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MANGROVE BIODIVERSITY SURVEY REPORT

Peam Krasop Wildlife Sanctuary & Koh Kapik Ramsar Site Cambodia 2023

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MANGROVE BIODIVERSITY SURVEY REPORT PEAM KRASOP WILDLIFE SANCTUARY & KOH KAPIK RAMSAR SITE CAMBODIA 2023

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Cover images: (Main) Chinese pond heron; (inserts) buffy fish owl, flowering shrub, fishing cat & greater short-nosed fruit bat.
Following double page image: Aerial view of Cambodian coast, Koh Kong.

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OVERVIEW

Peak Krasop Wildlife Sanctuary is a 23,750 ha protected area declared in 1993 in Cambodia’s Koh Kong province. Adjacent Koh Kapik Ramsar site is 12,000 ha and declared in 1999. Together, they cover the country's largest expanse of mangrove forest and one of the largest in mainland Southeast Asia.

Mangrove forests, straddling the connection between land and sea, are incredibly important ecosystems for nature and people. For example, they provide natural protection against coastal erosion and storm surges; they capture and store large amounts of carbon (often referred to as ‘blue carbon’), thus representing an excellent nature-based solution against climate change; they offer important nursing grounds for fish, shrimps and crabs, playing a key role in supporting the food security and livelihoods of local communities; they help improve water quality; and they provide habitat and refuge to a wide array of wildlife.

Despite the importance of mangrove forests and the substantial swathe of this ecosystem along Cambodia’s westernmost coastline, little was known about its biodiversity. This report presents the most comprehensive biodiversity survey of mangroves in Cambodia to date, offering baseline data to help inform the long-term management of Peam Krasop Wildlife Sanctuary and Koh Kapik Ramsar site.

Survey work was led by Fauna & Flora and Fishing Cat Ecological Enterprise, in collaboration with the Ministry of Environment and the Faculty of Fisheries and Aquaculture, Royal University of Agriculture. It involved camera trapping and targeted survey field trips during the 2023 dry and wet seasons. A total of 57 cameras were set across the protected area, resulting in over 4000 trap nights. Additionally, experts conducted targeted surveys focusing on bats, reptiles, amphibians, invertebrates, juvenile fish and plants. For the most part, with the probable exception of large and medium-sized mammals, these results only offer a first glimpse at the biodiversity of the area, and further survey will undoubtedly reveal additional species. Yet these results evidence an important array of wildlife

in need of protection, including several threatened species such as Endangered long-tailed macaques, hairy-nosed otters and large spotted civets, and Vulnerable fishing cats and smooth-coated otters.

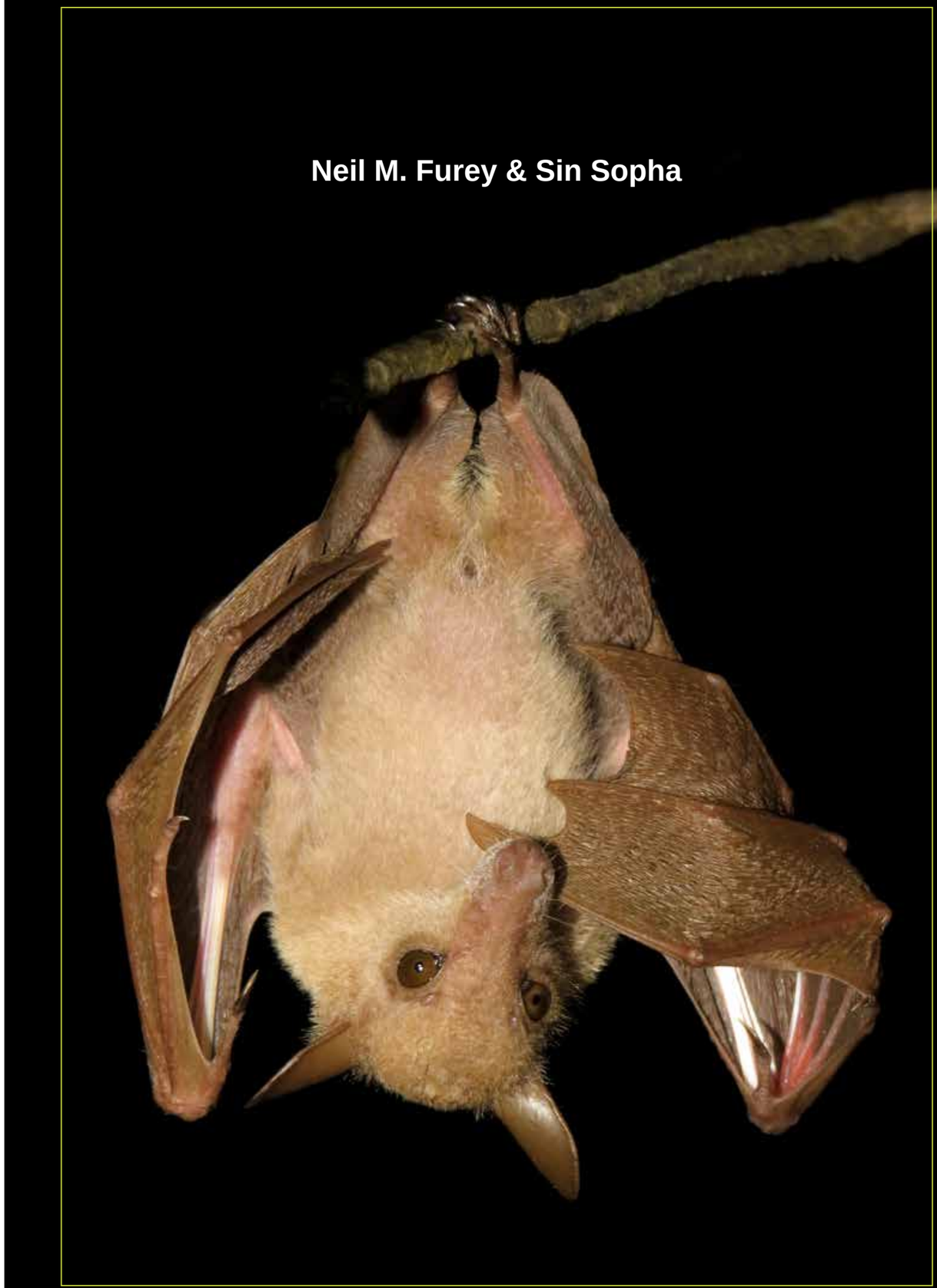
Overall, priority should be given to maintaining forest condition and cover within the sanctuary, since the loss of older, larger trees (which typically provide more cavities, hollows and crevices) particularly threatens foliage-roosting species, whereas fragmentation of mature forest stands erodes the connectivity between suitable habitat. Cleared areas of mixed mangrove that have been abandoned should be left to regenerate naturally, as these areas are connected to natural seedling recruitment. Protection and patrolling activities should be conducted regularly in order to make sure that no further disturbance to these areas takes place.

