia being a relatively small country latitudinally whereas Thailand is so extended that its fauna includes Malesian species in the south and Burmese species in the north. Additionally, Cambodia is a predominantly low-lying country with not so many mountains, which are biodiversity hotspots. However, judging by the speed which the known butterfly fauna of Cambodia increased with new records in the recent years preceding the pandemic, and considering the popularity of butterflies in wildlife photography, our list undoubtedly remains incomplete and will surely continue to grow in the near future. There are still many species recorded in the neighbouring territories of Thailand, Laos and Vietnam that have yet to be recorded in Cambodia (Inayoshi, 2022). Given the distribution of existing records in these countries (Inayoshi, 2022), none of the 90 species we report as new for Cambodia can be considered surprising. These are skewed toward Hesperiidae, which likely reflects the fact that previous studies presumably concentrated more on other butterfly families.

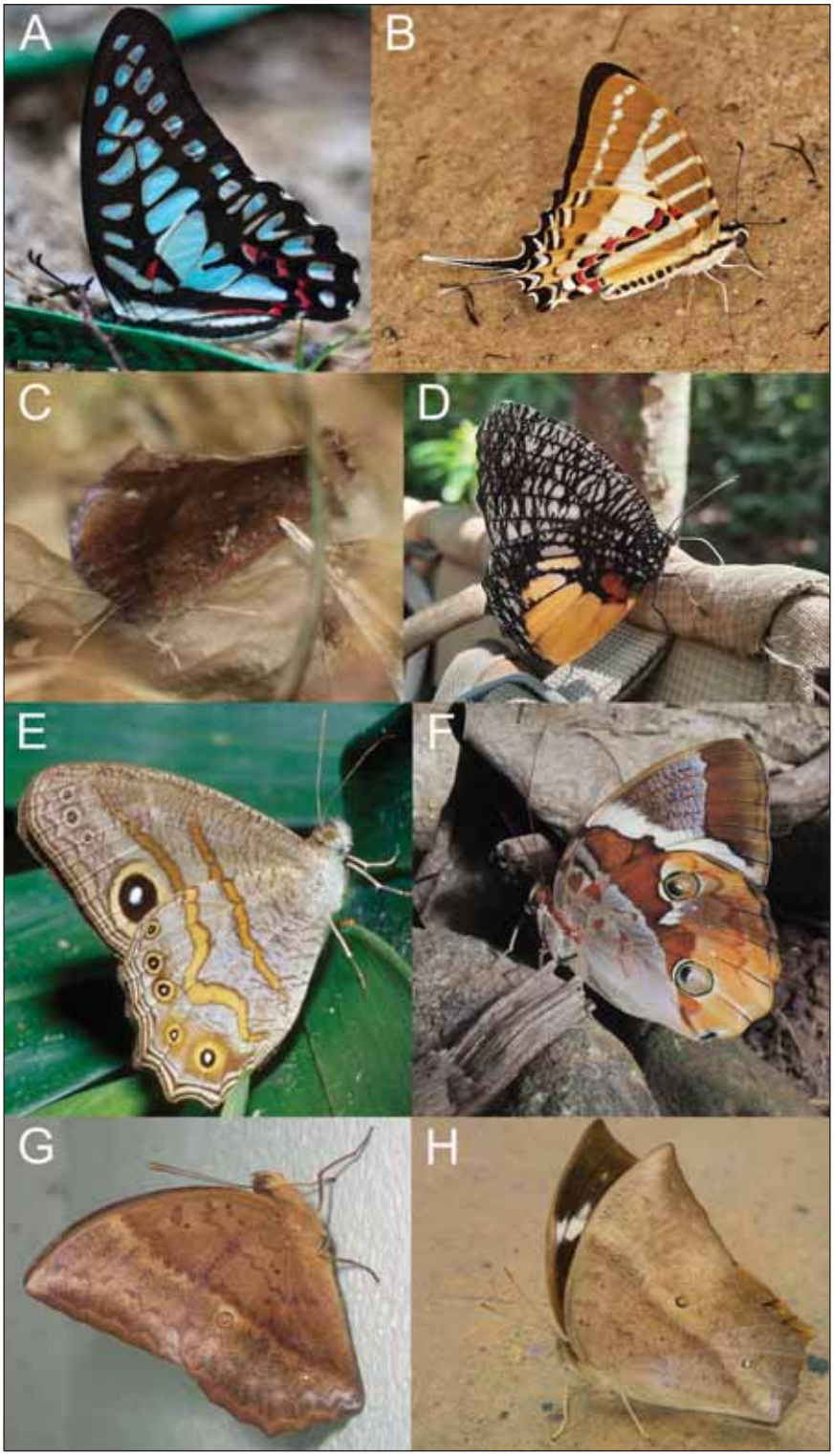

Fig. 1 First records of Papilioninae and Satyrinae taxa in Cambodia: A) *Graphium eurypylus acheron*, Koh Kong, 28.08.2012; B) *G. nomius swinhoei*, Siem Reap, 7.02.2021; C) *Melanitis phedima ganapati*, Stueng Treng, 28.01.2021; D) *Elymnias vasudeva*, Mondulkiri, 5.11.2020; E) *Erites medura rotundata*, Kratie, 5.11.2020; F) *Thauria* sp., Kampong Speu, 9.10.2014; G) *Discophora sondaica zal* ♂, Koh Kong, 31.07.2016; H) *D. s. zal* ♀, Koh Kong, 29.06.2018. A, G, H by G. Chartier; B by E. Smith; C by C. Jones; D by K. Winney; E by H. Böckler; F by D. Jump. Licenses: D - CC BY NC; F - used with kind permission of author; Others - CC BY. Not to scale.

Fig. 2 First records of Charaxinae, Heliconiinae and Limenitinae taxa in Cambodia: A) *Polyura delphis delphis*, Koh Kong, 10.04.2012; B) *P. jalysus jalysus*, Koh Kong, 15.02.2012; C) *Cirrochroa emalea emalea*, Pursat, 15.07.2020; D) *Cethosia biblis biblis*, Koh Kong, 23.08.2012; E) *Lasippa monata monata*, Siem Reap, 31.01.2015; F) *Neptis harita preeyai*, Siem Reap, 26.04.2021; G) *N. ilira cindia*, Koh Kong, 9.01.2012; H) *N. miah nolana*, Siem Reap, 26.02.2014; I) *Athyma sinope sinope*, Koh Kong, 1.01.2011. A, B, D, G, I by G. Chartier; C by Srun S.; E by E. Smith; F by D. Jump; H by Y. Bas. Licenses: F - used with kind permission of author, H - CC BY NC; Others - CC BY. Not to scale.

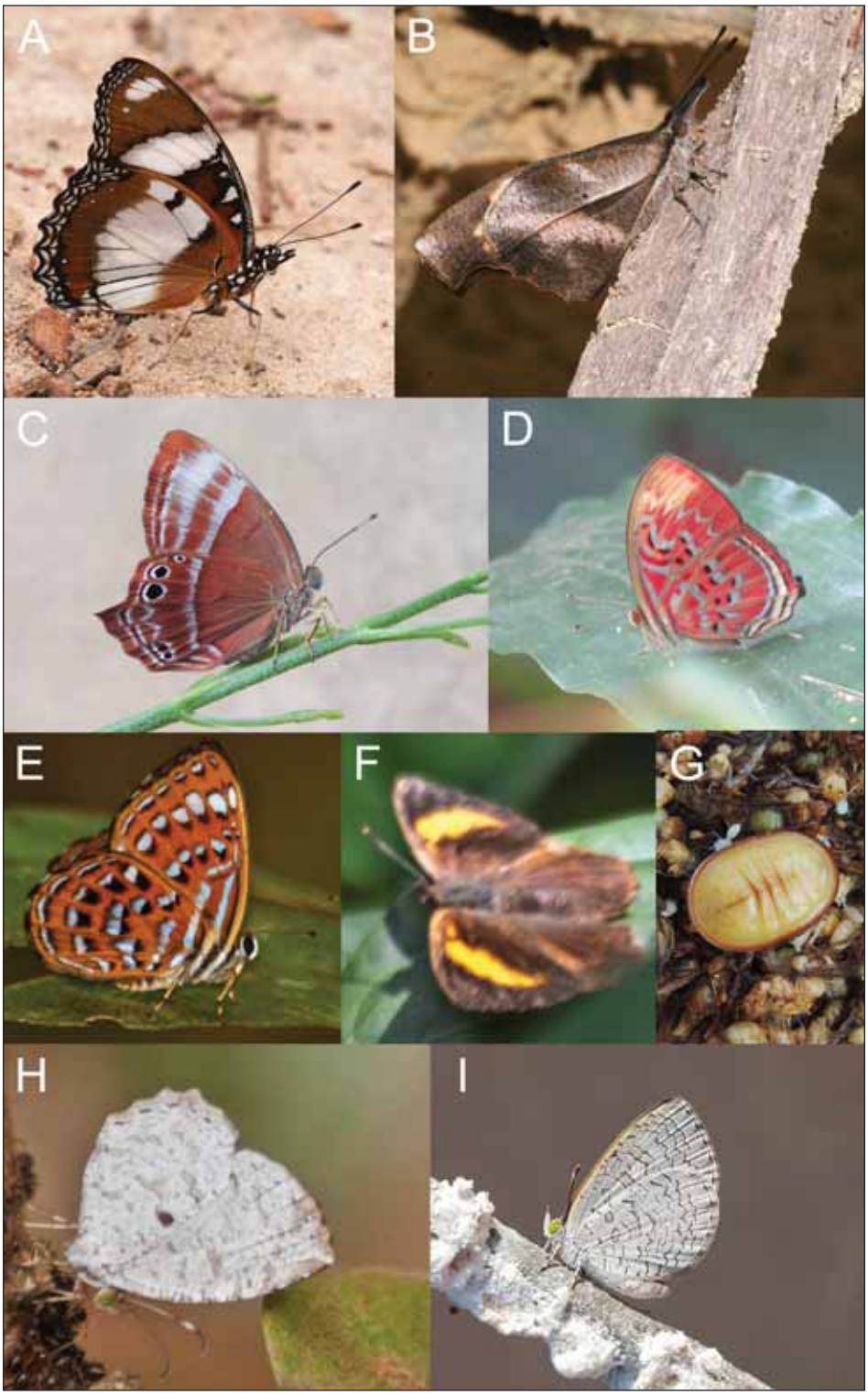

Fig. 3 First records of Nymphalinae, Lybitheinae, Riodinidae, Poritinae and Miletinae taxa in Cambodia: A) *Hipolymnas misippus*, Siem Reap, 21.07.2015; B) *Libythea myrrha sanguinalis*, Siem Reap, 13.06.2019; C) *Abisara saturata meta*, Siem Reap, 15.09.2013; D) *Paralaxita telesia boulleti*, Mondulkiri, 29.12.2019; E) *Laxita thuisto ephorus*, Koh Kong, 30.09.2012; F) *Simiskina phalia potina*, Koh Kong, 10.11.2012; G) *Liphyra brassolis brassolis*, Siem Reap, 24.04.2014; H) *Allotinus substrigosus substrigosus*, Koh Kong, 9.02.2019; I) *Spalgis epius epius*, Siem Reap, 9.08.2021. A, B by E. Smith; C, G, I by D. Jump; D by Srun S.; E, F, H by G. Chartier. Licenses: C, G, I - used with kind permission of author; D - CC BY NC; Others - CC BY. Not to scale.

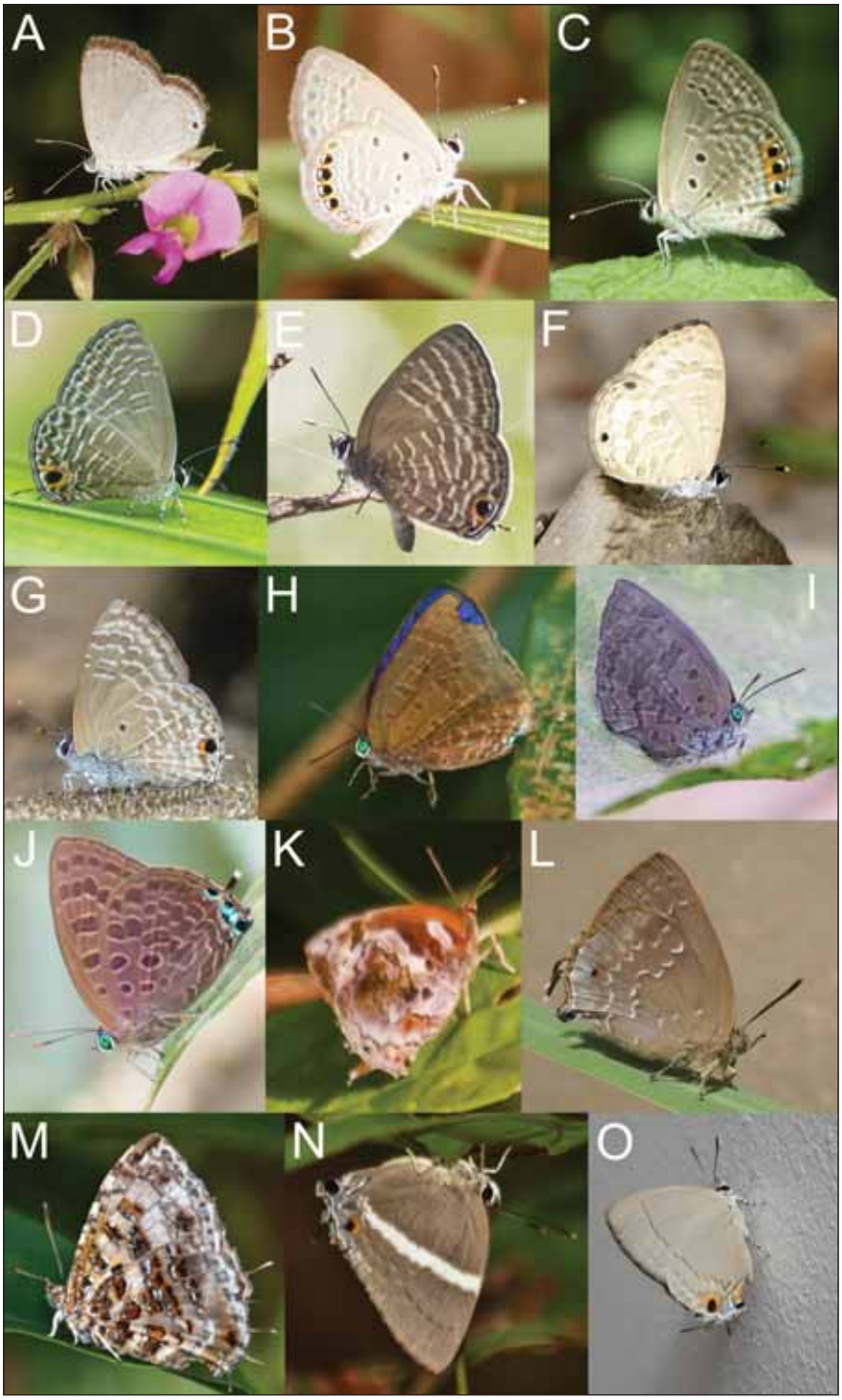

Fig. 4 First records of Polyommatinae and Theclinae (part) taxa in Cambodia: A) *Famegana nisa*, Siem Reap, 8.10.2019; B) *Freyeria putli*, Siem Reap, 28.05.2019; C) *F. trochylus orientalis*, Kandal, 24.06.2016; D) *Jamides bochus bochus*, Koh Kong, 12.11.2014; E) *Nacaduba pactolus continentalis*, Koh Kong, 4.09.2011; F) *Prosotas lutea sivoka*, Siem Reap, 16.03.2018; G) *Anthene lycaenina lycambes*, Koh Kong, 26.07.2016; H) *Arhopala milleri*, Koh Kong, 28.02.2012; I) *A. asinarus asinarus*, Siem Reap, 8.01.2020; J) *A. corinda corestes*, Koh Kong, 19.03.2014; K) *Flos asoka*, Koh Kong, 5.01.2014; L) *Zinaspa todara karennia*, Siem Reap, 14.10.2015; M) *Catapaecilma major albicans*, Koh Kong, 29.03.2012; N) *Dacalana* sp., Koh Kong, 29.03.2012; O) *Bullis buto buto*, Mondulkiri, 9.03.2021. A, B, F by E. Smith; C–E, G, H, J, K, M, N by G. Chartier; I by C.A. Lim; L by D. Jump; O by K. Winney. Licenses: I, O - CC BY NC; L - used with kind permission of author; Others - CC BY. Not to scale.

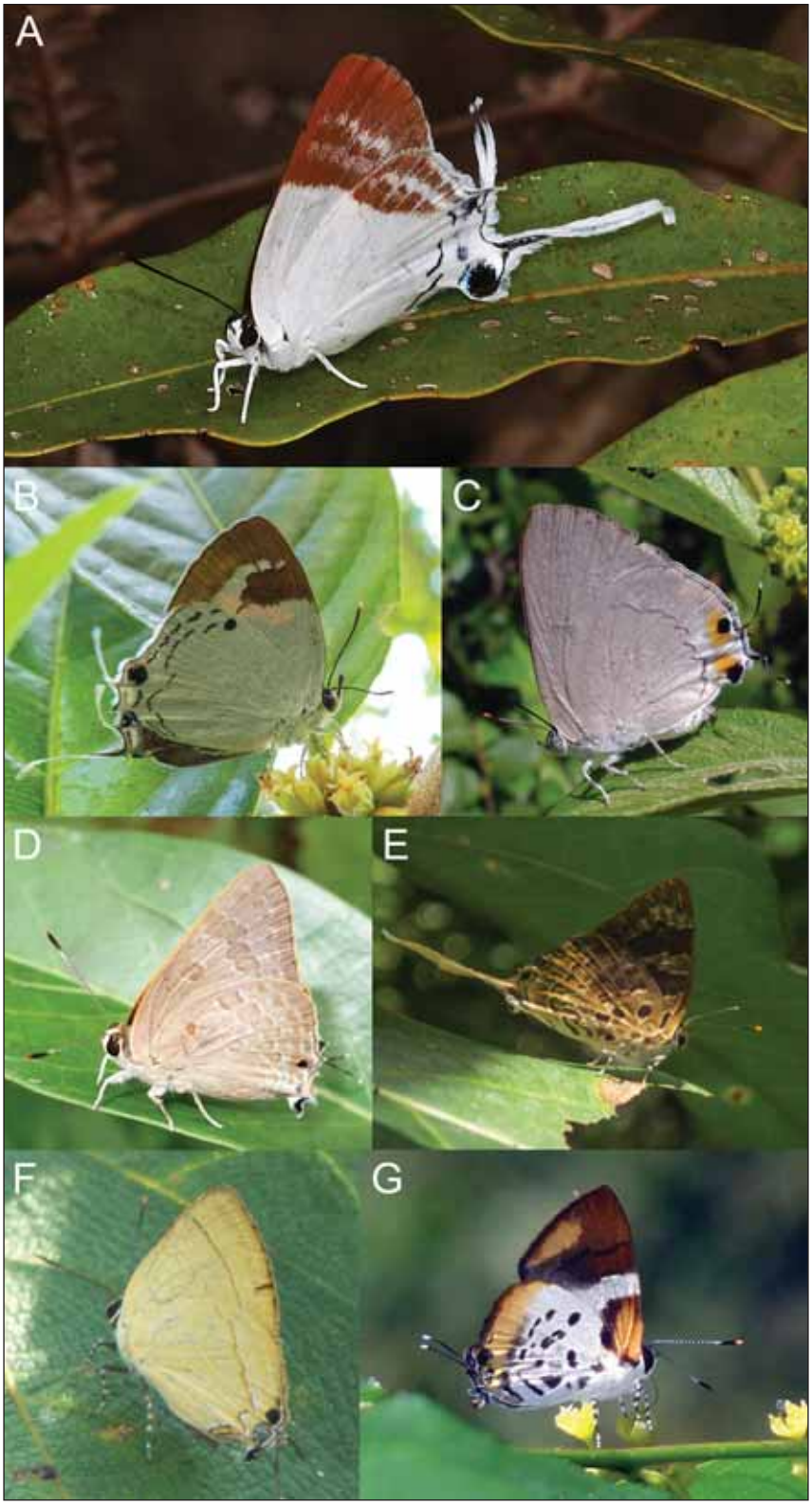

Fig. 5 First records of Theclinae taxa (part) in Cambodia: A) *Neocheritra fabronia fabronia*, Siem Reap, 15.12.2018; B) *Suasa lisides*, Koh Kong, 21.01.2014; C) *Ancema blanka minturna*, Siem Reap, 19.19.2014; D) *Virachola perse perse*, Siem Reap, 31.12.2016; E) *Bindahara phocides phocides*, Koh Kong, 31.07.2016; F) *Rapala suffusa suffusa*, Koh Kong, 11.05.2015; G) *Araotes lapithis lapithis*, Siem Reap, 19.09.2014. A, C, D, G by E. Smith; B, E, F by G. Chartier. Licenses: All - CC BY. Not to scale.

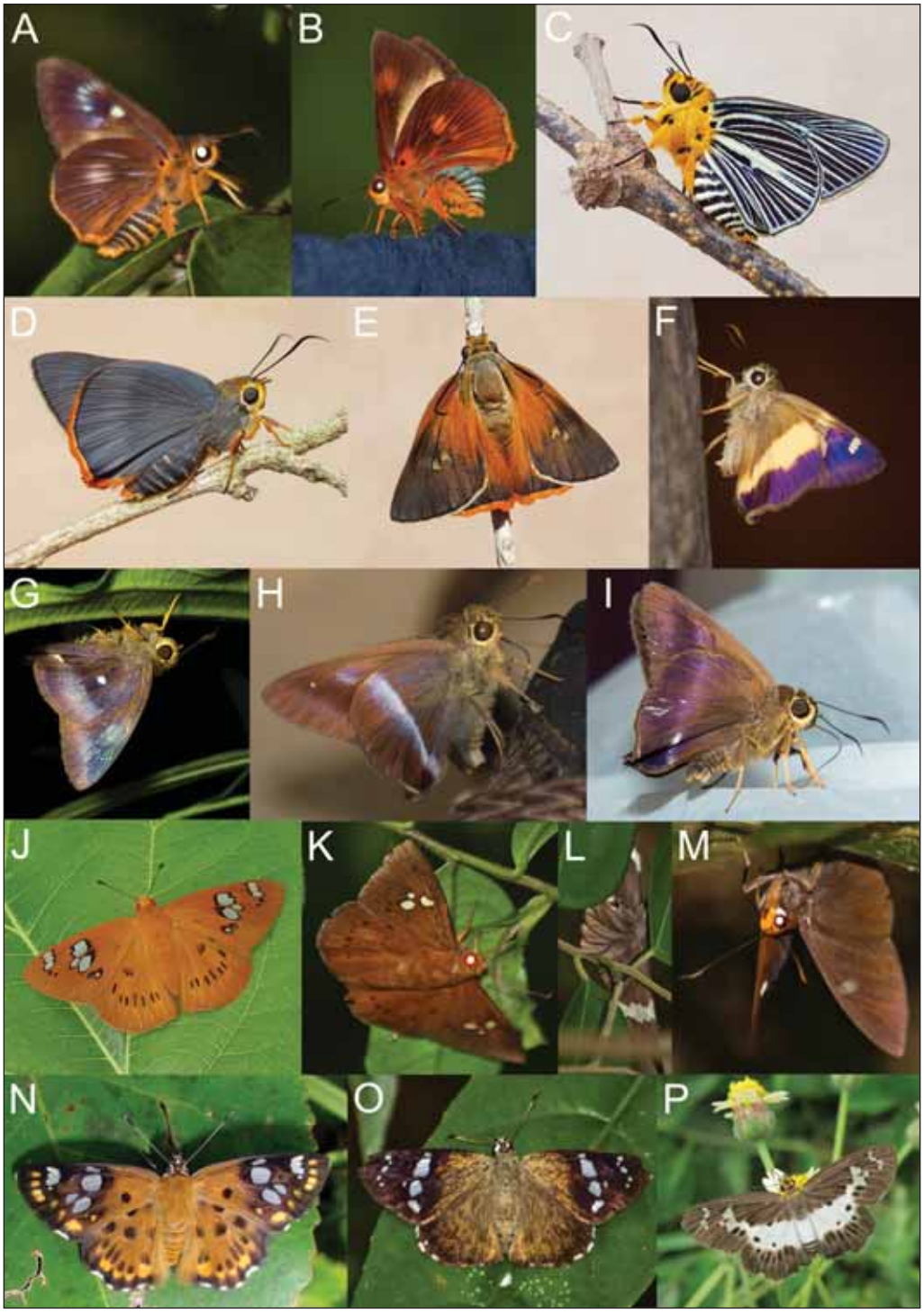

Fig. 6 First records of Coeliadinae and Pyrginae (part) taxa in Cambodia: A) *Burara jaina margana*, Koh Kong, 30.05.2013; B) *B. etelka etelka*, Koh Kong, 7.08.2011; C) *B. gomata gomata*, Siem Reap, 5.09.2020; D & E) *Bibasis mahintha*, Siem Reap, 9.03.2021; F) *Hasora schoenherr gaspa*, Koh Kong, 1.06.2012; G) *H. badra badra*, Koh Kong, 18.11.2017; H) *H. vitta indica*, Koh Kong, 3.01.2012; I) *H. leucospila leucospila* ♂, Koh Kong, 7.01.2015; J) *Capila phanaeus decoloris*, Siem Reap, 1.08.2021; K) *C. phanaeus falta*, Koh Kong, 20.03.2012; L) *C. hainana hainana* ♀, Koh Kong; 10.04.2012; M) *C. hainana hainana* ♂, Koh Kong, 15.03.2012; N) *Coladenia indrani uposathra*, Siem Reap, 5.11.2014; O) *Chamunda chamunda*, Koh Kong, 26.09.2013; P) *Gerosis bhagava bhagava*, Siem Reap, 14.08.2019. A, B, F–I, K–M, O by G. Chartier; C–E, J by D. Jump; N by E. Smith; P by Srun S. Licenses: P - CC BY NC; C–E, J - used with kind permission of author; Others - CC BY. Not to scale.

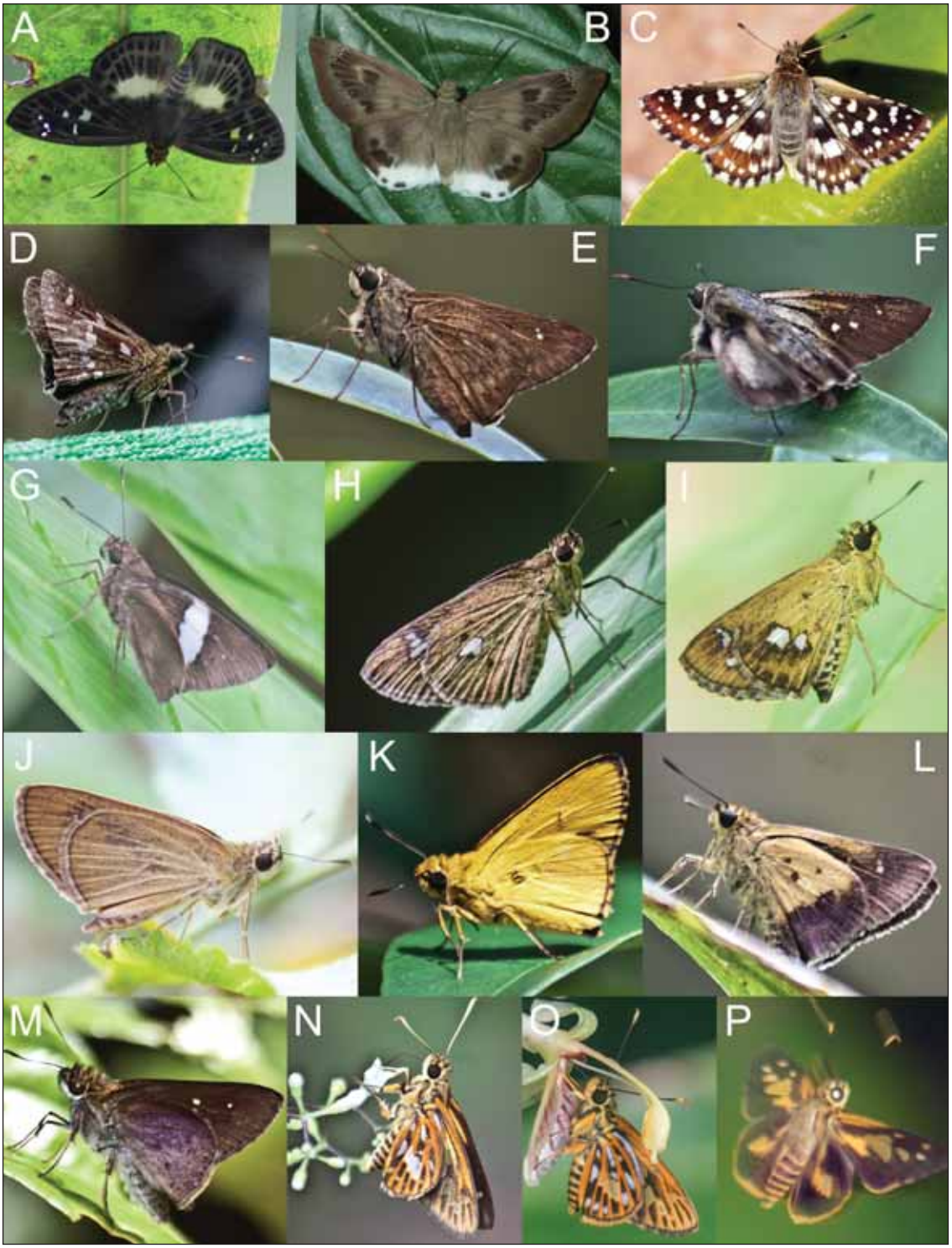

Fig. 7 First records of Pyrginae (part) and Hesperiinae (part) taxa in Cambodia: A) *Gerosis limax dirae*, Koh Kong, 27.01.2011; B) *Tagiades parra gala*, Koh Kong, 21.11.2019; C) *Spialia galba chenga*, Siem Reap, 23.12.2014; D) *Thoressa cerata*, Mondulkiri, 22.09.2022; E & F) *Pithauria stramineipennis stramineipennis*, Koh Kong, 30.06.2012; G) *Notocrypta clavata theba*, Koh Kong, 18.02.2012; H) *Scobura phiditia*, Koh Kong, 26.09.2013; I) *S. isota*, Koh Kong, 25.07.2014; J) *Suada swerga suava*, Koh Kong, 15.01.2011; K) *Cupitha purreea*, Koh Kong, 10.04.2012; L) *Zographetus satwa*, Koh Kong, 14.07.2013; M) *Isma protoclea bicolor*, Siem Reap, 6.09.2012; N) *Pyroneura callineura natalia*, Koh Kong, 22.09.2012; O & P) *P. margherita miriam*, Koh Kong, 17.06.2019. A & B, E–P by G. Chartier; C by E. Smith. Licenses: CC BY; D - Y. Bigant CC BY NC. Not to scale.