The results provided in this report, while an incomplete picture of the area's biodiversity, highlight the conservation value of the Peam Krasop/Koh Kapik mangrove forests, and can serve to underpin stronger management of the area, as well as inform initiatives such as eco-tourism and further research.

◁ Aerial view of mangrove forest in Peam Krasop Wildlife Sanctuary.

Common greenshank *Tringa nebularia* on mudflats. The Koh Kapik Ramsar Site is a crucial stopover for wading birds that pass through Cambodia on migration.

BAT SURVEY



Title image: Female *Macroglossus minimus*, Peam Krasop.

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INTRODUCTION

This chapter details the results of a rapid bat survey undertaken during the 2023 dry season in Peam Krasop Wildlife Sanctuary in Koh Kong Province, west Cambodia. The purpose of the survey was to generate a species list for bats inhabiting the sanctuary and evaluate its potential significance for Cambodian bat conservation.

The assessment comprised a literature and collections review and passive and active sampling for bats within the sanctuary. Field methods included live-sampling with mist nets and a harp trap and acoustic sampling with ultrasound detectors, which were employed from 15 to 24 February 2023. Acoustic sampling emphasized *Rhizophora* mangroves in intertidal areas of the sanctuary, although this and live-trapping were also undertaken in areas of mixed *Melaleuca* and semi-evergreen forest inland.

Desk review revealed that 27 bat species have been previously documented in Koh Kong Province and adjacent areas. Live-trapping within the sanctuary resulted in the capture of 113 bats representing nine species, whereas acoustic sampling detected 13 phonically-distinct taxa, ten of which were identifiable to species. As six of the latter were not captured in live-traps and local reports indicate flying foxes (species unconfirmed) also occur in Peam Krasop (although these were not seen and have apparently declined markedly), this increases the total number of bat species recorded in the sanctuary to at least 16 and possibly as many as 19 taxa (with the inclusion of three unidentified phonic types). Aside from the flying foxes and *Murina walstoni* which is Data Deficient, the remaining species are currently regarded as Least Concern.

These figures represent 19–23% of the known bat fauna of Cambodia (83/16–19 species) but undoubtedly fall short of the true site total for several reasons including the A) absence of entire subfamilies and limited representation of diverse genera on the current species list, B) occurrence of at least 19 additional species in Koh Kong Province, many of which may also occur within the sanctuary (particularly its northern areas), and C) relatively low survey effort thus far achieved at the site, coupled with the reality that the detection of many bat taxa requires sustained effort.

◁ Lesser short-nosed fruit bat *Cynopterus brachyotis* from coastal Cambodia.

As a consequence, the bat species richness of Peam Krasop is undoubtedly greater than presently known, although there is no reason to suppose that any of the species present might be endemic to the sanctuary or Cambodia as a whole. Notwithstanding this, the site has good prospects for supporting bat species that occur in eastern Thailand which have yet to be recorded nationally, including Near Threatened taxa such as *Rhinolophus trifoliatus*. As such, further surveys will undoubtedly reveal additional bat species at the site and if undertaken, should employ multiple detection methods and ideally encompass both the dry and wet seasons.

CONTEXT

Bat Biodiversity in SE Asia & Cambodia

Bats are divided into two suborders: the Yinpterochiroptera (Rhinolophoid bats and Old-World fruit bats) and Yangochiroptera (all other bats), whose ability to perceive their surroundings using echolocation, together with powered flight, has allowed them to master the night skies and exploit a wide range of niches worldwide (Schnitzler et al. 2001, Jones & Teeling 2006). Over 1,460 bat species are currently recognized (Simmons & Cirranello 2023) and this figure continues to grow each year with the discovery of new species, particularly in Southeast Asia (Tsang et al. 2016).

Bats form an important component of the Southeast Asia's mammal fauna, as the group constitutes ca. 30% of the region's mammal species and can comprise as many as half of all mammal species in tropical rainforests (Kingston et al. 2006). Southeast Asia is also pivotal area for global bat conservation as it supports over 25% of the world's bat fauna and as >197 of 342 species known from the region are endemic to it (Kingston 2010).

Despite the economic and conservation importance of bats (Kunz et al. 2011) the natural history of the Cambodian bats is relatively poorly known. With 83 species now confirmed (Furey et al. 2021, Csorba & Furey 2022, Furey unpubl. data) however, knowledge regarding species composition has increased dramatically in recent years. As elsewhere in Southeast Asia, the group is seriously threatened by habitat loss, hunting — particularly of flying foxes and cave-dwelling bats — and other disturbance (Furey et al. 2012, 2016, Ravon et al. 2014, Lim et al. 2018).

Of the 83 species known in Cambodia, 12 are frugivorous or insectivorous bats within the Pteropodidae, whereas the remainder mostly comprise insectivores arranged in seven families. While discovery of additional species is likely, particularly in understudied border areas (Furey et al. 2021), only 11 bat species known for the country are currently listed in categories other than Least Concern by IUCN (2022)[1], whereas three are listed in CITES Appendix II[2]. One is also listed in Cambodian legislation as nationally rare (*P. hypomelanus*: MAFF 2007) although the species annexes associated with this legislation are currently being revised.

The aim of the study in Peam Krasop was to undertake a survey to generate a species list for bats inhabiting the sanctuary and evaluate its potential significance for Cambodian bats. This was of considerable interest in representing the first survey of bats in Cambodian mangroves to the authors knowledge. The field survey was undertaken mid-way through the dry season from 15–24 February 2023.

[1] Although seven species in Cambodia are yet to be formally assessed, including two which qualify as data deficient, thus far being known from 1–3 individuals globally (Furey et al. 2021, Csorba & Furey 2022).
[2] Convention on International Trade in Endangered Species of Wildlife Fauna and Flora, Annex II: *Pteropus hypomelanus, P. lylei & P. vampyrus.*
[3] Although some government documents give its area as 25,897 ha (An et al. 2009).

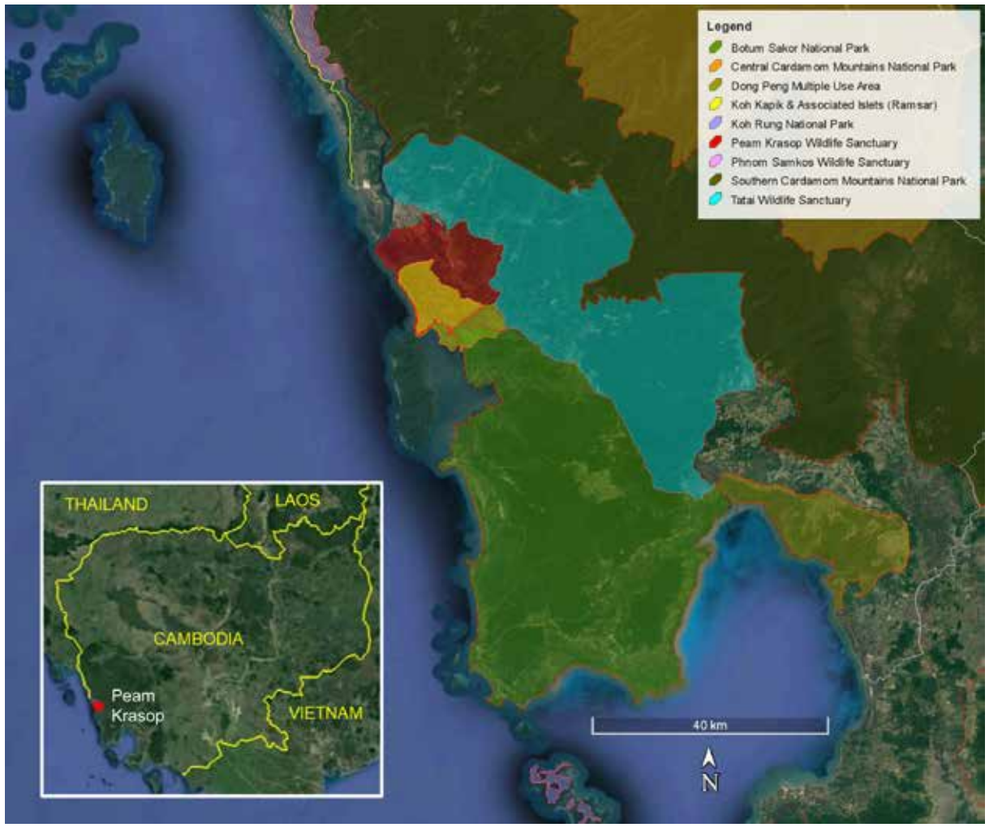

Fig. 1: Location and protected area context of Peam Krasop in Cambodia.

SURVEY METHODS

Alongside review of literature and specimen collections, the survey focused on passive and active sampling for bats within the Wildlife Sanctuary. Sampling methods comprised live-trapping using mist nets and a harp trap and acoustic surveys using passive and active ultrasound detectors.

Data Collection

Desk Review and Live Sampling

A desk review of previous records of bats from Koh Kong Province was undertaken. This included review of specimens from the province in the zoological collection of the Centre for Biodiversity Conservation (CBC), Royal University of Phnom Penh.

Away from roost sites, the success of live-sampling efforts in any bat survey are largely determined by the extent to which the terrain and habitat concentrate commuting bats into discreet flyways. Selection of sampling locations therefore focused on putative flyways within the widest range of vegetation types in-situ, including ecotones and the interior (e.g., trails, watercourses and natural linear breaks) and edge of each. Geo-coordinates, basic habitat data and photo-documentation were recorded at all sites.

Because bat species vary in their relative susceptibility to capture with mist nets and harp traps (Francis 1989, Berry et al. 2004) and the aim was to maximize inventory completeness, both capture devices were employed. A variety of mist nets were used depending on topography (e.g., 7x3m, 10x3m & 12x3m) all of which were 70 denier nets (Fig. 2). One four-bank harp trap was employed, with a capture surface of 2.9 m^2 (Fig. 2). To standardize sampling effort between these, effort for mist nets was calculated as m^2 of net multiplied by the hours of use (m^2mnh), whereas harp trap effort was similarly calculated as m^2 multiplied by the hours of use (m^2 hth).

Fig. 2: Mist net (left) and harp trap (right).

The mist nets and harp trap were employed from ≈1745–2200 hrs each night, although for logistical reasons sampling concluded on one occasion at 2000 hrs, and twice at 2100 hrs. These were checked for captures every 10–30 minutes and live-trapping was avoided on consecutive nights at the same location to avoid trap familiarity.

All bats captured during live-sampling were measured, photographed and identified in the field using the appropriate field guides/monographs e.g., Kruskop (2013) & Francis (2019) and released at their capture site the same night. Reference echolocation calls were recorded from each released individual using the appropriate species-specific methods to facilitate identification of unseen bats registered in the acoustic sampling (see below). A M500-384 USB ultrasound microphone (Pettersson Electronik AB, Sweden) connected to an Android smartphone (Samsung Galaxy S6) running the Bat Recorder app (vers. 1.0R156) was employed to this end.

Acoustic Sampling

Acoustic sampling with ultrasound (bat) detectors is extensively used in temperate regions and is recognized as an important complement to conventional capture methods (e.g., mist nets and harp traps) for bat species inventories in the tropics (MacSwiney et al. 2008, Furey et al. 2009). This is particularly true for insectivorous species that habitually fly in open areas and at higher altitudes outside the range of ground-based live-traps (Fenton 1990, Furey et al. 2009).

Fixed-point recordings were made each sampling night with two Song Meter 4 full spectrum (SM4) bat detectors (Wildlife Acoustics, USA: Fig. 3) and ten AudioMoth full spectrum (AM) bat detectors (Open Acoustic Devices, UK: Fig. 3). The SM4 detectors were moved each night during the survey (hereafter ‘mobile sampling’) whereas the AM detectors were stationary (hereafter ‘static sampling’) to maximize coverage of representative habitats in each area for the entire survey. Both were set to record from 30 minutes before sunset until sunrise (although the SM4s ultimately had to be retrieved by 2200–2300 hrs each night for logistical reasons), with SM4 recordings triggered by sounds between 16–384 kHz and AM detectors recording between 16–250 kHz on a 25% duty cycle (= one 5-sec recording every 20-secs).

Local sunset and sun rise times during the survey period were ≈1815 and ≈0630 hrs, respectively. Geo-coordinates, basic habitat data and photo-documentation were recorded at all sampling sites.

Fig. 3: Song Meter 4 (left) and AudioMoth (right) bat detectors.