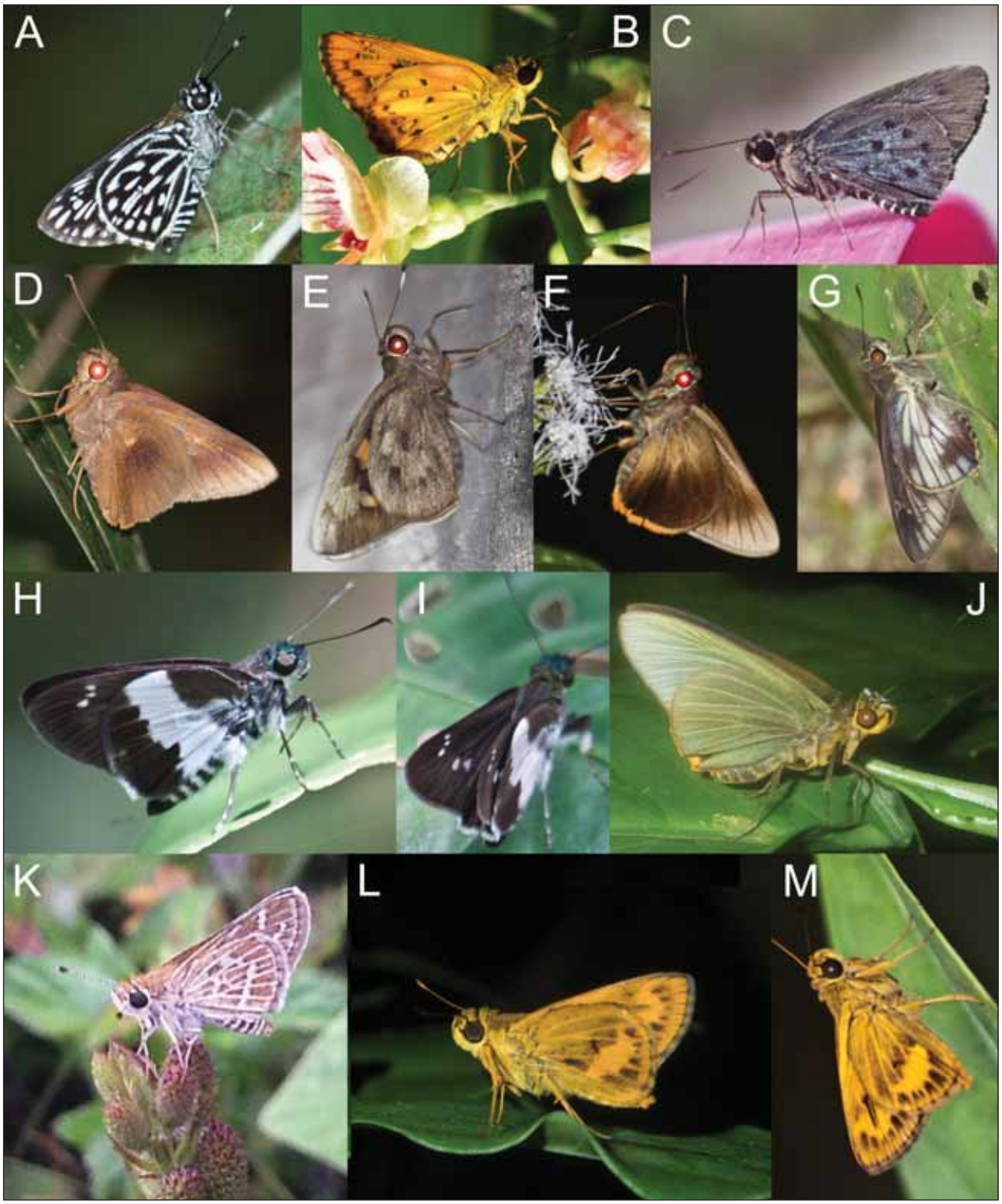

Fig. 8 First records of Hesperiinae (part) taxa in Cambodia: A) *Plastingia naga*, Koh Kong, 3.11.2012; B) *Salanoemia tavoyana*, Siem Reap, 10.08.2018; C) *Salanoemia sala*, Koh Kong, 5.11.2013; D) *Zela zeus optima*, Koh Kong, 23.06.2014; E) *Erionota acroleuca apicalis*, Koh Kong, 7.07.2011; F) *Matapa cresta*, Koh Kong, 18.12.2011; G) *Unkana ambasa attina*, Koh Kong; 16.05.2018; H & I) *Acerbas anthea pista*, Koh Kong, 17.03.2012; J) *Pirdana distanti spenda*, Koh Kong; 10.12.2018; K) *Taractrocera maevius sagara*, Preah Sihanouk, 12.09.2020; L) *Oriens gola pseudolus*, Koh Kong, 1.03.2017; M) *O. gola pseudolus*, Koh Kong, 23.08.2013. A, C–J, L, M by G. Chartier; B by E. Smith; K by D. Snow. Licenses: K - CC BY NC; Others - CC BY. Not to scale.

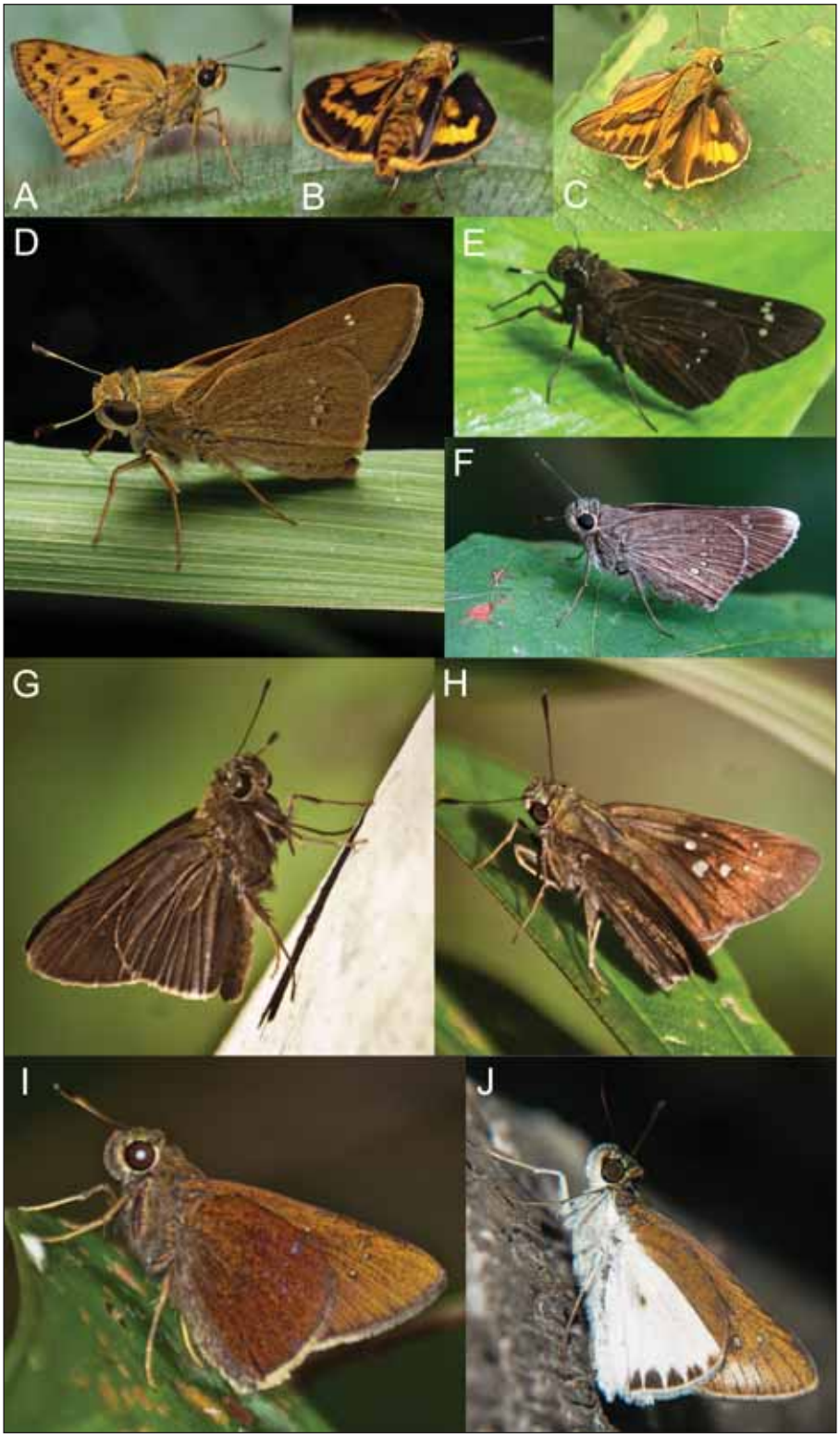

Fig. 9 First records of Hesperiinae (part) taxa in Cambodia: A & B) *Potanthus rectifasciata*, Koh Kong, 18.06.2012; C) *Telicota colon stinga*, Preah Sihanouk, 3.01.2021; D) *Parnara bada bada*, Takeo, 26.06.2021; E) *Pelopidas assamensis*, Koh Kong, 31.08.2010; F) *Polytremis annama*, Siem Reap, 11.08.2017; G & H) *Baoris* sp., ca. *farri*, Koh Kong, 12.07.2013; I) *Caltoris cormasa*, Koh Kong, 25.07.2012; J) *Iton semamora semamora*, Koh Kong, 8.01.2015. A, B, E, G–J by G. Chartier; C, F by E. Smith; D by M. Jeanes. Licenses: D - CC BY NC; Others - CC BY. Not to scale.

Acknowledgements

We are very grateful to Yutaka Inayoshi for reviewing photographs published by Kosterin (2019a, 2019b, 2020) and all those included herein, and for his help resolving some taxonomic issues. We would also like to thank all of the reviewers of previous versions of this article. In particular, we thank Adam Cotton for helping us to resolve taxonomic issues and for liaising with Yutaka Inayoshi. We are grateful to Tek Lin Seow for helping us to identify some difficult butterfly species from photographs. We are also grateful to Eddie Smith and Dani Jump for allowing us to use their images, to Eddie for uploading his observations to iNaturalist (2022), and to Vladimir Dubatolov for helping with literature sources. The work of the second author was partly supported by the Russian State Scientific Project FWNR-2022-0019.

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Annex 1 Annotated checklist of butterflies recorded in Cambodia

For each species, the Latin name, the source of the first record for Cambodia and a list of provinces where it has been recorded are provided.

Citations for first records are coded as follows: 1=Ohya (1983), 2=Fruhstorfer (1902), 3=Onodera (2007), 4=Racheli & Cotton (2010), 5=Monastyrskii *et al*. (2011), 6=Woodfield & Murton (2006), 7=Onodera (2008), 8=Dubois & Vitalis de Salvaza (1914), 9=Boullet & Le Cerf (1912), 10=Kosterin (2019a), 11=Dubois & Vitalis de Salvaza (1919), 12=Shirôzu & Yata (1973), 13=Kosterin (2020), 14=Kosterin (2019b), 15=Monastyrskii (2011), 16=Fruhstorfer (1910), 17=Dubois & Vitalis de Salvaza (1921), 18=Dubois & Vitalis de Salvaza (1924), 19=Fruhstorfer (1911), 20=Fruhstorfer (1914), 21=Onodera (2009), 22=Fruhstorfer (1913), 23=Morishita (1978), 24=Shirôzu & Saigusa (1962), 25=Saito *et al*. (2011), 26=Evans (1957), 27=Cowan (1967), 28=Chartier (2019).

Abbreviations for provinces are as follows: Bbg=Battambang, BM=Banteay Meanchey, KCm=Kampong Cham, KCg=Kampong Chhnang, Kdl=Kandal, KK=Koh Kong, Kpt=Kampot, KS=Kampong Speu, KT=Kampong Thom, Kte=Kratie, MK=Mondulkiri, OM=Oddar Meanchey, PS=Preah Sihanouk, PP=Phnom Penh, Pst=Pursat, PV=Preah Vihear, RK=Ratanakiri, SR=Siem Reap, ST=Stueng Treng, Tak=Takeo, TK=Tbong Kmoun (Fig. 10).

Newly recorded species are indicated with an asterisk after the scientific name and these entries cite the relevant figure in this article and the source of the best (or only) image(s). Where the source is iNaturalist, the reference is given in the format "iN/< ID>" (replace "iN" with "https://www.inaturalist.org/observations" to obtain the link). Where the source is Bees Unlimited, the reference is given in the format "BU/post/<ID>" or "BU/photo/<ID>" (replace "BU" with "https://web.facebook.com/beesunlimited" to obtain the link). Data from both platforms were also taken into account with respect to butterfly species occurrence by provinces.

Fig. 10 Provinces of Cambodia. Note this map is simplified and depicts indicative rather than precise boundaries.

With a few exceptions, taxonomic treatments follow Inayoshi (2022), which currently provides the most comprehensive treatment for the Indochinese butterflies. It should be noted that the first records cited for many species used names other than those accepted by Inayoshi (2022) and here. Such cases are not commented on here and may be resolved by consulting Inayoshi (2022).

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
	Papilionidae			
1	*Troides helena cerberus* (C. & R. Felder, 1865)	1	Kep, KK, KT	
2	*Troides aeacus aeacus* (C. & R. Felder, 1860)	2	Bbg, Kpt, MK, PP, PS, PV, SR	
3	*Atrophaneura varuna* (White, 1842)			
	ssp. *astorion* (Westwood, 1842)	3	RK	
	ssp. *zaleucus* (Hewitson, [1865])	4	West	
4	*Byasa adamsoni adamsoni* (Grose-Smith, 1886)	3	RK	
5	*Byasa polyeuctes polyeuctes* (Doubleday, 1842)	5	Pst	
6	*Losaria doubledayi doubledayi* (Wallace, 1865)	6	KK, PS, RK	
7	*Pachliopta aristolochiae goniopeltis* (Rothschild, 1908)	7	Bbg, Kdl, KK, Kte, MK, PP, Pst, RK, SR	
8	*Chilasa slateri marginata* (Oberthür, 1893)	5	Pst	
9	*Chilasa clytia clytia* (Linnaeus, 1758)	8	Bbg, Kep, KK, MK, PS, Pst, RK, SR	
10	*Chilasa paradoxa telearchus* (Hewitson, 1852)	8	KK, KT, ST	
11	*Papilio demoleus malayanus* Wallace, 1865	9	Bbg, KCg, Kdl, KK, Kep, MK, OM, PP, PS, Pst, PV, RK, SR, ST, Tak	
12	*Papilio demolion demolion* Cramer, 1776	6	KK, SR	
13	*Papilio castor mahadeva* Moore, [1879]	9	MK, PP, PS, Pst, SR	
14	*Papilio nephelus chaon* Westwood, 1845	9	KK, MK, Pst, SR	
15	*Papilio helenus helenus* Linnaeus, 1758	9	KK, Kpt, MK, Pst, RK	
16	*Papilio polytes romulus* Cramer, 1775	9	Kep, KK, Kdl, MK, PP, PS, Pst, RK, SR	
17	*Papilio memnon agenor* Linnaeus, 1758	6	KK, Kte, MK, PS, Pst, SR, RK, Tak	
18	*Papilio paris paris* Linnaeus, 1758	5	Pst, MK	
19	*Graphium sarpedon luctatius* (Fruhstorfer, 1907)	6	KK, MK, PS, Pst, RK, SR, Tak	
20	*Graphium doson actor* Fruhstorfer, 1907	6	KK, MK, PS, RK, SR, ST	
21	*Graphium eurypylus acheron* (Moore, 1885) *	iN/62626430	KK	1A
22	*Graphium agamemnon agamemnon* (Linnaeus, 1758)	6	Bbg, KK, MK, PP, PS, Pst, RK, SR, ST	
23	*Graphium arycles arycles* (Boisduval, 1836)	7	Btg, Kte, KK, PS, SR	
24	*Graphium antiphates nebulosus* (Butler, 1881)	6	Kep, Kpt, KK, MK, PS, RK, SR	
25	*Graphium nomius swinhoei* (Moore, 1878) *	iN/69452672	MK, SR	1B
26	*Graphium aristeus hermocrates* (C. & R. Felder, 1865)	5	Pst, SR	
27	*Graphium agetes agetes* (Westwood, 1843)	10	KK	
28	*Graphium macareus indochinensis* (Fruhstorfer, 1901)	5	Pst, SR	
29	*Graphium xenocles lindos* (Fruhstorfer, 1902)	6	KK, PS, Pst, SR	
30	*Graphium megarus megapenthes* (Fruhstorfer, 1902)	6	KK, PS, Pst, SR	
31	*Lamproptera curius curius* (Fabricius, 1787)	6	KK, Kpt, PS, Pst, SR	
32	*Lamproptera meges annamiticus* (Fruhstorfer, 1909)	6	Kep, KS, MK, PV, RK, SR, ST	
	Pieridae			
	Pierinae			
33	*Leptosia nina nina* (Fabricius, 1793)	6	KK, Kpt, PP, PS, Pst, RK, SR, ST	
34	*Delias vietnamensis pequini* Davenport, 2015	5	Pst	
35	*Delias pasithoe pasithoe* (Linnaeus, 1767)	6	KK, MK, PS, Pst, SR	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
36	*Delias acalis shinkaii* Morita, 1998	5	MK, Pst	
37	*Delias descombesi descombesi* Boisduval, 1836	5	MK, PS, Pst	
38	*Delias agostina annamitica* Fruhstorfer, 1901	5	Pst	
39	*Delias hyparete indica* (Wallace, 1867)	5	KK, MK, PP, PS, Pst, SR, Tak	
40	*Cepora nerissa dapha* (Moore, [1879])	11	PV, RK, SR	
41	*Cepora nadina nadina* (Lucas, 1852)	6	KK, MK, Pst	
42	*Cepora iudith lea* (Doubleday, 1846)	11	Pst, RK, SR, ST	
43	*Prioneris philonome clemanthe* (Doubleday, 1846)	10	KK, Pst, RK	
44	*Prioneris thestylis thestylis* (Doubleday, 1842)	5	Pst	
45	*Appias olferna olferna* Swinhoe, 1890	5	BM, PP, Pst, SR, RK	
46	*Appias lyncida eleonora* (Boisduval, 1836)	3	Kdl, KK, Kpt, Kte, MK, Pst, RK, SR, ST	
47	*Appias albina darada* (C. & R. Felder, 1865)	5	Kep, KK, Kpt, Pst, RK, SR, ST	
48	*Appias paulina adamsoni* Moore, 1905	11	KK	
49	*Appias indra thronion* Fruhstorder, 1910	5	Pst	
50	*Ixias pyrene verna* Druce, 1874	11	Bbg, KK, MK, PV, RK, SR	
51	*Hebomoia glaucippe glaucippe* (Linnaeus, 1758)	5	Kep, KK, Pst, SR	
52	*Pareronia anais anais* Lesson, 1837	3	Bbg, Kep, KK, PV, RK, SR	
	Coliadinae			
53	*Catopsilia scylla cornelia* (Fabricius, 1787)	6	Kep, KK, RK, SR	
54	*Catopsilia pyranthe pyranthe* (Linnaeus, 1758)	3	KK, PP, RK, SR	
55	*Catopsilia pomona pomona* (Fabricius, 1775)	6	Kdl, Kep, KK, Kpt, MK, OM, PP, PS, RK, SR, ST	
56	*Dercas verhuelli doubledayi* Moore, [1905]	7	MK	
57	*Gandaca harina burmana* Moore, 1906	3	KK, Kte, PS, SR	
58	*Eurema brigitta hainana* (Moore, 1878)	6	KK, OM, PV, SR	
59	*Eurema laeta pseudolaeta* (Moore, 1906)	5	Pst	
60	*Eurema hecabe hecabe* (Linnaeus, 1758)	3	Bbg, KK, Kte, MK, PP, PS, PV, RK, SR, ST	
61	*Eurema blanda silhetana* (Wallace, 1867)	7	KK, MK, Tak	
62	*Eurema simulatrix sarinoides* (Fruhstorfer, 1910)	12	KK, Kpt, MK	
63	*Eurema sari sodalis* (Moore, 1886)	12	KK, Kpt, PS, SR	
64	*Eurema andersoni sadanobui* Shirôzu & Yata, 1982	12	KK, Kte, MK, SR	
65	*Eurema novapallida* Yata,1992	5	Pst	
66	*Eurema ada indosinica* Yata, 1991	5	KK, Pst	
	Nymphalidae			
	Danainae			
67	*Danaus chrysippus chrysippus* (Linnaeus, 1758)	13	Bbg, Kte, PP, PS, PV, SR, Tak	
68	*Danaus genutia genutia* (Cramer, 1779)	5	Bbg, KCg, KK, Kte, MK, PP, PS, Pst, RK, SR	
69	*Danaus affinis malayana* (Fruhstorfer, 1899)	10	KK	
70	*Danaus melanippus hegesippus* (Cramer, 1777)	6	KK, PS, PV, SR	
71	*Tirumala gautama gautama* (Moore, 1877)	3	RK	
72	*Tirumala limniace limniace* (Cramer, 1775)	14	MK, ST	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
73	*Tirumala septentrionis septentrionis* (Butler, 1874)	5	Kep, KK, MK, Pst, PV, RK, SR	
74	*Parantica aglea melanoides* Moore, 1883	6	Kep, KK, MK, RK, SR, ST	
75	*Parantica agleoides agleoides* (C. & R. Felder, 1860)	15	KK, PS	
76	*Parantica aspasia aspasia* (Fabricius, 1787)	5	KK, Pst	
77	*Parantica melaneus* (Cramer, 1775)	11	MK	
78	*Parantica swinhoei szechuana* (Fruhstorfer, 1899)	5	Pst	
79	*Parantica sita sita* (Kollar, [1844])	5	Pst	
80	*Ideopsis similis persimilis* (Moore, 1879)	11	PS, SR	
81	*Ideopsis vulgaris contigua* Talbot, 1939	14	KK, PS, SR	
82	*Euploea modesta modesta* Butler, 1866	16	KK, PV, SR, ST	
83	*Euploea crameri praedicabilis* Fruhstorfer, 1914	5	Pst, KK	
84	*Euploea camaralzeman caramalzeman* Butler, 1866	6	KK, SR	
85	*Euploea core godarti* Lucas, 1853	6	Kep, KK, Kpt, MK, PP, PS, RK, SR, ST	
86	*Euploea algea limborgii* Moore, [1879]	7	MK, PV, RK, SR, ST	
87	*Euploea doubledayi doubledayi* (C. & R. Felder, 1860)	3	MK, RK, SR	
88	*Euploea eyndhovii gardineri* (Fruhstorfer, 1898)	3	KK, MK, PS, RK, SR, ST	
89	*Euploea sylvester harrisii* C. & R. Felder, 1865	17	KK, MK, PP, Pst, PV, SR	
90	*Euploea mulciber mulciber* (Cramer, 1777)	6	Kep, KK, KS, MK, PS, RK, SR	
91	*Euploea phaenareta castelnaui* C. & R. Felder, 1865	10	KK, PS	
92	*Euploea midamus chloe* (Guérin-Méneville, [1843])	17	KK, PP, RK	
93	*Euploea klugii erichsonii* (C. & R. Felder, 1865)	3	SR	
94	*Euploea radamanthus radamanthus* (Fabricius, 1793)	11	KK, MK, Pst, RK	
	Satyrinae			
95	*Melanitis leda leda* (Linnaeus, 1758)	6	Btg, Kep, KK, MK, PP, PS, Pst, PV, RK, SR	
96	*Melanitis phedima ganapati* Fruhstorfer, 1908 *	iN/68723543	ST	1C
97	*Elymnias hypermnestra meridionalis* Fruhstorfer, 1902	6	Kep, KK, Kpt, MK, PS, Pst, PV, SR	
98	*Elymnias patna patna* (Westwood, 1851)	5	KK, Pst	
99	*Elymnias nesaea apelles* Fruhstorfer, 1902	6	KK, Pst, RK, SR	
100	*Elymnias malelas* (Hewitson, 1863)	3	Pst, RK	
101	*Elymnias vasudeva* Moore, [1858] *	iN/64500919	MK	1D
102	*Lethe europa niladana* Fruhstorfer, 1911	11	KK, Pst, SR	
103	*Lethe rohria rohria* (Fabricius, 1787)	14	MK	
104	*Lethe confusa confusa* Aurivillius, [1898]	5	Pst	
105	*Lethe mekara crijnana* Fruhstorfer, 1911	10	KK	
106	*Lethe chandica suvarna* Fruhstorfer, 1908	5	Pst	
107	*Lethe vindhya vindhya* (C. & R. Felder, 1859)	5	Pst	
108	*Lethe kansa* (Moore, 1857)	5	Pst	
109	*Lethe minerva tritogeneia* Fruhstorfer, 1911	5	KK, Pst, RK	
110	*Penthema darlisa mimetica* Lathy, 1900	6	KK, Pst	
111	*Orsotriaena medus medus* (Fabricius, 1775)	6	Kep, KK, OM, Pst, PV, RK, SR, ST	
112	*Mycalesis mnasicles perna* Fruhstorfer, 1906	6	KK	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
113	*Mycalesis sangaica tunicula* Fruhstorfer, 1911	3	RK	
114	*Mycalesis perseus tabitha* (Fabricius, 1793)	3	KK, MK, Pst, PV, RK, ST	
115	*Mycalesis perseoides perseoides* (Moore, [1892])	3	KK, Pst, RK, SR	
116	*Mycalesis mineus* (Linnaeus, 1758)	3	Kte, MK, Pst, RK	
117	*Mycalesis intermedia* (Moore, [1892])	3	Kep, KK, MK, RK, SR	
118	*Mycalesis gotama charaka* Moore, 1874	5	Pst	
119	*Mycalesis anaxias aemate* Fruhstorfer (1911)	6	KK, Pst	
120	*Mycalesis anaxioides* Marshall & Nicéville, 1883	10	KK	
121	*Mycalesis annamitica annamitica* Fruhstorfer, 1906	7	MK	
122	*Mycalesis lepcha kohimensis* Tytler, 1914	5	Pst	
123	*Coelites nothis nothis* Westwood, 1850	14	RK	
124	*Erites medura rotundata* Nicéville, 1893 *	iN/51369698	Kte	1E
125	*Erites falcipennis* Wood-Mason & Nicéville, 1883	5	Pst	
126	*Ragadia crisilda* Hewitson, 1862	5	KS, Pst	
127	*Ypthima baldus baldus* (Fabricius, 1775)	3	Kep, KK, MK, Pst, PV, RK, SR	
128	*Ypthima singorensis indosinica* Uémura & Monastyrskii, 2004	3	MK, Pst, RK	
129	*Ypthima nebulosa* Aoki & Uémura, 1982	5	Pst	
130	*Ypthima lisandra lisandra* (Cramer, 1780)	5	Pst	
131	*Ypthima savara* Grose-Smith, 1887	18	KK, PP, Pst	
132	*Ypthima norma annamitica* Fruhstorfer, 1911	5	MK, Pst	
133	*Ypthima huebneri* Kirby, 1871	7	KK, MK, PS, SR	
134	*Faunis canens arcesilas* Stichel, 1933	5	Pst	
135	*Melanocyma faunula kimurai* Saitoh, 2003	19	KK, Pst	
136	*Stichophthalma cambodia* (Hewitson, [1862])	11	KK, MK, Pst	
137	*Amathusia phidippus phidippus* (Linnaeus, 1763)	11	KK, MK, PS, Pst, SR	
138	*Amathuxidia amythaon annamensis* Talbot, 1932	5	Pst, SR	
139	*Zeuxidia masoni tannowai* Saito & Kimura, 2016	6	KK	
140	*Thaumantis diores* Doubleday, 1845	5	Pst	
	Thauria Moore, 1894 sp. *	BU/photos/ 733830503358661	SR	1F
141	*Discophora sondaica zal* Westwood, [1861] *	iN/62459713 iN/62459708	KK, SR	1G-H
142	*Discophora aestheta* Monastyrskii & Devyatkin, 2003	6 [1]	KK	
143	*Discophora deo fruhstorferi* Stichel, 1901	5	Pst	
144	*Discophora timora timora* Westwood, [1850]	10	KK	
145	*Enispe euthymius congi* Saito, 2015	5 [2]	Pst	
	Charaxinae			
146	*Polyura schreiber assamensis* (Rothschild, 1899)	6	KK, Pst, SR	
147	*Polyura delphis delphis* (Doubleday,1843) *	iN/61935221	KK, MK	2A
148	*Polyura jalysus jalysus* (C. & R. Felder, [1867]) *	iN/61935688	KK, SR	2B
149	*Polyura athamas athamas* (Drury, [1773])	5	KK, Kpt, MK, PS, Pst, RK, SR	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
150	*Polyura arja arja* (C. & R. Felder, 1867)	6	KK, MK, RK, SR	
151	*Polyura eudamippus nigrobasalis* Lathy, 1898	20	PP	
152	*Charaxes solon sulphureus* Rothschild, 1900	21	KK, MK, SR	
153	*Charaxes durnfordi* Distant, 1884	5	Pst	
154	*Charaxes bernardus hierax* C. & R. Felder, [1867]	6	KK, Kte, MK, PV, SR, ST	
	Heliconiinae			
155	*Acraea terpsicore* (Linnaeus, 1758)	21	KK, Kpt, Kte, PP, PS, RK, SR	
156	*Cupha erymanthis erymanthis* (Drury, [1773])	6	Kep, KK, MK, PS, RK, SR, ST	
157	*Phalanta phalantha phalantha* (Drury, 1773)	5	PS, Pst, PV, SR	
158	*Phalanta alcippe alcippoides* (Moore, 1900)	11	Pst	
159	*Vagrans sinha sinha* (Kollar, [1884])	5	KCg, KK, MK, Pst	
160	*Vindula erota erota* (Fabricius, 1798)	6	KK, Kpt, MK, Pst, SR	
161	*Vindula dejone erotella* (Butler, [1879])	3	RK, SR	
162	*Cirrochroa tyche mithila* Moore, 1872	6	KK, MK, Pst, RK, SR, ST, Tak	
163	*Cirrochroa surya siamensis* Fruhstorfer, 1906	13	SR, PV	
164	*Cirrochroa emalea emalea* (Guérin-Méneville, [1843]) *	iN/69917641	Pst	2C
165	*Algia fasciata fasciata* (C. & R. Felder, 1860)	5	Pst, SR	
166	*Terinos terpander intermedia* Godfrey, 1916	6	KK, PS, PV, RK	
167	*Terinos clarissa militum* Oberthür, 1897	5	KK, Pst, RK	
168	*Cethosia biblis biblis* (Drury, 1773) *	iN/62176842	KK	2D
169	*Cethosia cyane euanthes* (Fruhstorfer, 1912)	3	KCg, Kep, KK, Kpt, MK, PS, Pst, PV, SR, ST, Tak	
	Limenitidinae			
170	*Pantoporia hordonia hordonia* (Stoll, 1790)	3	KK, MK, PS, Pst, PV, SR, RK	
171	*Pantoporia sandaka davidsoni* Eliot, 1969	7	KK, MK, Pst, PV, SR, ST	
172	*Pantoporia paraka paraka* (Butler, [1879])	3	KK, SR, ST	
173	*Lasippa camboja* (Moore, 1879)	11	KK, MK, PS, SR	
174	*Lasippa monata monata* (Weyenbergh, 1874) *	iN/68261443	SR	2E
175	*Neptis clinia susruta* Moore, 1872	5	KK, Pst, SR	
176	*Neptis hylas kamarupa* Moore, 1875	3	Bbg, Kep, KK, KT, MK, PP, PS, Pst, PV, RK, SR, ST	
177	*Neptis soma shania* Evans,1924	5	Pst	
178	*Neptis nata adipala* Moore, 1872	3	KK, MK, RK, SR	
179	*Neptis leucoporos cresina* Fruhstorfer, 1908	5	Pst, ST	
180	*Neptis harita preeyai* Kimura, 1993 *	BU/posts/5469051613169836	KK, SR	2F
181	*Neptis ilira cindia* Eliot, 1969 *	iN/62386022	KK	2G
182	*Neptis miah nolana* Druce, 1874 *	iN/39646852	SR	2H
183	*Neptis cartica* Moore, 1872	5	KK, Pst, SR	
184	*Neptis magadha magadha* C. & R. Felder, [1867]	3	KK, MK, SR	
185	*Neptis anjana* Moore, 1881	5	Pst	
186	*Phaedyma columella martabana* (Moore, 1881)	6	KK, Pst, SR, ST	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
187	*Athyma pravara indosinica* Fruhstorfer,1906	5	Pst	
188	*Athyma perius perius* (Linnaeus, 1758)	6	KCg, KK, MK, PS, Pst, RK, SR	
189	*Athyma kanwa phorkys* (Fruhstorfer, 1912)	5	KK, Pst	
190	*Athyma ranga obsolescens* (Fruhstorfer, 1906)	13	KK, SR, ST	
191	*Athyma selenophora bahula* Moore, [1858]	11	KK, Pst, SR	
192	*Athyma zeroca galaesus* (Fruhstorfer,1912)	11	Pst	
193	*Athyma cama camasa* (Fruhstorfer, 1906)	18	Pst	
194	*Athyma nefte asita* Moore, [1858]	3	KK, Pst, SR	
195	*Athyma sinope sinope* (Moore, [1858]) *	iN/62386907	KK	2I
196	*Sumalia daraxa daraxa* (Doubleday, 1848)	5	Pst	
197	*Tacola larymna siamensis* (Fruhstorfer, 1906)	5	KK, Pst	
198	*Moduza procris procris* Cramer, 1777	6	KK, Kte, MK, PS, SR, ST	
199	*Parthenos sylvia sylla* (Westwood, 1838)	6	KK, MK, Pst, RK, SR, ST	
200	*Lebadea martha martha* (Fabricius, 1787)	6	Kep, KK, Kpt, MK, PS, Pst, PV, RK, SR, ST, Tak	
201	*Tanaecia julii julii* (Lesson, 1837)	6	Kep, KK, Kpt, MK, PS, Pst, SR, ST	
202	*Tanaecia jahnu* (Moore, [1858])	6	KK, Kte, Pst, PV, SR	
203	*Cynitia lepidea cognata* Moore, [1897]	22	KK, Pst, PS, PV, SR, ST	
204	*Cynitia cocytus ambrysus* (Fruhstorfer, 1913)	11	KK, MK, SR	
205	*Euthalia djata siamica* Riley & Godfrey, 1925	7	KK, MK, SR	
206	*Euthalia lubentina lubentina* (Cramer, 1777)	6	KK, Pst, SR	
207	*Euthalia malaccana malaccana* Fruhstorder, 1899	10	KK	
208	*Euthalia anosia anosia* (Moore, [1858])	3	KK, SR	
209	*Euthalia eriphylae lioneli* Fruhstorfer, 1905	3	SR	
210	*Euthalia phemius phemius* (Doubleday, [1848])	10	Kep, KK, MK	
211	*Euthalia aconthea garuda* (Moore, 1858)	5	BM, Keo, KK, PS, Pst, PV, SR	
212	*Euthalia alpheda verena* Fruhstorfer, 1913	5	KK, Pst, MK	
213	*Euthalia monina kesava* (Moore, 1859)	22	KK, SR	
214	*Euthalia monilis* (Moore, [1897])	13	SR	
215	*Euthalia evelina annamita* (Moore, 1879)	6	KK, PS, SR	
216	*Lexias albopunctata albopunctata* (Crowley, 1895)	6	KK, Pst, PV, SR, ST, Tak	
217	*Lexias pardalis jadeitina* (Fruhstorfer, 1913)	21	KK, MK, Pst, PV, RK, SR, ST	
	Cyrestinae			
218	*Cyrestis themire* Honarth, 1884	10	KK, SR, MK	
219	*Cyrestis cocles cocles* (Fabricius, 1787)	3	Kpt, Pst. RK, SR	
220	*Cyrestis thyodamas thyodamas* Doyère, 1840	5	Kpt, Pst, SR	
221	*Chersonesia risa risa* (Doubleday, [1848])	5	KK, Pst	
222	*Chersonesia intermedia rahrioides* Moore, [1899]	5	KK, Pst, SR	
	Pseudergolinae			
223	*Dichorragia nesimachus nesimachus* (Doyère, 1840)	5	Pst	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
	Biblidinae			
224	*Ariadne ariadne pallidior* (Fruhstorfer, 1899)	11	Kte, PS, Pst, RK, SR	
225	*Ariadne specularia arca* (Fruhstorfer, 1906)	5	Kep, KK, Pst, RK, SR	
226	*Ariadne merione tapestrina* (Moore, 1884)	5	KK, MK, Pst, SR, ST	
	Apaturinae			
227	*Rohana parisatis pseudosiamensis* Nguyen-Phung, 1985	5	Pst, SR	
228	*Euripus nyctelius nyctelius* (Doubleday, 1845)	14	KK, MK, PV, SR	
	Nymphalinae			
229	*Kaniska canace canace* (Linnaeus, 1763)	5	MK, Pst, SR	
230	*Symbrenthia lilaea lilaea* (Hewitson, 1864)	5	Pst	
231	*Symbrenthia hypselis cotanda* Moore, 1874	5	Pst	
232	*Yoma sabina vasuki* Doherty, [1886]	14	MK, SR, ST	
233	*Hypolimnas bolina jacintha* (Drury, [1773])	5	BM, KCg, Kdl, Kep, KK, Kpt, MK, PP, PS, Pst, RK, SR	
234	*Hypolimnas misippus* (Linnaeus, 1764) *	iN/68268027	SR, Bbg	3A
235	*Junonia iphita iphita* (Cramer, 1779)	7	KK, MK, Pst, PV, RK, SR	
236	*Junonia atlites atlites* (Linnaeus, 1763)	6	Bbg, KCm, Kep, KK, Kpt, KS, KT, MK, PP, Pst, RK, SR, ST, Tak	
237	*Junonia almana almana* (Linnaeus, 1758)	6	Bbg, KCg, Kep, KK, Kte, MK, PP, PS, Pst, PV, RK, SR, ST, Tak	
238	*Junonia lemonias lemonias* (Linnaeus, 1758)	7	Bbg, Kep, KK, MK, PP, Pst, RK, SR, ST	
239	*Junonia orithya ocyale* (Hübner, 1819)	6	KCg, Kep, KK, MK, PS, RK, SR, ST, Tak	
240	*Junonia hierta hierta* (Fabricius, 1798)	14	MK, PS, RK, SR	
241	*Kallima inachus alboinachus* Nakamura & Wakahara, 2013	14	MK	
242	*Kallima alicia kishii* Nakamura & Wakahara, 2014 [3]	5	Pst	
243	*Doleschallia bisaltide siamensis* Fruhstorfer, 1912	13	PS, SR	
	Libytheinae			
244	*Libythea myrrha sanguinalis* Fruhstorfer, 1898 *	iN/67512948	SR	3B
245	*Libythea narina rohini* Marshall, [1881]	5	Pst, SR	
	Riodinidae			
246	*Zemeros flegyas flegyas* (Cramer, [1780])	5	Kep, KK, MK, PS, Pst	
247	*Dodona deodata deodata* Hewitson, 1876	5	Pst	
248	*Abisara echerius paionea* Fruhstorfer, 1914	10	KK	
249	*Abisara bifasciata angulata* Moore, [1879]	14	RK	
250	*Abisara latifasciata* Inoué & Kawazoé, 1965	3	MK	
251	*Abisara saturata meta* Fruhstorfer, [1904] *	BU/photos/521711341237246	PV, SR	3C
252	*Archigenes neophron gratius* Fruhstorfer, 1912	5	KK, Pst	
253	*Paralaxita telesia boulleti* (Fruhstorfer, 1914) *	iN/69917778	MK	3D
254	*Laxita thuisto ephorus* (Fruhstorfer, [1904]) *	iN/61288667	KK	3E