Phonically distinct bat species were identified through visual inspection of the recordings (via call frequencies, structure and duration) in Adobe Audition (Adobe Systems, USA) and Batsound (Pettersson Elecktronic, Sweden) and 19 parameters were measured per call for each phonic type using SCAN’R software (Binary Acoustic Technology, USA). Identifications were made to the lowest taxonomic level possible based on discriminant function analysis employing A) reference call data generated by the survey for identified species (this study), and B) datasets of verified recordings for known bat species from Cambodia (e.g., Phauk et al. 2013) and neighbouring countries held by the lead author. These reference data were subsequently employed to determine the presence/absence of species and phonic types in each location using a filtering pipeline in SZAPP software (Armstrong & Aplin 2014, Armstrong et al. 2016).

Analysis of site-based variations in bat activity were confined to recordings generated by the SM4 detectors as these directly reflect actual activity in being triggered by bat calls and other sounds (as opposed to recordings generated by AM devices which operate on fixed schedules). SCAN'R software was initially employed to remove a large proportion of the recordings comprising non-bat sounds, after which the remainder were manually validated. Because bat detectors cannot distinguish between different individuals (and so a single circling bat can be acoustically equivalent to many bats passing just once), an index of activity was employed for analysis based on the number of bat passes. Following international standards, a bat pass was defined as a sequence of >2 echolocation calls, with each sequence, or pass, separated by >1 second (Kunz et al. 2007). Temporal variations in bat activity were quantified using proprietary code in the R program environment (R Core Team, Austria).

Analysis

The conservation significance of all bat species recorded was evaluated using IUCN (2022) and refined where necessary with reference to existing literature and unpublished data held by the first author for Cambodia and mainland SE Asia. Taxonomy and nomenclature follow Simmons & Cirranello (2023).

Ecological Traits

Ecological trait data for each bat species were obtained from Francis (2019) Kruskop (2013) Furey et al. (2010, 2011) Furey & Racey (2016) and unpublished data held by the first author.

All bat species were assigned to one or more of three categories regarding their roosting preferences. These categories comprised: 1) Caves, defined here as including other subterranean sites such as mines and rock voids, 2) Foliage, inclusive here of tree hollows, and 3) Artificial roosts, recognized here as including all human-made structures above ground. As the roosting preferences of some poorly-studied species are currently unknown, these were necessarily inferred from the preferences of related taxa and land cover of known localities for each species.

The wing morphology of bats determines their mobility and directly influences their foraging preferences, home range areas and dispersal abilities, including capacity for migration (Norberg & Rayner 1987). Because the classification of McKenzie et al. (1995) reflects the differential foraging strategies and propensities for migration of bat species, all species registered were categorized using Furey & Racey (2016) and associated publications as follows:

- Strategy I: Insectivorous species that forage in the highly cluttered airspace within the forest interior (or forest interior specialists);
- Strategy II: Insectivorous species that forage in partially cluttered spaces such as clearings, streams or other tunnels within the forest or just above the canopy (edge and gap foragers);
- Strategy III: Insectivorous bats that forage in unobstructed airspaces found in large clearings or high above the forest canopy (open-space foragers);
- Strategy IV: Fruit and nectar-eating bats that fly into the partially cluttered air-spaces between tree canopies, roost in small numbers and forage locally;
- Strategy V: Fruit and nectar-eating bats that fly in unobstructed airspaces, roost in large colonies and forage over large areas.

RESULTS

Desk Review

Review of literature and specimen collections indicates that at least 27 bat species have been recorded in Koh Kong Province and adjacent areas (Table 1). Three of these species are currently listed in categories other than Least Concern by IUCN (2022): *Pteropus hypomelanus* (Near Threatened), *Murina walstoni* (Data Deficient) and *Kerivoula picta* (Near Threatened), whereas *P. hypomelanus* is also considered nationally rare in Cambodian legislation (MAFF 2007).

Table 1: Bat species recorded in Koh Kong Province and adjacent areas, Cambodia (DD=Data Deficient, LC=Least Concern, NA=Not Assessed, NT=Near Threatened).

No.	Family / Species	IUCN Status[1]	Source
I	**Pteropodidae**		
1	*Pteropus hypomelanus*	NT[2]	Ravon et al. 2014
2	*Cynopterus brachyotis*	LC	CBC; Furey, unpubl. data
3	*Cynopterus sphinx*	LC	Furey, unpubl. data
4	*Megaerops niphanae*	LC	Furey, unpubl. data
5	*Macroglossus sobrinus*	LC	Furey, unpubl. data
II	**Megadermatidae**		
6	*Lyroderma lyra*	LC	Furey, unpubl. data
7	*Megaderma spasma*	LC	Furey, unpubl. data
III	**Hipposideridae**		
8	*Hipposideros armiger*	LC	Furey, unpubl. data;
9	*Hipposideros gentilis*	LC	Furey, unpubl. data; CBC
10	*Hipposideros larvatus* s. l.	-	Furey, unpubl. data
IV	**Rhinolophidae**		
11	*Rhinolophus acuminatus*	LC	CBC
12	*Rhinolophus lepidus*	LC	Furey, unpubl. data
13	*Rhinolophus malayanus*	LC	CBC; Furey, unpubl. data
14	*Rhinolophus microglobosus*	LC	Furey, unpubl. data
15	*Rhinolophus* cf. *yunanensis*	- [3]	Ith et al. 2011
16	*Rhinolophus perniger*	NA	Furey, unpubl. data
17	*Rhinolophus pusillus*	LC	CBC; Furey, unpubl. data
18	*Rhinolophus shameli*	LC	CBC; Furey, unpubl. data
V	**Vespertilionidae**		
19	*Myotis horsfieldii*	LC	Furey, unpubl. data
20	*Myotis muricola*	LC	Furey, unpubl. data
21	*Pipistrellus coromandra*	LC	Furey, unpubl. data
22	*Pipistrellus paterculus*	LC [3]	Furey et al. 2012
23	*Hesperoptenus blanfordi*	LC	Furey, unpubl. data
24	*Murina harrisoni*	LC [3]	Csorba & Bates 2005
25	*Murina walstoni*	DD	Csorba et al. 2011; Furey, unpubl.
26	*Kerivoula hardwickii*	LC	CBC; Furey, unpubl. data
27	*Kerivoula picta*	NT	Furey, unpubl. data

[1] As of November 2022, [2] Recorded in Koh Rong archipelago, [3] Recorded in Kirirom National Park.