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
255	*Taxila haquinus berthae* Fruhstorfer, 1904	6	KK, Kpt, PS, Pst	
256	*Stiboges nymphidia nymphidia* Butler,1876	5	Pst	
	Lycaenidae			
	Poritinae			
257	*Poritia erycinoides elsiei* Evans, 1925	14 [4]	MK	
258	*Poritia hewitsoni tavoyana* Doherty, 1889	13	KK, ST	
259	*Simiskina phalia potina* (Hewitson, 1874) *	iN/61286547	KK	3F
	Miletinae			
260	*Liphyra brassolis brassolis* Westwood, [1864] *	BU/photos/ 637780946296951	SR	3G
261	*Miletus chinensis learchus* C. & R. Felder, 1865	5	KK, Pst, SR	
262	*Miletus mallus mallus* (Fruhstorfer, 1913)	5	KK, Pst	
263	*Miletus ancon siamensis* (Godfrey, 1916)	13	SR	
264	*Allotinus unicolor rekkia* Riley & Godfrey. 1921	3	KK, PS, Pst, SR	
265	*Allotinus substrigosus substrigosus* (Moore, 1884) *	iN/60783790	KK	3H
266	*Logania marmorata marmorata* Moore, 1884	5	KK, Pst	
267	*Spalgis epius epius* (Westwood, [1851]) *	BU/posts/ 5977438032331189	KK, SR	3I
	Curetinae			
268	*Curetis bulis bulis* (Westwood, [1851])	7	KK, SR	
269	*Curetis metayei* Inoué & Kawazoé, 1965	23	?	
270	*Curetis saronis indosinica* Fruhstorfer, 1908	7	KK, MK, PP, SR	
	Polyommatinae			
271	*Castalius rosimon rosimon* (Fabricius, 1775)	24	Bbg, Kep, KK, MK, PP, PS, Pst, PV, RK, SR, ST	
272	*Tarucus callinara* Butler, 1886	25	KS	
273	*Discolampa ethion ethion* (Westwood, [1851])	3	KK, MK, Pst, RK, SR	
274	*Caleta roxus roxana* (Nicéville, 1897)	3	KK, MK, Pst, RK, SR	
275	*Caleta elna noliteia* (Fruhstorfer, 1918)	7	MK, SR	
276	*Caleta decidia decidia* (Hewitson, [1876])	7	MK	
277	*Everes lacturnus rileyi* Godfrey, 1916	7	KK, PS, MK, Pst, SR	
278	*Pithecops corvus correctus* Cowan, 1966	5	MK, Pst	
279	*Neopithecops zalmora zalmora* (Butler, [1870])	24	KK, MK, PS, Pst, PV, RK, SR	
280	*Megisba malaya sikkima* Moore, 1884	7	KK, MK, Pst, SR	
281	*Lestranicus transpectus* (Moore, 1879)	5	Pst	
282	*Udara dilecta dilecta* (Moore, 1879)	5	Pst	
283	*Udara placidula howarthi* (Cantlie & Norman, 1960)	5	Pst	
284	*Udara selma cerima* (Corbet, 1937)	10	Kpt	
285	*Udara albocaerulea albocaerulea* (Moore, 1879)	5	Pst	
286	*Acytolepis puspa gisca* (Fruhstorfer, 1910)	6	KK, MK, Pst, RK, SR, ST	
287	*Celatoxia marginata marginata* (Nicéville, [1884])	5	Pst	
288	*Celastrina lavendularis limbata* (Moore, 1879)	5	KK, MK, Pst	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
289	*Callenya melaena melaena* (Doherty, 1889) [5]	5	Pst	
290	*Zizina otis sangra* (Moore, [1866])	3	KK, MK, PP, PS, Pst, PV, RK, SR	
291	*Pseudozizeeria maha maha* (Kollar, 1844)	14	MK	
292	*Zizeeria karsandra* (Moore, 1865)	10	Kdl, Kep, KK, PP, PS, SR	
293	*Zizula hylax hylax* (Fabricius, 1775)	5	Bbg, Kep, PP, PS, Pst, SR	
294	*Famegana nisa* (Wallace & Moore, 1866) *	iN/67509510	SR	4A
295	*Freyeria putli* (Kollar, [1844]) *	iN/67509507	PV, SR	4B
296	*Freyeria trochylus orientalis* (Forster, 1980) *	iN/39569324	Kdl	4C
297	*Chilades lajus lajus* (Stoll, 1780)	3	Pst, MK, PP, SR	
298	*Chilades pandava pandava* (Horsfield, [1829])	24	Bbg, BM, Kep, KT, MK, PP, PS, SR, ST	
299	*Euchrysops cnejus* (Fabricius, 1798)	5	Bbg, KK, Pst, PV, SR, ST	
300	*Catochrysops strabo strabo* (Fabricius, 1793)	21	KK, PS, Pst, MK, SR, ST	
301	*Catochrysops panormus exiguus* (Distant, 1886)	7	KK, MK, Pst, ST	
302	*Leptotes plinius plinius* (Fabricius, 1793)	7	Kte, MK, Pst, SR	
303	*Lampides boeticus* (Linnaeus, 1758)	10	Bbg, KK, MK	
304	*Jamides bochus bochus* (Stoll, 1782) *	iN/60971906	KK, MK, SR	4D
305	*Jamides celeno aelianus* (Fabricius, 1793)	24	Kep, KK, MK, SR, ST, PV	
306	*Jamides pura pura* (Moore, 1886)	3	KK, RK, SR	
307	*Jamides philatus subditus* (Moore, 1886)	5	KK, Pst	
308	*Jamides alecto alocina* Swinhoe, 1915	3	Kep, KK, Kte, PS, Pst, RK	
309	*Nacaduba pactolus continentalis* Fruhstorfer, 1916 *	iN/61186740	KK	4E
310	*Nacaduba solta* Eliot, 1955	5	Pst	
311	*Nacaduba subperusia lysa* Fruhstorfer, 1916	5	KK, Pst	
312	*Nacaduba sanaya elioti* Corbet, 1938	5	KK, Pst, SR	
313	*Nacaduba kurava euplea* Fruhstorfer, 1916	5	KK, Pst	
314	*Nacaduba beroe gythion* Fruhstorfer, 1916	5	KK, MK, Pst	
315	*Nacaduba berenice aphya* Fruhstorfer, 1916	21	KK, MK, SR	
316	*Nacaduba calauria* (C. Felder, 1860)	5	Pst	
317	*Nacaduba kirtoni* Eliot, 1984	5	Pst	
318	*Ionolyce helicon merguiana* (Moore, 1884)	5	KK, Pst	
319	*Prosotas aluta coelestis* (Wood-Mason & Niceville, [1887])	13	SR	
320	*Prosotas bhutea bhutea* (Nicéville, [1884])	5	Pst	
321	*Prosotas nora ardates* (Moore, 1874)	3	KK, PP, Pst, SR, ST	
322	*Prosotas pia marginata* Tite, 1963	5	Pst	
323	*Prosotas dubiosa indica* (Evans, 1925)	21	KK, PP, SR, ST	
324	*Prosotas lutea sivoka* (Evans, 1910) *	iN/67565123	SR	4F
325	*Una usta usta* (Distant, 1886)	7	KK, MK	
326	*Anthene emolus emolus* (Godart, 1824)	24	KK, MK, PS, PV, RK, SR, ST	
327	*Anthene lycaenina lycambes* (Hewitson, [1878]) *	iN/60805458	KK, Kpt	4G
328	*Anthene licates dusuntua* Corbet, 1940	13	KK, SR	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
	Lycaeninae			
329	*Heliophoris epicles latilimbata* (Fruhstorfer, 1908)	5	Pst	
	Aphnaeinae			
330	*Spindasis vulcanus tavoyanus* Evans, 1925	3	RK, ST	
331	*Spindasis syama peguanus* (Moore, 1884)	3	Kep, PV, RK, SR, ST	
332	*Spindasis lohita himalayana* (Moore, 1884)	10	KK, MK, PP, PS, PV, SR, ST, Tak	
	Theclinae			
333	*Arhopala centaurus nakula* (C. & R. Felder, 1860)	3	Btg, KK, Kpt, MK, PP, PS, PV, RK, SR, ST, Tak	
334	*Arhopala anthelus* (Westwood, 1852)	21	KK, KS, SR, ST	
335	*Arhopala camdana* Corbet, 1941	13	KK	
336	*Arhopala bazaloides bazaloides* (Hewitson, 1878)	10	PS	
337	*Arhopala atosia jahara* Corbet, 1941	10	KK, Pst	
338	*Arhopala allata atarana* (Tytler, 1926)	13	SR	
339	*Arhopala moolaiana maya* (Evans, 1932)	13	Pst	
340	*Arhopala perimuta perimuta* (Moore, 1858)	6	KK, MK, PS, Pst, SR	
341	*Arhopala elopura* Druce, 1894	14	KK, MK, PS, PV, SR, ST	
342	*Arhopala alitaeus mirabella* Doherty, 1889	10	KK, SR, ST	
343	*Arhopala aida aida* Nicéville, 1889	10	Kep, KK, Kpt, PS, SR	
344	*Arhopala atrax* (Hewitson, 1862)	13	PV, SR, ST	
345	*Arhopala agrata binghami* Corbet, 1946	13	KK, Pst	
346	*Arhopala milleri* Corbet, 1941 *	iN/61449629	KK	4H
347	*Arhopala nicevillei* Bethune-Baker, 1903	14	MK	
348	*Arhopala cleander regia* (Evans, 1825)	5	Pst	
349	*Arhopala athada apha* Nicéville, 1895	7	KK, SR	
350	*Arhopala silhetensis silhetensis* (Hewitson, 1862)	13	KK, SR	
351	*Arhopala agaba* (Hewitson, 1862)	5	Pst, SR	
352	*Arhopala paralea* (Evans, 1925)	5	Pst	
353	*Arhopala arvina aboe* Nicéville, 1895	5	Pst	
354	*Arhopala alesia sacharja* Fruhstorfer, 1914	13	PV, SR	
355	*Arhopala asinarus asinarus* C. & R. Felder, 1865 *	iN/38325269	SR	4I
356	*Arhopala eumolphus eumolphus* (Cramer, 1780)	7	MK, SR	
357	*Arhopala hellenore hellenore* Doherty, 1889	26	KK, Pst	
358	*Arhopala corinda corestes* Corbet, 1941 *	iN/61451144	KK	4J
359	*Arhopala paraganesa zephyretta* (Doherty, 1891)	5	Pst	
360	*Arhopala ammonides ammonides* (Doherty, 1891)	13	Pst	
361	*Flos abseus indicus* (Riley, 1923)	10	KK	
362	*Flos diardi diardi* (Hewitson, 1862)	5	KK, PS, Pst, SR	
363	*Flos fulgida fulgida* (Hewitson, [1863])	26	KK	
364	*Flos apidanus ahamus* Doherty, 1891	5	KK, Pst	
365	*Flos areste* (Hewitson, 1862)	5	Pst	
366	*Flos asoka* (Nicéville, [1884]) *	iN/61649400	KK	4K

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
367	*Semanga superba siamensis* Talbot, 1936	5	KK, Pst	
368	*Surendra quercetorum quercetorum* (Moore, 1858)	3	MK, Pst, RK, SR	
369	*Surendra vivarna neritos* (Fruhstorfer, 1907)	5	KK, Pst	
370	*Zinaspa todara karennia* (Evans, 1925) *	BU [6]	SR	4L
371	*Iraota timoleon timoleon* (Stoll, 1790)	7	MK, Pst	
372	*Iraota rochana pandara* Fruhstorfer, 1907	21	KK, MK	
373	*Amblypodia anita anita* Hewitson, 1862	7	KK, MK, SR	
374	*Catapaecilma major albicans* Corbet, 1941 *	iN/61465744	KK	4M
375	*Drina donina donina* (Hewitson, 1865)	5	Pst	
376	*Neomyrina hiemalis* (Distant & Salvin, 1878)	3	KK, MK, RK, SR	
377	*Loxura atymnus continentalis* Fruhstorfer, [1912]	6	Kep, KK, MK, PS, Pst, PV, RK, SR	
378	*Loxura cassiopea* Distant, 1884	5	KK, Pst	
379	*Yasoda tripunctata tripunctata* (Hewitson, 1863)	6	KK, MK, PS, Pst, SR	
380	*Thamala marciana* (Hewitson, [1863])	21	SR	
381	*Cheritra freja evansi* Cowan, 1965	3	KK, Kte, MK, PS, Pst, RK, SR, ST	
382	*Ticherra acte acte* (Moore, [1858])	27	?	
383	*Ahmetia achaja achaja* (Fruhstorfer, [1912])	14	RK	
384	*Drupadia ravindra boisduvalii* Moore, 1884	6	KK, Pst, SR	
385	*Drupadia theda fabricii* Moore, 1884	13	KK, SR, ST	
386	*Horaga syrinx moulmeina* Moore, [1884]	5	Pst	
	Dacalana Moore, 1884 sp *	iN/61571413	KK	4N
387	*Pratapa icetoides icetoides* (Elwes, [1893])	5	Pst	
388	*Tajuria cippus cippus* (Fabricius, 1798)	5	KK, Pst	
389	*Bullis buto buto* (Nicéville, 1895) *	iN/71545620	MK	4O
390	*Rachana jalindra indra* (Moore, 1884)	6	KK, Pst	
391	*Neocheritra fabronia fabronia* (Hewitson, [1878]) *	iN/67510129	SR	5A
392	*Suasa lisides* (Hewitson, [1863]) *	iN/61765378	KK	5B
393	*Remelana jangala ravata* (Moore, [1866])	3	KK, SR	
394	*Ancema blanka minturna* (Fruhstorfer, [1912]) *	iN/68261656	SR	5C
395	*Hypolycaena thecloides thecloides* (C. & R. Felder, 1860)	25	KK, KS, MK	
396	*Hypolycaena erylus himavantus* Fruhstorfer, 1912	24	KK, Kpt, MK, PS, Pst, PV, RK, SR, ST	
397	*Hypolycaena amasa amasa* (Hewitson, [1865])	6	KK, Kpt, MK, PS, Pst, RK, SR, ST	
398	*Hypolycaena othona othona* Hewitson, [1865]	6	KK	
399	*Deudorix epijarbas epijarbas* (Moore, [1858])	5	Pst	
400	*Artipe eryx eryx* (Linnaeus, 1771)	5	Pst	
401	*Virachola perse perse* (Hewitson, [1863]) *	iN/68261618	SR	5D
402	*Virachola smilis* (Hewitson, [1863])	5	Pst	
403	*Virachola kessuma* (Horsfield, 1829)	14	MK, SR	
404	*Sinthusa nasaka amba* Kirby, 1878	10	Kpt	
405	*Sinthusa chandrana margala* Fruhstorfer, [1912]	14	MK	

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
406	*Bindahara phocides phocides* (Fabricius, 1793) *	iN/61465415	KK	5E
407	*Rapala duma duma* (Hewitson, [1878])	5	Pst	
408	*Rapala pheretima petosiris* (Hewitson, 1863)	3	KK, MK, PS, RK, SR	
409	*Rapala suffusa suffusa* (Moore, [1879]) *	iN/61763659	KK	5F
410	*Rapala persephone* Saito, 2011 [7]	21	SR	
411	*Rapala damona* Swinhoe, 1890	7	MK	
412	*Rapala dieneces dieneces* (Hewitson, [1878])	7	KK, MK, PV, ST	
413	*Rapala iarbus iarbus* (Fabricius, 1787)	3	KK, MK, RK, SR	
414	*Rapala manea schistacea* (Moore, 1879)	5	KK, MK, Pst, SR	
415	*Rapala scintilla scintilla* Nicéville, 1890	5	Pst	
416	*Rapala varuna orseis* Hewitson, [1863]	5	Pst, SR	
417	*Araotes lapithis lapithis* (Moore, [1858]) *	iN/40752780	SR	5G
	Hesperiidae			
	Coeliadinae			
418	*Burara oedipodea belesis* (Mabille, 1876)	13	SR	
419	*Burara jaina margana* Fruhstorfer, 1911 *	iN/36818296	KK	6A
420	*Burara etelka etelka* (Hewitson, [1867]) *	iN/36818228	KK, SR	6B
421	*Burara harisa harisa* (Moore, [1866])	10	KK, PS	
422	*Burara gomata gomata* (Moore, [1866]) *	BU/posts/ 4386592534749088	SR	6C
423	*Bibasis mahintha* (Moore,[1875]) *	BU/posts/ 4283746771700332	SR	6D-E
424	*Bibasis sena sena* (Moore, 1866)	14	RK, SR	
425	*Hasora proxissima siamica* Evans, 1932	21	KK, SR, ST	
426	*Hasora chromus chromus* (Cramer, 1780)	13	KK, ST	
427	*Hasora malayana malayana* (C. & R. Felder, 1860)	21	KK, SR	
428	*Hasora schoenherr gaspa* Evans, 1949 *	iN/47829737	KK	6F
429	*Hasora badra badra* (Moore, [1858]) *	iN/47818219	KK, SR	6G
430	*Hasora vitta indica* Evans, 1932 *	iN/47833688	KK	6H
431	*Hasora leucospila leucospila* (Mabille, 1891) *	iN/47818669	KK	6I
432	*Badamia exclamationis* (Fabricius, 1775)	10	KK, PV, SR, ST	
	Pyrginae			
433	*Capila phanaeus* (Hewitson, 1867) *			
	ssp. *decoloris* Inoué & Kawazoé 1964 *	BU/photos/ 6092573990817592	SR	6J
	ssp. *falta* Evans, 1949 *	iN/60591557	KK	6K
434	*Capila hainana hainana* Crowley, 1900 *	iN/60590674 iN/60590675	KK	6L-M
435	*Celaenorrhinus asmara consertus* Nicéville, 1890	3	SR	
436	*Odina decorata* (Hewitson,1867)	10	KK, SR	
437	*Pseudocoladenia dan dhyana* (Fruhstorfer, 1909)	13	SR	
438	*Coladenia indrani uposathra* Fruhstorfer, 1910 *	iN/68261376	SR	6N

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
439	*Sarangesa dasahara dasahara* (Moore, [1866])	7	MK, PV	
440	*Chamunda chamunda* (Moore, [1866]) *	iN/60592598	KK	6O
441	*Gerosis bhagava bhagava* (Moore, [1866]) *	iN/69917674	SR	6P
442	*Gerosis limax dirae* (Nicéville, 1895) *	iN/60592753	KK	7A
443	*Tagiades japetus ravi* (Moore, 1866)	3	Kep, KK, Kpt, PS, PV, SR, ST	
444	*Tagiades gana meetana* Moore, 1879	3	Kep, KK, MK, PS, SR	
445	*Tagiades parra gala* Evans, 1949 *	iN/60595441	KK	7B
446	*Tagiades vajuna vajuna* Fruhstorfer, 1910	3	KK, RK, SR	
447	*Tagiades menaka menaka* (Moore, 1866)	10	Kpt	
448	*Odontoptilum angulata angulata* (C. Felder, 1862)	3	KT, MK, PS, RK, SR	
449	*Caprona agama agama* (Moore, 1858)	14	BM, KK, PV, RK, SR	
450	*Caprona alida alida* (Nicéville, 1891)	14	MK, SR	
451	*Spialia galba chenga* Evans, 1957 *	iN/40753344	BM, SR	7C
	Hesperiinae			
452	*Astictopterus jama olivascens* Moore, 1878	3	Kep, KK, KT, MK, PS, RK	
453	*Ampittia dioscorides camertes* (Hewitson, 1868)	7	KK, Kpt, MK, PS, SR	
454	*Aeromachus dubius impha* Evans, 1943	7	MK	
455	*Thoressa masoni* (Moore, 1878)	10	KK, RK	
456	*Thoressa cerata* (Hewitson,1876) *	iN/136898988	MK	7D
457	*Halpe porus* (Mabille, [1877])	3	KK, RK	
458	*Pithauria stramineipennis stramineipennis* Wood-Mason & Nicéville, [1887] *	iN/48199329	KK	7E-F
459	*Iambrix salsala salsala* (Moore, [1866])	24	Kep, KK, MK, PS, PV, RK, SR, ST	
460	*Koruthaialos rubecula hector* Watson, 1893	3	PV, RK	
461	*Koruthaialos sindu sindu* (C. & R. Felder, 1860)	13	Pst	
462	*Psolos fuligo subfasciatus* (Moore, 1879)	3	Kep, KK, PV, RK, SR	
463	*Ancistroides nigrita maura* (Snellen [1880])	10	KK, MK, PS, SR	
464	*Notocrypta paralysos asawa* Fruhstorfer, 1911	3	Kep, KK, MK, PS, PV, RK, SR	
465	*Notocrypta clavata theba* Evans, 1949 *	iN/47977921	KK	7G
466	*Notocrypta curvifascia curvifascia* (C. & R. Felder, 1862)	3	KK, RK, SR	
467	*Udaspes folus* (Cramer, 1775)	10	KK, PS, PV, RK, SR, ST	
468	*Scobura phiditia* (Hewitson, [1866]) *	iN/60422495	KK	7H
469	*Scobura isota* (Swinhoe, 1893) *	iN/60419731	KK	7I
470	*Suada swerga suava* Evans, 1949 *	iN/60489764	KK	7J
471	*Suastus gremius gremius* (Fabricius, 1798)	24	PP, PS, SR, ST	
472	*Suastus minutus aditia* Evans, 1943	10	KK, SR	
473	*Cupitha purreea* (Moore, 1877) *	iN/52785876	KK, SR	7K
474	*Zographetus satwa* (Nicéville, [1884]) *	iN/60495928	KK	7L
475	*Hyarotis adrastus praba* (Moore, 1860)	10	KK, PS, SR, ST	
476	*Isma protoclea bicolor* Evans, 1926 *	iN/57723782	KK	7M

Annex 1 Cont'd

#	Scientific name	First record	Provinces	Fig No.
477	*Pyroneura callineura natalia* Devyatkin et Monastyrskii, 2003 *	iN/60316287	KK	7N
478	*Pyroneura margherita miriam* (Evans, 1941) *	iN/60401243	KK, Kpt	7O-P
479	*Plastingia naga* (Nicéville, 1884) *	iN/60305787	KK, SR	8A
480	*Salanoemia tavoyana* (Evans, 1926) *	iN/40685335	KK, SR	8B
481	*Salanoemia sala* (Hewitson, [1866]) *	iN/60401679	KK	8C
482	*Lotongus calathus* balta Evans, 1949	10	KK	
483	*Zela zeus optima* (Fruhstorfer, 1911) *	iN/60493675	KK	8D
484	*Gangara thyrsis thyrsis* (Fabricius, 1775)	14	KK, RK, SR	
485	*Gangara lebadea lebadea* (Hewitson, 1868)	10	KK	
486	*Erionota torus* Evans, 1941	10	Kep, KK	
487	*Erionota acroleuca apicalis* Evans, 1932 *	iN/52786781	Kpt, KK	8E
488	*Matapa aria* (Moore, 1866)	10	KK, PS, SR	
489	*Matapa sasivarna* (Moore, 1866)	10	KK	
490	*Matapa cresta* Evans, 1949 *	iN/59417955	KK	8F
491	*Unkana ambasa attina* (Hewitson, [1866]) *	iN/39524635	KK, SR	8G
492	*Hidari irava* (Moore, [1858])	28	KK	
493	*Hidari bhawani* Nicéville, [1889]	28	KK, SR	
494	*Acerbas anthea pista* Evans, 1949 *	iN/51678952	KK	8H-I
495	*Pirdana hyela rudolphii* Elwes & Nicéville, 1887	10	KK, Kpt, SR	
496	*Pirdana distanti spenda* Evans, 1949 *	iN/59546656	KK	8J
497	*Taractrocera maevius sagara* (Moore, [1866]) *	iN/59339360	PS	8K
498	*Taractrocera archias quinta* Swinhoe, 1913	3	Bbg, RK	
499	*Oriens gola pseudolus* (Mabille, 1883) *	iN/60502656 iN/60502632	KK, PS, TK	8L-M
500	*Potanthus rectifasciata* (Elwes & Edwards, 1897) *	iN/60515424	KK	9A-B
501	*Potanthus omaha omaha* (Edwards, 1863)	3	?	
502	*Telicota colon stinga* Evans, 1949 *	iN/67510901	Bbg, Kte, PS, SR	9C
503	*Cephrenes acalle oceanica* (Mabille, 1904)	10	KK, PP, SR	
504	*Parnara ganga* Evans, 1837	13	SR	
505	*Parnara bada bada* (Moore,1878) *	iN/88930383	Tak	9D
506	*Borbo cinnara* (Wallace, 1866)	13	KK, MK, SR	
507	*Pelopidas assamensis* Nicéville, 1882 *	iN/51676491	KK	9E
508	*Pelopidas mathias mathias* (Fabricius, 1798)	21	Bbg, Kep, KK, PS, SR	
509	*Polytremis lubricans lubricans* (Herrich-Schaeffer, 1869)	10	KK, PS	
510	*Polytremis annama* Evans, 1937 *	iN/40685450	SR	9F
	Baoris Moore, 1881 sp., ca. *B. farri* *	iN/48213640	KK	9G-H
511	*Caltoris cormasa* (Hewitson, 1876) *	iN/48206053	KK	9I
512	*Iton semamora semamora* (Moore, [1866]) *	iN/104701651	KK	9J

[1] Originally reported at genus level, listed by Inayoshi (2022) at species level. [2] Originally reported as *Enispe duranius* Fruhstorfer, 1911, listed as *E. euthymius congi* Saito, 2015 by Inayoshi (2022). [3] Originally reported as *Kallima inachus siamensis* Fruhstorfer, [1913], re-identified by A. Monastyrskii (pers. comm.). [4] Reported as sub. *P.* cf. *hewitsoni*. [5] Originally recorded as *Callenya lenya lenya* (Evans, 1932) by Monastyrskii *et al*. (2011); listed as *C. melaena melaena* by Inayoshi (2022). [6] << https://www.beesunlimited.com/images/nature-folder/butterflies-landscape/butterflies-landscape-045DSCN2090.jpg >>. [7] Originally reported as *Rapala hades* (Nicéville, 1895)

New records of Orchidaceae from Cambodia V

André SCHUITEMAN[1,*], NAY Sikhoeun[2] & ATT Sreynak[2]

[1] Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, United Kingdom.