Sampling Effort

Over the course of the survey (nine sampling nights), 4,644.8 m^2 mist-net-hours, 55.4 m^2 harp-trap-hours and 68.5 hrs of acoustic sampling with SM4 detectors were achieved at nine discrete locations within or adjacent to Peam Krasop Wildlife Sanctuary (Table 2, Fig. 4). A further 765 hrs of acoustic sampling with AM detectors was achieved at ten locations over six nights (Table 3, Fig. 4). Indicative images of habitats at each sampling location are provided in Figs. 5 & 6. No rain fell during live-trapping sessions during the survey, although light rain briefly occurred in the early afternoon of 20 February.

Fig. 4: Bat survey locations in Peam Krasop, February 2023.

Table 2: Mobile sampling locations and effort in Peam Krasop, February 2023.

Date	Site Code	Lat/Long	Mist net (m^2hth)	Harp Trap (m^2mnh)	Detector Hours	Habitat
15/2	PKWS-01	11.55991 102.98996	399.8		6.5	*Rhizophora* boardwalk
16/2	PKWS-02	11.51304 102.98774	331.5		6.5	*Rhizophora* mangrove
17/2	PKWS-03	11.49857 103.05074	586.5		8.5	*Rhizophora* mangrove, Lumnitzera, highly disturbed
18/2	PKWS-04	11.47959 103.06162	561.0	12.2	8.5	*Rhizophora* mangrove
19/2	PKWS-05	11.43646 103.00594	216.0	6.5	4.5	Semi-evergreen forest
20/2	PKWS-06	11.43945 103.02244	714.0		8.5	Mixed Melaleuca forest
21/2	PKWS-07	11.48445 103.13929	714.0	12.2	8.5	Mixed Melaleuca forest
22/2	PKWS-08	11.49431 103.12340	586.5	12.2	8.5	Mixed Melaleuca forest
23/2	PKWS-09	11.51268 103.12398	535.5	12.2		Mixed Melaleuca/ semi-evergreen forest
			4,644.8	**55.4**	**68.5**	

Table 3: Static sampling locations and effort in Peam Krasop, February 2023.

Start - End Dates	Site Code	Lat/Long	Detector Hours	Habitat
17–23/2	AM-01	11.52653 102.9707	76.5	*Rhizophora* mangrove. Outer island on coast. Channel 11m wide
16–22/2	AM-02	11.53792 103.12282	76.5	Semi-evergreen forest. Secondary channel (21m wide) of the Tatai River
17–23/2	AM-03	11.49857 103.05074	76.5	Terrestrial mangrove. Small (5,500 m^2) inland flooded area
17–23/2	AM-04	11.46959 103.03997	76.5	*Rhizophora* mangrove. Water body (1,400 m^2) mangroves, with exit to main river
17–23/2	AM-05	11.43831 103.05034	76.5	*Rhizophora* mangrove, *Lumnitzera*, highly disturbed
16–22/2	AM-06	11.44295 103.0958	76.5	*Rhizophora* mangrove. Secondary channel (12m wide) from river
16–22/2	AM-07	11.47652 103.09163	76.5	*Rhizophora* mangrove and *Lumnitzera*. Channel (191m wide) in main river of interior zone
16–22/2	AM-09	11.48494 103.1392	76.5	Mixed Melaleuca forest. Small open area surrounded by forest, on island in Tatai River
16–22/2	AM-10	11.50898 103.12973	76.5	Semi-evergreen forest. Secondary channel (13m wide) on Tatai River
17–23/2	AM-11	11.50907 103.00178	76.5	*Rhizophora* mangrove. Large inland flooded area, channel 100m wide
			765	

Each unit was active from 1745–0630 hrs for six nights, albeit with a recording duty cycle of 25%.

Fig. 5: Indicative images of mobile sampling habitats in Peam Krasop, February 2023.

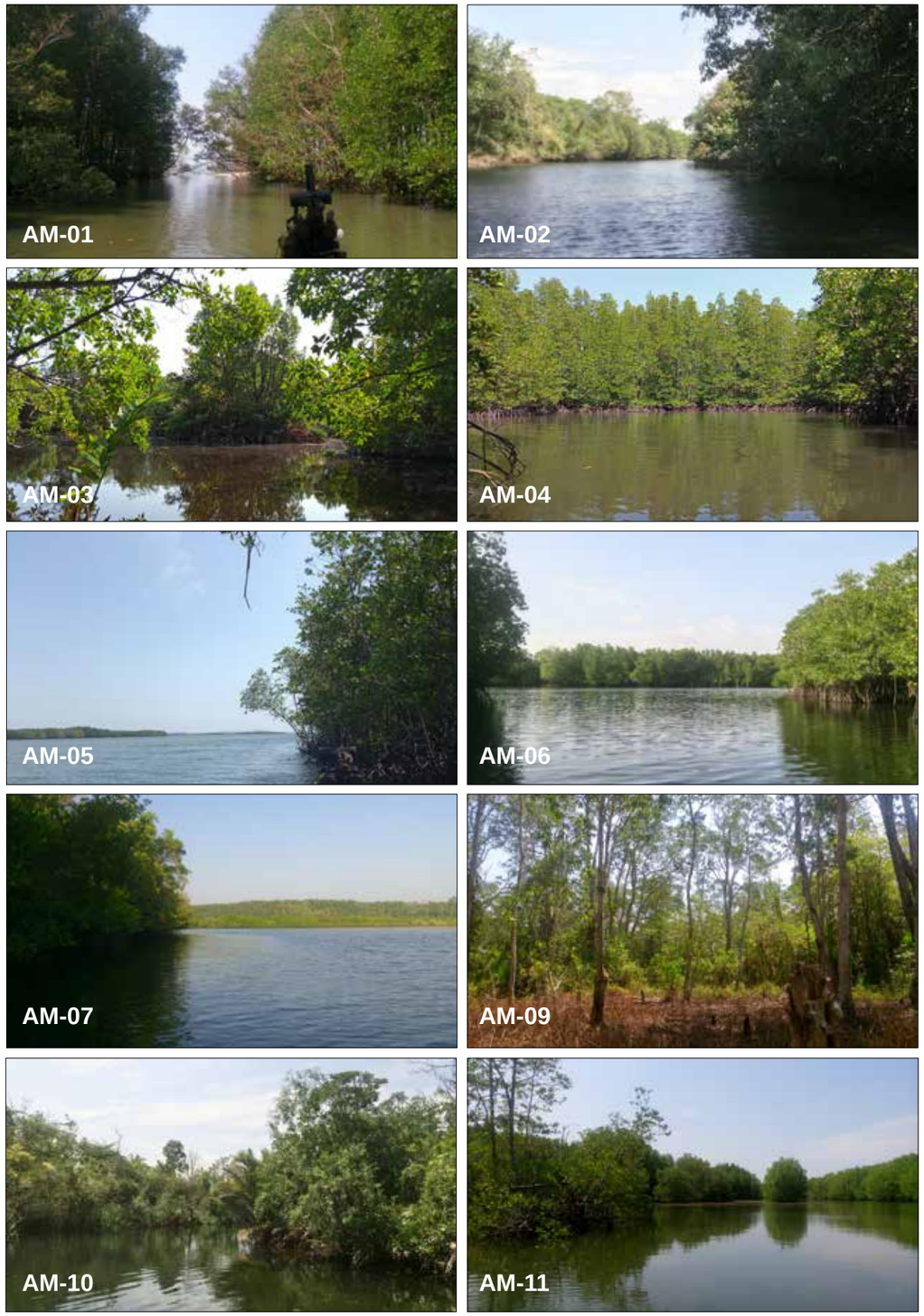

Fig. 6: Indicative images of static sampling habitats in Peam Krasop, February 2023.

Bat Species Composition

During the field survey, 113 bats representing nine species arranged in five families were captured in live traps and subsequently released (Table 4, Fig. 7). Leaf-nosed bats (Hipposideridae) accounted for most captures (50%, 56 bats) with two species, followed closely by frugivorous bats (Pteropodidae, 44%, 50 bats) with three species. The remainder comprised sheath-tailed (Emballonuridae), horseshoe (Rhinolophidae) and evening (Vespertilionidae) bats, which collectively accounted for 6% of captures (seven bats) and four species.

With the exception of *Murina walstoni* which is currently listed as Data Deficient, the remaining species are variably common within mainland SE Asia and presently regarded as Least Concern (IUCN 2022). However, one ranger (Mr. Tan Menghou) reported that ≈100 flying foxes (*Pteropus* spp.) existed in an area of the sanctuary known as 'Prey Chroeng' approximately 20 years previously, although numbers had apparently declined since this time, with only around ten observed in the same area in 2022. While only three *Pteropus* species occur in Cambodia (*P. hypomelanus* NT, *P. lylei* VU and *P. vampyrus* EN) and *P. hypomelanus* occurs in the Koh Rong archipelago (Ravon et al. 2014) the species present in Peam Krasop remains unconfirmed as none were seen on visiting the area or during the wider survey.

Two day-roosts were found during the survey, both located in the Koh Moul area (PKWS-05: Fig. 4). The first comprised an abandoned salt store from the colonial era which was occupied by <10 *Taphozous melanopogon* (Fig. 8) whereas the second consisted of an abandoned mansion (also colonial-era) whose basement was inhabited by similar numbers of *T. melanopogon* and 150–300 *Hipposideros larvatus* s. l. (Figs. 9-10).

Thirteen phonically distinct bat taxa were detected in the acoustic sampling, including nine not captured during the survey. Presence/absence data for these are provided in Table 4 and exemplar calls are shown in Figs. 11–12. Reference data from Peam Krasop and other sites in Cambodia and neighbouring countries permitted specific assignment of ten of these, including six not captured in live-traps (*Mops plicatus, Myotis hasseltii, Rhinolophus perniger, R. pearsonii, R. shameli* and *R. pusillus*, all of which are currently regarded as Least Concern by IUCN (2022)) whereas calls for three others remain as yet unidentified (phonic types 1–3).

While these acoustic identifications are necessarily provisional due to geographical variation in call frequencies and paucity of data on the calls of bat species in west Cambodia, the signals emitted by these taxa differ greatly from all other species captured during the survey and therefore unequivocally increase the number of bat species recorded in Peam Krasop to at least 16 and possibly as many as 19 taxa (with the inclusion of the three unidentified phonic types).

Table 4: Bat species recorded in Peam Krasop, February 2023.

	Date	15	16	17	18	19	20	21	22	23
	Site Code, PKWS-	01	02	03	04	05	06	07	08	09
I	**Pteropodidae**									
1	*Pteropus* sp.[1]									
2	*Cynopterus sphinx*							9		
3	*Cynopterus brachyotis*						1	16	11	9
4	*Macroglossus minimus*			1	2		1			
II	**Emballonuridae**									
5	*Taphozous melanopogon*	A	A	A	A	3[A]	A	A	A	A
III	**Rhinolophidae**									
6	*Rhinolophus malayanus*	A		A			2[A]			
7	[*Rhinolophus shameli*]	A	A				A		A	A
8	[*Rhinolophus pearsonii*]									
9	[*Rhinolophus perniger*]									
10	[*Rhinolophus pusillus*]								A	
IV	**Hipposideridae**									
11	*Hipposideros cineraceus*						2			
12	*Hipposideros larvatus* s.l.			A	A	47[A]	7[A]			
V	**Vespertilionidae**									
13	*Myotis ater*	A					A	1[A]	A	A
14	[*Myotis hasseltii*]	A	A	A	A		A	A	A	A
15	*Murina walstoni*							1		
VI	**Molossidae**									
16	[*Mops plicatus*]			A	A		A	A	A	A
Phonic Types										
17	Phonic type 1				A		A	A	A	A
18	Phonic type 2									
19	Phonic type 3									
Bats captured		-	-	1	2	52	11	27	11	9
Species captured		-	-	1	1	3	4	4	1	1
Combined species [2]		**4**	**3**	**7**	**6**	**3**	**10**	**8**	**8**	**7**

[1] Solely based on local reports, [2] Including species recorded in acoustic sampling,
[A] Acoustic detection. Square brackets indicate taxa solely recorded in acoustic sampling.

	AudioMoth Sampling (Site Code, AM-)									
	01	02	03	04	05	06	07	09	10	11
I	**Pteropodidae**									
1	*Pteropus* sp. [1]									
2	*Cynopterus sphinx*									
3	*Cynopterus brachyotis*									
4	*Macroglossus minimus*									
II	**Emballonuridae**									
5	*Taphozous melanopogon*	A	A	A		A	A	A	A	A	A
III	**Rhinolophidae**									
6	*Rhinolophus malayanus*									
7	[*Rhinolophus shameli*]					A					
8	[*Rhinolophus pearsonii*]		A								
9	[*Rhinolophus perniger*]		A								
10	[*Rhinolophus pusillus*]										
IV	**Hipposideridae**										
11	*Hipposideros cineraceus*										
12	*Hipposideros larvatus* s.l.										
V	**Vespertilionidae**										
13	*Myotis ater*	A	A	A		A	A	A	A	A	A
14	[*Myotis hasseltii*]	A	A	A		A	A	A	A	A	A
15	*Murina walstoni*										
VI	**Molossidae**										
16	[*Mops plicatus*]					A	A	A	A	A	A
Phonic Types											
17	Phonic type 1	A	A	A		A	A	A	A	A	
18	Phonic type 2	A		A		A	A	A	A	A	A
19	Phonic type 3			A					A	A	
Bats captured		-	-	-	-	-	-	-	-	-	-
Species captured		-	-	-	-	-	-	-	-	-	-
Combined species [2]		**6**	**6**	**6**	**-**	**7**	**6**	**6**	**7**	**7**	**5**

Macroglossus minimus

Murina walstoni

Hipposideros cineraceus

Cynopterus sphinx

Rhinolophus malayanus

Taphozous melanopogon

Cynopterus brachyotis

Hipposiderus larvatus s. l.