[2] Department of Wildlife & Biodiversity, Forestry Administration, Ministry of Agriculture Forestry and Fisheries, 40 Preah Norodom Boulevard, Phnom Penh, Cambodia.

* Corresponding author. Email a.schuiteman@kew.org

Paper submitted 11 August 2022, revised manuscript accepted 11 October 2022.

មូលន័យសង្ខេប

កំណត់ត្រាថ្មីនៃប្រភេទកេសរកូលព្រៃចំនួន២៥ប្រភេទ ត្រូវបានរកឃើញនិងកត់ត្រាវត្តមាននៅក្នុងប្រទេសកម្ពុជា ដោយក្នុងនោះរួមបញ្ចូលទាំងការរកឃើញកំណត់ត្រាថ្មីចំនួន០៩ពួក ដែលរួមមានពួក *Acanthophippium*, *Adenoncos*, *Didymoplexiella*, *Eria* sensu stricto, *Erythrodes*, *Phreatia*, *Pomatocalpa*, *Seidenfadenia* និង *Thunia*។ ចំណាប់អារម្មណ៍ទៅលើកេសរកូលព្រៃនៅក្នុងប្រទេសកម្ពុជាមានការកើនឡើង ដែលជាហេតុនាំឱ្យមានការបណ្តុះកេសរកូលនៅក្រៅទីជម្រកធម្មជាតិរបស់វា។ ស្របពេលជាមួយគ្នានេះដែរ ការការពារនិងអភិរក្សកេសរកូលឱ្យកាន់តែមានភាពប្រសើរឡើងនៅក្នុងតំបន់ធម្មជាតិរបស់វាក៏មានភាពចាំបាច់ផងដែរ។ ទីជម្រកធម្មជាតិសំខាន់ៗរបស់កេសរកូលព្រៃចាំបាច់ត្រូវមានការសិក្សានិងកំណត់បង្ហាញ ព្រោះវាជាវិធីសាស្ត្រមួយជួយដល់ការរៀបចំកំណត់តំបន់សម្រាប់រុក្ខជាតិសំខាន់ៗឱ្យបានសមស្រប។

Abstract

Twenty-five new records of orchid species for Cambodia are reported, including nine new generic records for the genera *Acanthophippium*, *Adenoncos*, *Didymoplexiella*, *Eria* sensu stricto, *Erythrodes*, *Phreatia*, *Pomatocalpa*, *Seidenfadenia* and *Thunia*. There is a growing interest in orchids in Cambodia, which has led to substantial ex situ cultivation efforts. At the same time, better in situ protection is needed. Important habitats need to be identified, for which the methodology for the designation of Important Plant Areas would be suitable.

Keywords Ex-situ conservation, Important Plant Areas, new genus and species records, plant diversity.

Introduction

Interest in Cambodian orchids has grown considerably since we published the first article in this series (Schuiteman *et al*., 2015). There we noticed that little had been added to the 164 species reported for Cambodia by Seidenfaden (1992). Now, seven years later, we are aware of at least 308 species having been found growing naturally in the country, partly through new records published in the literature (Averyanov, 2013; Tagane *et al*., 2015; Averyanov *et al*. 2016a, 2016b, 2018; Gale *et al*., 2016; Nuraliev *et al*., 2016; Suetsugu *et al*., 2017), partly through photographs shared with us by Cedric Jancloes, Khou Eang Hourt and Song Det, and partly through plants found during our own fieldwork (Schuiteman, 2016; Schuiteman *et al*., 2016a, 2016b, 2017). In this paper, we document first records of 25 additional orchid species in Cambodia based on material collected during fieldwork between 2013 and 2018 and subsequently cultivated in the Royal Botanic Gardens, Kew (UK), and at the Forestry Administration in Phnom Penh. Nine genera are here recorded for the first time from Cambodia: *Acanthophippium*, *Adenoncos*, *Didymoplexiella*, *Eria* sensu

CITATION: Schuiteman, A., Nay S. & Att S. (2022) New records of Orchidaceae from Cambodia V. *Cambodian Journal of Natural History*, **2022**, 127–143.

stricto, *Erythrodes*, *Phreatia*, *Pomatocalpa*, *Seidenfadenia* and *Thunia*.

Methods

Plants were collected in situ in the Battambang, Kampot, Koh Kong, Mondulkiri and Pursat provinces in November 2013, May 2015, November 2016 and April 2018 for cultivation at the Forestry Administration shadehouses in Phnom Penh and in the Royal Botanic Gardens, Kew. During fieldwork, the collected plants were labelled the same day and were kept on sheaths of plastic in the shade and watered once or twice daily. Plants destined for Kew were exported and imported with CITES permits and were first accommodated in the Quarantine House at Kew until governmental plant health inspectors allowed their release into the orchid houses in the Tropical Nursery at Kew. Specimens flowering in cultivation were photographed, and vouchers are kept in the spirit collection at Kew. Global distribution data mentioned follow Govaerts *et al*. (2022), unless indicated otherwise. All photos were taken by André Schuiteman, unless stated otherwise.

Results

Acanthophippium gougahense **(Guillaumin) Seidenf. (voucher specimen: cult. Kew 2018-1176, albinistic form: cult. Kew 2022-406; Figs 1–3)**

This is a terrestrial orchid that was found growing in leaf litter in shady places in evergreen forest between 430 and 490 m elevation near Ta Tey Leu in Koh Kong Province, flowering on 21 April 2018. Among the specimens brought back for cultivation, one, which was not in flower at the time, produced flowers that lacked the usual red-brown markings, having yellow-and-white flowers instead (Fig. 3). This species is also known from China (Guangdong), Thailand, Vietnam and Peninsular Malaysia.

Adenoncos vesiculosa **Carr (voucher specimen: cult. Kew 2018-1154; Figs 4 & 5)**

This is a small twig epiphyte in tall trees which often grows together with *Microsaccus griffithii* (C.S.P.Parish & Rchb.f.) Seidenf. It is probably fairly common in the Cardamom Mountains, where it was found both in montane forest at c. 900 m (2013) and on *Artocarpus* trees in the village of Thmor Bang at c. 450 m elevation (2018). It was previously known from Thailand, Vietnam and Peninsular Malaysia.

Bulbophyllum careyanum **(Hook.) Spreng. (voucher specimen: cult. Kew 2013-1672; Figs 6 & 7)**

A member of the taxonomically difficult section *Racemosae*, *B. careyanum* is a variable species, especially in colouration, which ranges from reddish brown with darker spots to ochre-yellow with maroon stripes; the column can be bright yellow or whitish. It is a continental Asian species that has been recorded from nearly every country between northeast India and Vietnam, except Malaysia and, until now, Cambodia. Here it was found in 2013 as an epiphyte in evergreen forest at 430 m elevation in the foothills of the Cardamom Mountains.

Bulbophyllum dasystachys **J.J.Verm., Thavipoke & Phelps (voucher specimen: Kew cult. 2018-1186; Figs 8 & 9)**

This recently described species is a member of section *Hirtula*, of which most species have strikingly hairy flowers, albeit usually quite small and inconspicuous ones. *Bulbophyllum dasystachys* was first described from a cultivated specimen of unknown origin (Vermeulen *et al*., 2014) and was also known from a photograph taken in the wild in Thailand. A few years later it was recorded from Vietnam (Averyanov *et al*., 2017). We found it, without flowers, in 2018 near Ta Tey Leu in Koh Kong Province, growing in a tree crown at 490 m elevation in evergreen forest. It subsequently flowered in the National Orchid Collection at Phnom Penh, where the photographs here shown were taken, and more recently at Kew.

Bulbophyllum mucronatum **(Blume) Lindl. (voucher specimen: cult. Kew 2013-693; Figs 10–12)**

This member of section *Minutissima* is a small, mat-forming epiphyte with pseudobulbs that are only about 5 mm tall. We here record it from evergreen montane forest in the Cardamom Mountains (2013) at 895 m and probably also from Pursat Province (2016) at 870 m elevation, although we have not seen the latter in flower. This species was known from Thailand, Laos, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and the Philippines.

Cleisostoma duplicilobum **(J.J.Sm.) Garay (voucher specimen: cult. Kew 2013-1673 and 2016-2590; Figs 13 & 14)**

The flowers of this epiphytic species are remarkably similar in size and colour to those of *C. fuerstenbergianum* Kraenzl., also known from Cambodia, but the latter is easily distinguished by the terete leaves. *Cleisostoma duplicilobum* is a widespread orchid, previously recorded from northeast India, Myanmar, Thailand, Laos, Vietnam, Peninsular Malaysia, Sumatra, Java, Borneo and the Philippines. In Cambodia, it was found in deciduous dipterocarp forest at 270 m elevation near Pramoy in Pursat Province (2016) and in evergreen forest at 430 m in the foothills of the Cardamom Mountains (2013).

Fig. 1 *Acanthophippium gougahense* (Guillaumin) Seidenf., in situ.

Fig. 2 *Acanthophippium gougahense* (Guillaumin) Seidenf., cult. Kew 2018-1176.

Fig. 3 *Acanthophippium gougahense* (Guillaumin) Seidenf., albinistic form, cult. Kew 2022-406.

Fig. 4 *Adenoncos vesiculosa* Carr, cult. Kew 2018-1154.

Fig. 5 *Adenoncos vesiculosa* Carr, cult. National Orchid Collection Cambodia (© Att Sreynak).

Fig. 8 *Bulbophyllum dasystachys* J.J.Verm., Thavipoke & Phelps, cult. National Orchid Collection Cambodia (© Att Sreynak).

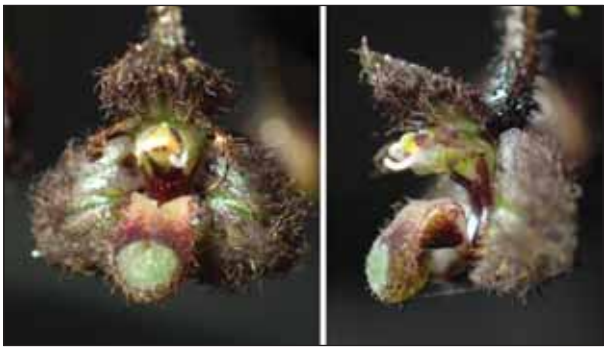

Fig. 9 *Bulbophyllum dasystachys* J.J.Verm., Thavipoke & Phelps, cult. National Orchid Collection Cambodia (© Att Sreynak).

Fig. 6 *Bulbophyllum careyanum* (Hook.) Spreng., cult. Kew 2013-1672.

Fig. 7 *Bulbophyllum careyanum* (Hook.) Spreng., cult. Kew 2013-1672.

Fig. 10 *Bulbophyllum mucronatum* (Blume) Lindl., in situ.

Fig. 12 *Bulbophyllum mucronatum* (Blume) Lindl., cult. Kew 2013-693.

Fig. 13 *Cleisostoma duplicilobum* (J.J.Sm.) Garay, cult. Kew 2013-1673.

Fig. 11 *Bulbophyllum mucronatum* (Blume) Lindl., cult. Kew 2013-693.

Fig. 14 *Cleisostoma duplicilobum* (J.J.Sm.) Garay, cult. Kew 2016-2590.

Dendrobium parciflorum **Rchb.f. ex Lindl. (voucher specimen: cult. Kew 2018-1181; Fig. 15)**

An epiphytic species of section *Aporum* with fleshy, bilaterally flattened leaves and ephemeral flowers. Our 2018 record is from near Ta Tey Leu in Koh Kong Province, where it occurred at 490 m elevation together with *Bulbophyllum dasystachys* (see above). This species was previously known from northeast India, Thailand, China, Laos, Vietnam and the Philippines

Didymoplexiella siamensis **(Rolfe ex Downie) Seidenf. (voucher specimen: Schuiteman *et al*. 18-44; Figs 16 & 17)**

Only a single specimen was found, growing in damp forest on a slope above a stream at 490 m elevation, east of Ta Tey Leu in Koh Kong Province, flowering on 22 April 2018. This is a leafless, mycoheterotrophic orchid previously known from Thailand, Laos, Vietnam, eastern China, Taiwan and Japan.

Eria scabrilinguis **Lindl. (voucher specimen: cult. Kew 2016-2574; Figs 18 & 19)**

This is a species that evidently prefers a shady, humid environment, as it is usually found on mossy boulders and tree trunks along streams in montane forest. In such conditions it was found in 2016 at 870 m elevation, about 24 km southwest of Pramoy in Pursat Province. It is better known as *Eria corneri* Rchb.f., which is a synonym, and was previously recorded from northeast India, Nepal, China, Laos, Vietnam, Taiwan and Japan (Yakushima).

Erythrodes blumei **(Lindl.) Schltr. (voucher specimen: cult. Kew 2018-1239; Figs 20 & 21)**

Being a member of subtribe Goodyerinae, *Erythrodes* is related to the famous jewel orchids, of which *Anoectochilus lylei* Rolfe ex Downie was reported here previously (Schuiteman *et al*., 2016a). However, there is nothing jewel-like about *Erythrodes blumei*, which lacks the beautifully marked leaves of *Anoectochilus* and similar orchids. We found only one flowering specimen on 25 April 2018, growing at 530 m elevation in evergreen hill forest, northeast of Ta Tey Leu in Koh Kong Province. This species has been recorded from northeast India, Bangladesh, Myanmar, China, Thailand, Vietnam, Taiwan, Peninsular Malaysia, Sumatra, and Java. For reasons unclear to us, Govaerts *et al*. (2022) gave a much more limited distribution which excluded continental Asia, even though the type is from northeast India (Schuiteman *et al*., 2022).

Liparis atrosanguinea **Ridl. (voucher specimen: Schuiteman *et al*. 18-23; Figs 22 & 23)**

This is a delicate herb with broad, soft leaves that betray its preference for humid, shady spots on the forest floor. It was found in flower on 21 April 2018 at c. 440 m elevation in evergreen forest near Ta Tey Leu, Koh Kong Province. It was previously known from the Andaman and Nicobar Islands, Thailand, Vietnam, Peninsular Malaysia, Sumatra and Borneo.

Liparis cespitosa **(Lam.) Lindl. (voucher specimen: cult. Kew 2015-1286; Figs 24 & 25)**

A widespread and rather common but inconspicuous epiphytic orchid. It is widespread within Cambodia as well. We can report it from evergreen hill forest at 420 m elevation in the Cardamom Mountains (2013), from open woodland on white sand along a stream in Koh Kong Province at c. 350 m elevation (2018), and from a forest remnant along a waterfall at 640 m elevation in Mondulkiri Province (2015). It occurs from East Africa and Madagascar in the west, throughout tropical continental Asia and the Malay Archipelago to as far east as the Society Islands. Govaerts *et al*. (2022) already recorded it from Cambodia but as we have not seen a published reference with a definite Cambodian locality, we have included it here.

Liparis rheedei **Lindl. (voucher specimen: cult. Kew 2017-24; Figs 26 & 27)**

Unlike most terrestrial *Liparis* species, *L. rheedei* (often misspelled *L. rheedii*) usually occurs in open, sunny positions. It was observed in November 2016 on moss-and-herb-covered rocks along rapids under sparse tree cover on Mount Bokor at 910 m elevation. At that time, the specimens were in the fruiting stage. This species is known from Thailand, Vietnam, and occurs throughout the Malay Archipelago to as far east as New Guinea. It has apparently not yet been found in the Philippines. *Liparis rheedei* was already recorded by Govaerts *et al*. (2022) from Cambodia, but we have not seen a published reference with a definite Cambodian locality.

Luisia psyche **Rchb.f. (voucher specimen: cult. Kew 2016-2552; Fig. 28)**

Luisia is one of the few orchid genera known to contain species that are pollinated by beetles (Pedersen *et al*., 2013; Arakaki *et al*., 2016; Wakamura *et al*., 2020), but the pollinator of the decidedly beetle-like *L. psyche* is still unknown. We found this species in 2016 southwest of Pramoy in Pursat Province as an epiphyte on lichen-covered branches in open, deciduous dipterocarp woodland with a dense undergrowth of grasses, at an elevation of 285 m. It was previously known from northeast India, Myanmar, Thailand, Laos and Vietnam.

Fig. 15 *Dendrobium parciflorum* Rchb.f. ex Lindl., cult. Kew 2018-1181.

Fig. 16 *Didymoplexiella siamensis* (Rolfe ex Downie) Seidenf., in situ, Schuiteman *et al*. 18-44.

Fig. 17 *Didymoplexiella siamensis* (Rolfe ex Downie) Seidenf., in situ, Schuiteman *et al*. 18-44.

Fig. 18 *Eria scabrilinguis* Lindl., in situ.

Fig. 19 *Eria scabrilinguis* Lindl., cult. Kew 2016-2574.

Fig. 20 *Erythrodes blumei* (Lindl.) Schltr., in situ.

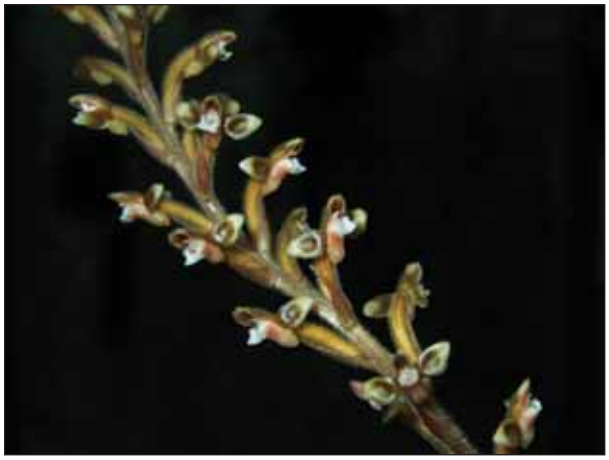

Fig. 21 *Erythrodes blumei* (Lindl.) Schltr., cult. Kew 2018-1239.

Fig. 22 *Liparis atrosanguinea* Ridl., in situ, Schuiteman *et al*. 18-23.

Fig. 23 *Liparis atrosanguinea* Ridl., Schuiteman *et al*. 18-23.

Fig. 24 *Liparis cespitosa* (Lam.) Lindl., cult. Kew 2015-1286.

Fig. 25 *Liparis cespitosa* (Lam.) Lindl., cult. Kew 2015-1286.

Fig. 26 *Liparis rheedei* Lindl., in situ.

Fig. 27 *Liparis rheedei* Lindl., cult. Kew 2017-24.

Fig. 28 *Luisia psyche* Rchb.f., cult. Kew 2016-2552.

Fig. 29 *Nervilia plicata* (Andrews) Schltr., in situ.

Fig. 30 *Nervilia viridis* S.W.Gale, Watthana & Suddee, cult. Kew 2016-2540.

Fig. 31 *Nervilia viridis* S.W.Gale, Watthana & Suddee, cult. Kew 2016-2540.

Nervilia plicata **(Andrews) Schltr. (voucher specimen: not made; Fig. 29)**

The leaves of this well-known species are so distinctive that we have little doubt that the plant we photographed in November 2016 in humid evergreen forest along a stream at 350 m elevation, c. 8 km north-northwest of Pramoy in Pursat Province, represents this species. Unfortunately, the plant failed to flower in cultivation, so that our identification is not absolutely certain; in theory it could represent an as yet undescribed species with similar foliage. In nearly all species of *Nervilia* the leaves emerge when the flowers have gone over. *Nervilia plicata* occurs throughout tropical continental Asia, Taiwan, the Malay Archipelago and the Philippines, east to New Guinea and northern Australia.

Nervilia viridis **S.W.Gale, Watthana & Suddee (voucher specimen: cult. Kew 2016-2540; Figs 30 & 31)**

In 2016, we visited some limestone hills in Battambang Province, but were disappointed to discover that the ones we managed to gain access to were covered with secondary forest in which hardly any epiphytic orchids could be found. Nevertheless, our visit was not fruitless, as in some places, especially where the forest was more open, various terrestrial orchids were common. On 20 November, good numbers of *Habenaria hosseusii* Schltr. (Schuiteman *et al*., 2017), *H. dentata* (Sw.) Schltr., *H. lindleyana* Steud. and *Liparis deflexa* Hook.f. flowered on steep, rocky slopes. Between them grew what undoubtedly was a *Nervilia* species, but no flowers were present, only the characteristic angular-cordate leaves could be seen. The small, round, knobbly tubers finally produced their first flowers at Kew in July 2019, which enabled us to identify it as *N. viridis*, only described the previous year from Thailand (Gale *et al*., 2018). Coincidentally, in that same year, it was also described as a new species, *N. viridiflora* Q.Liu & J.W.Li, from Yunnan (Tang *et al*., 2018), but the name was not validly published and *N. viridis* would have had priority in any case. We have here the remarkable circumstance that a species that was unknown to science until 2018 was independently discovered in three different countries at around the same time.

Phreatia plantaginifolia **(J.Koenig) Ormerod (voucher specimen: cult. Kew 2015-1350; Figs 32 & 33)**

This plant usually produces a single small fan of very fleshy, bilaterally flattened leaves that are not particularly similar to those of a plantain (*Plantago*), after which it was named. It is a common species throughout the Malay Archipelago and the Philippines, although apparently not reaching New Guinea in the east, and has also been recorded from the Andaman and Nicobar Islands, Thailand and Vietnam. Govaerts *et al*. (2022) already recorded *Phreatia plantaginifolia* from Cambodia, but as we are not aware of any published reference to a specific locality in Cambodia, we include it here. In Cambodia it is one of the more common epiphytic orchids; we can report it from primary evergreen montane forest at 700 m elevation in the Cardamom Mountains (2013), from scrub-like forest on Mount Bokor at c. 1000 m (2015 & 2016), and from open woodland on white sand in Koh Kong Province at c. 350 m (2018). Although this species is usually epiphytic, we also observed it growing on the mossy surface of overhanging slabs of rock on Mount Bokor.

Pinalia eriopsidobulbon **(C.S.P.Parish & Rchb.f.) Kuntze (voucher specimen: cult. Kew 2013-1730; Fig. 34)**

At first sight, this species could be mistaken for a smaller-flowered form of *Pinalia xanthocheila* (see below), but the latter is easily distinguished by the prolonged lip side-lobes and the three tall, raised crests on the lip. We have only found it once in Cambodia, as an epiphyte in primary montane evergreen forest in the Cardamom Mountains at 665 m elevation, in 2013. We had to wait until 2022 for it to flower at Kew, when it could finally be identified. It was previously known from Myanmar, Thailand, Laos and Vietnam, usually recorded under its synonym *Eria eriopsidobulbon* C.S.P.Parish & Rchb.f.

Pinalia floribunda **(Lindl.) Kuntze (voucher specimen: cult. Kew 2013-1687; Figs 35 & 36)**

So far, we only know this epiphytic species from one locality in Cambodia. In 2013, it was found in the Cardamom Mountains in relatively dry evergreen montane forest with little undergrowth at c. 900 m elevation. Outside Cambodia it is a fairly common and widespread orchid, known from Myanmar, Thailand, Vietnam, Peninsular Malaysia, Sumatra, Borneo and the Philippines, usually recorded under its synonym *Eria floribunda* Lindl.

Pinalia xanthocheila **(Ridl.) W.Suarez & Cootes (voucher specimens: cult. Kew 2013-1683, 2013-1704, 2017-61; Figs 37 & 38)**

This species would appear to be more common and widespread in Cambodia than the other two *Pinalia* species that are mentioned above. In the Cardamom Mountains, it co-occurred with *P. floribunda* at c. 900 m elevation but was also found there at 590 m (2013). On Mount Bokor (2016) it was encountered in open scrub-like forest at c. 1,000 m. Outside Cambodia, *P. xanthocheila* (formerly *Eria xanthocheila* Ridl.) has been recorded from Myanmar, Thailand, Vietnam, Peninsular Malaysia, Sumatra, Java and Borneo.

Fig. 32 *Phreatia plantaginifolia* (J.Koenig) Ormerod, in situ.

Fig. 33 *Phreatia plantaginifolia* (J.Koenig) Ormerod, cult. Kew 2015-1350.

Fig. 34 *Pinalia eriopsidobulbon* (C.S.P.Parish & Rchb.f.) Kuntze, cult. Kew 2013-1730.

Fig. 35 *Pinalia floribunda* (Lindl.) Kuntze, cult. Kew 2013-1687.

Fig. 36 *Pinalia floribunda* (Lindl.) Kuntze, cult. Kew 2013-1687.

Fig. 37 *Pinalia xanthocheila* (Ridl.) W.Suarez & Cootes, cult. Kew 2013-1704.

Fig. 38 *Pinalia xanthocheila* (Ridl.) W.Suarez & Cootes, cult. Kew 2013-1704.

Fig. 39 *Polystachya concreta* (Jacq.) Garay & H.R.Sweet, cult. Kew 2015-1116.

Fig. 40 *Pomatocalpa maculosum* (Lindl.) J.J.Sm., cult. Kew 2018-1258.

Fig. 41 *Pomatocalpa maculosum* (Lindl.) J.J.Sm., cult. Kew 2018-1258.

Fig. 42 *Seidenfadenia mitrata* (Rchb.f.) Garay, in situ.

Fig. 43 *Seidenfadenia mitrata* (Rchb.f.) Garay, cult. National Orchid Collection Cambodia.

Fig. 44 *Thrixspermum merguense* (Hook.f.) Kuntze, cult. Kew 2013-1584.

Fig. 45 *Thrixspermum merguense* (Hook.f.) Kuntze, cult. Kew 2013-1584.

Fig. 46 *Thunia pulchra* Rchb.f., cult. Kew 2017-73.

Polystachya concreta **(Jacq.) Garay & H.R.Sweet (voucher specimen: cult. Kew 2015-1116; Fig. 39)**

This is currently considered to be the only tropical orchid species that occurs naturally in the Americas as well as in Africa and Asia. Although it is possible that several different species are masquerading as *P. concreta* (Johan Hermans, pers. comm.), there is no doubt that they are closely related. Probably only one species occurs in Southeast Asia, which for now we will call *P. concreta*. Although Govaerts *et al*. (2022) already recorded *P. concreta* from Cambodia as well as from most tropical Asian countries, we are not aware of any published locality from Cambodia, although it is widespread there. We have found it in the Cardamom Mountains at c. 900 m in rather dry evergreen montane forest (2013), on isolated clumps of trees in secondary hill grassland at 900 m in Mondulkiri Province (2015), and on trees along rapids at 900 m on Mount Bokor (2016).

Pomatocalpa maculosum **(Lindl.) J.J.Sm. (voucher specimen: cult. Kew 2018-1258; Figs 40 & 41)**

In his revision of *Pomatocalpa*, Watthana (2007) distinguished two subspecies within *P. maculosum*: subsp. *andamanicum* (Hook.f.) S.Watthana and subsp. *maculosum*, which are differentiated on the size of the flowers. Based on this distinction, the specimens we found in Cambodia would belong to subsp. *maculosum*, albeit near the lower end of the size range. Curiously, this subspecies was previously known from Sri Lanka and Java, whereas subsp. *andamanicum* has been recorded from the Andaman and Nicobar Islands, Thailand, Peninsular Malaysia and Laos. In Cambodia we have only found *P. maculosum* once, in 2018, growing as an epiphyte in open evergreen forest bordering swampy grassland at 180 m elevation in Koh Kong Province, northeast of Areang village.

Seidenfadenia mitrata **(Rchb.f.) Garay (voucher specimen: not made; Figs 42 & 43)**

This is an attractive epiphyte with short monopodial stems and pendent, terete ('rat-tail') leaves. In 2016, it was the only epiphytic orchid that we encountered on the low limestone hills of Battambang Province, where the open secondary forest at 135 m elevation was probably too young to support a more diverse epiphytic orchid flora. It was previously known from Myanmar, Thailand and Laos.

Thrixspermum merguense **(Hook.f.) Kuntze (voucher specimen: cult. Kew 2013-1584; Figs 44 & 45)**

This little epiphyte is easily recognised by the two patches of thick, transparent, capitate hairs on the lip. It requires a good macro lens to appreciate its intricate beauty, as the flowers are only about 6 mm in diameter. We have only found it once, in 2013, growing in secondary, evergreen forest at 430 m elevation in the foothills of the Cardamom Mountains. This is a widespread species, known from northeast India, Myanmar, Andaman and Nicobar Islands, Thailand, Laos, Vietnam, Taiwan, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi and the Philippines.

Thunia pulchra **Rchb.f. (voucher specimen: cult. Kew 2017-73; Fig. 46)**

The National Orchid Collection in Phnom Penh has a plant of *Thunia pulchra* that was collected in the Seima Wildlife Sanctuary in Mondulkiri Province, and in 2018 we observed a large plant of this species (not in flower) that had been planted on a tree trunk near a house in Ta Tey Leu village in Koh Kong Province. The owner claimed that it had been collected in nearby forest, where it was said to grow on trees along a river. We were unable to find it there ourselves, unfortunately, but we were kindly allowed to take a piece of the plant, which subsequently flowered at Kew. It is certainly one of the showiest orchids of Cambodia. It had previously been recorded from Myanmar, Thailand and Vietnam.

Discussion

For almost all species here recorded from Cambodia it can be said that their occurrence was predictable, as they were known to occur in two or more of the neighbouring countries. In this respect, perhaps only the find of *Nervilia viridis* can be considered surprising. Another

noteworthy find is that of *Bulbophyllum dasystachys*, as this is a recently described and probably rare species. On the other hand, not every species that occurs in at least two neighbouring countries can be expected to be found in Cambodia, as suitable habitats may not (or may no longer) be available. We need actual records, 'ground-truthing', to confirm predicted species distributions. Only five of the 25 species listed here were seen in flower at the time of collecting in the field, showing once again the usefulness for taxonomy of well-maintained ex situ collections.

A positive development is that there is now a National Orchid Collection at Phnom Penh, maintained by the Forestry Administration (Ministry of Agriculture, Forestry and Fisheries), while the Ministry of Environment is engaged in expanding the orchid collection at Kesor Kol Sok An Phnom Kulen Research and Conservation Centre in Siem Reap Province. These developments will support ex-situ conservation, but at the same time, protecting the remaining orchid habitats in the country is as urgent and necessary as ever. Identifying species-rich orchid habitats in Cambodia should be a priority in conservation efforts. It is highly likely that good orchid habitats in Cambodia coincide with Important Plant Areas (IPAs) as defined by Darbyshire *et al*. (2017), such that the methodology for identifying IPAs could be used to support in situ orchid conservation in the country.

Acknowledgements

André Schuiteman would like to thank the participants in the four field trips he has so far been privileged to carry out in Cambodia. In 2013: Nut Menghor and Christopher Ryan; in 2015: Att Sreynak, Nay Sikhoeun and Christopher Ryan; in 2016: Att Sreynak, Rudolf Jenny, Khou Eang Hourt, Nay Sikhoeun and Neang Thy; in 2018: Att Sreynak, In Visattha, Rudolf Jenny and Nay Sikhoeun. We thank Dr Keo Omaliss, Director General of the Cambodia Forestry Administration, Ministry of Agriculture, Forestry and Fisheries for his untiring support before and during our visits, and the Director of the Department of Terrestrial Protected Areas, Ministry of Environment, Cambodia, for granting us access to protected areas. André Schuiteman received travel grants from the Bentham-Moxon Trust and from the American Society Board of the Kew Foundation. Cedric Jancloes provided much useful information. We are grateful to CITES Cambodia and CITES UK for issuing the necessary permits. The living specimens were imported into the UK under Defra Plant Health Licences.

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The present issue was also supported by the Swedish International Development Cooperation Agency (SIDA) through the SIDA-RUPP bilateral programme 'Enhancement of Research Capacity at the Royal University of Phnom Penh towards Poverty Reduction and Sustainable Development' (SIDA contribution no. 11599).

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The Editors are grateful to our reviewers and to Chhin Sophea, Khin Chandara, Meas Seanghun and Thi Sothearen for their kind assistance with the production of this issue.

Cambodian Journal of Natural History

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