Myotis ater

Fig. 7: Bat species captured and released in Peam Krasop, February 2023 [not to scale]

Fig. 8: Colonial-era salt store inhabited by *T. melanopogon* (inset), Peam Krasop.

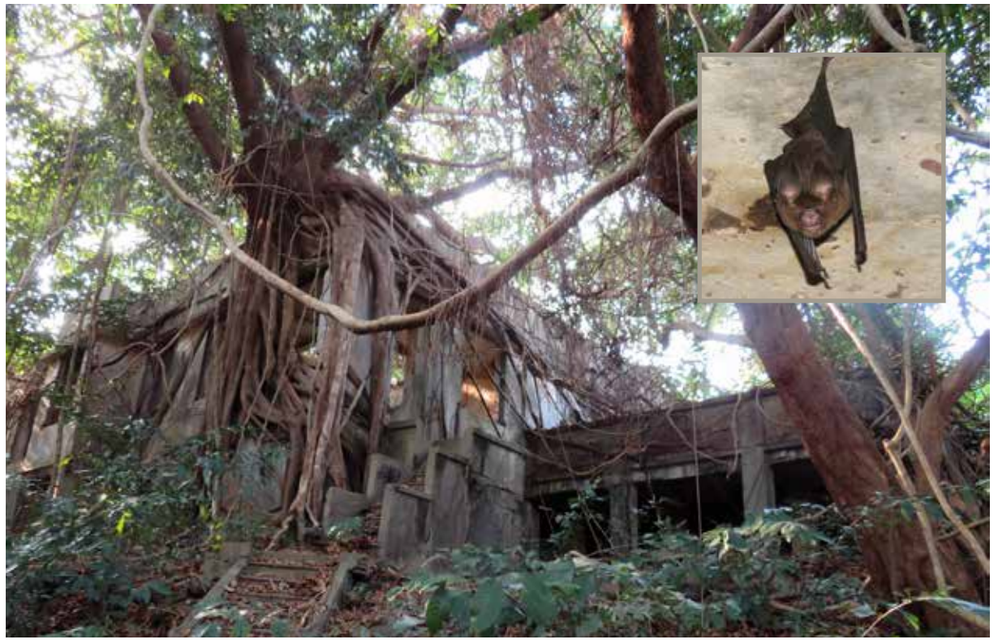

Fig. 9: Colonial-era mansion inhabited by *H.* cf. *larvatus* (inset), Peam Krasop.

Fig. 10: Colonial-era mansion with colony of *Hipposideros larvatus* s.l., Peam Krasop.

Insectivorous Bat Activity

Bat activity varied significantly between sampling sites and is depicted in Fig. 13. Mean activity for detector-nights was 35.2 bat passes (SD ± 28.2), with a maximum of 124 passes at PKWS-02(B) and a minimum of 7 passes at PKWS-04(A). Although nightly variation was significant, insectivorous bat activity was greatest between 1800–1900 hrs (with 46.2% of mean hourly activity registered during this period) and progressively declined thereafter (Fig. 14).

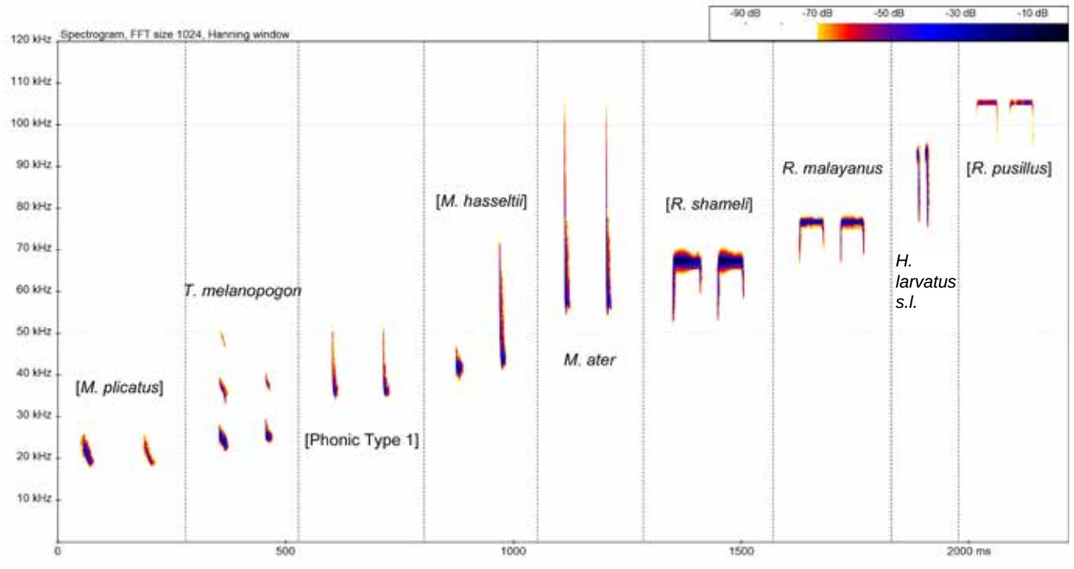

Fig. 11: Exemplar calls of bat species registered in acoustic sampling in Peam Krasop [Square brackets indicate taxa solely recorded in acoustic sampling].

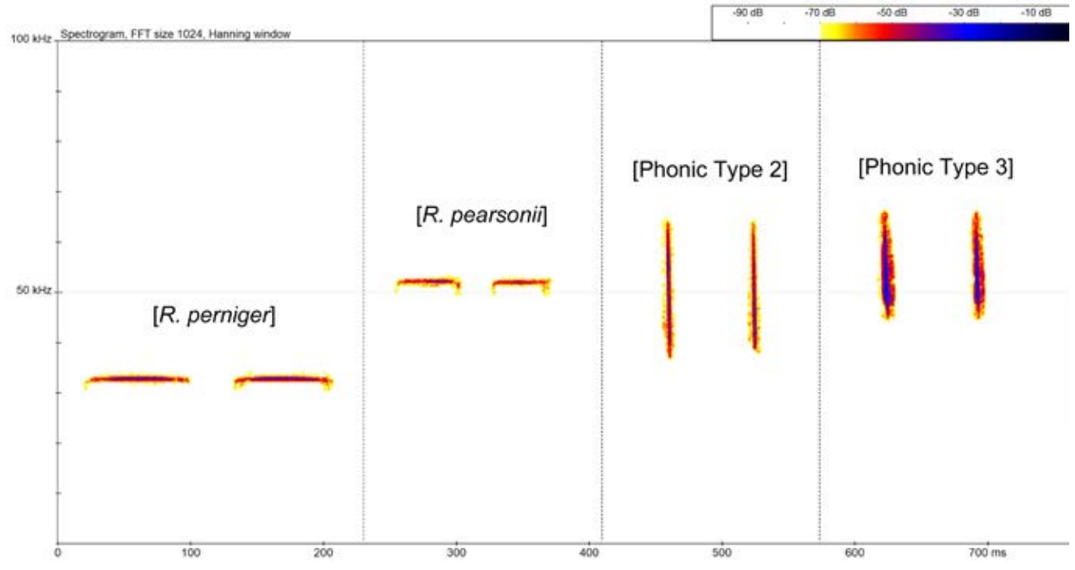

Fig. 12: Calls of additional bat species registered in Peam Krasop, February 2023 [Square brackets indicate taxa solely recorded in acoustic sampling].

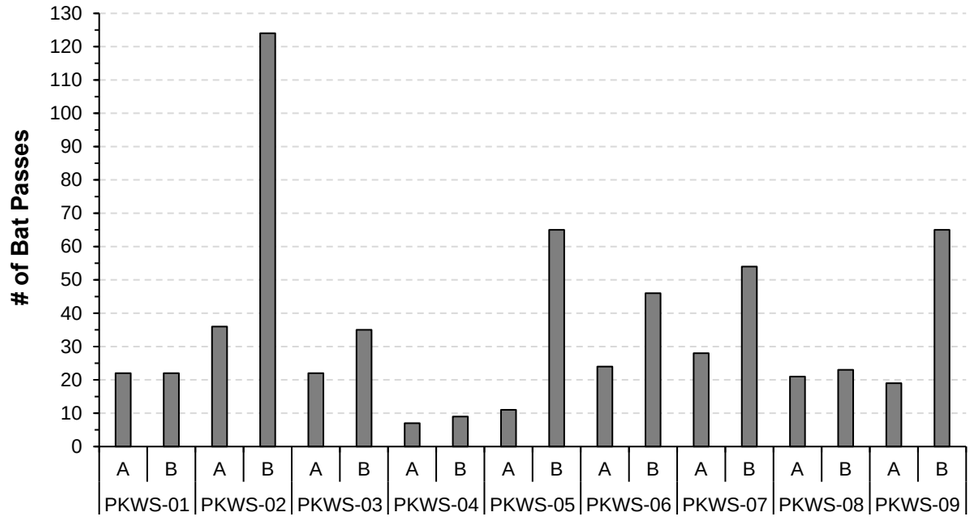

Fig. 13: Bat activity across active sampling sites in Peam Krasop, February 2023.

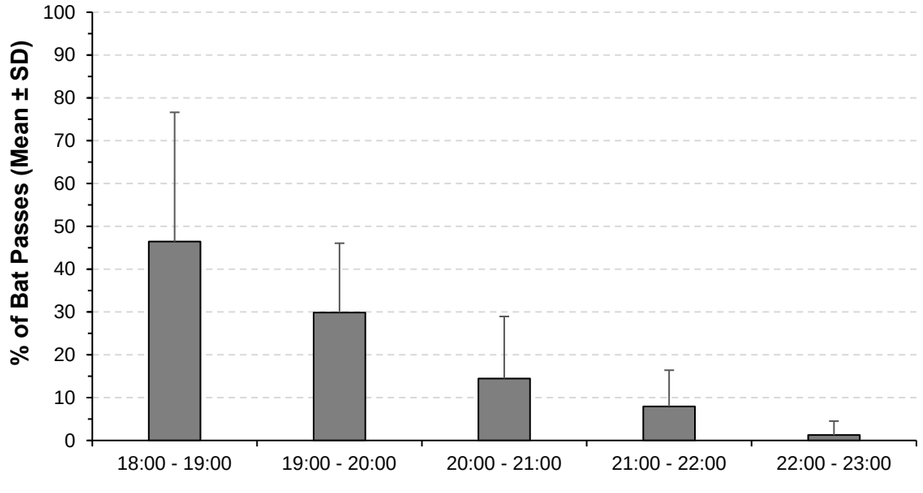

Fig. 14: Hourly variation in bat activity in Peam Krasop, February 2023.

INTERPRETATION

Conservation Significance & Future Prospects

Current data indicate at least 16 and possibly as many as 19 bat species occur in Peam Krasop Wildlife Sanctuary. Apart from *Pteropus* spp. and *Murina walstoni* (DD), all of these are currently regarded as Least Concern by the IUCN (2022) (Table 5). These figures represent 19–23% of the known bat fauna of Cambodia (83/16–19 species), but undoubtedly fall short of the true site total for several reasons including:

- The absence of entire subfamilies (Vespertilioninae, Kerivoulinae) and commonplace taxa (megadermatids) and limited representation of diverse genera (*Hipposideros, Myotis*) on the current species list for the site;
-
- The known occurrence of at least 19 other species in Koh Kong Province (Table 5), many of which may also occur within the sanctuary, particularly its northern areas; and,
- The relatively limited survey effort achieved to date (especially in terrestrial areas), coupled with the reality that detection of many bat species requires sustained effort.

As a consequence, further sampling will undoubtedly reveal additional bat species. Additionally, Peam Krasop has good prospects for supporting bat species which occur in eastern Thailand but have yet to be encountered in Cambodia, such as the Near Threatened *Rhinolophus trifoliatus* (Furey et al. 2021). As such, the bat species richness of the site is undoubtedly greater than presently documented, although there is no reason to suppose that any of the taxa present might be locally or nationally endemic.

▷ [1] A=Artificial (anthropogenic) roosts, C=Caves, F=Foliage. [2] See Ecological traits section, [3] As of November 2022: DD=Data Deficient, LC=Least Concern, NA=Not Assessed, NT=Near Threatened, [4] Recorded in Koh Rong archipelago, [5] Recorded in Kirirom N.P. Square brackets indicate taxa solely recorded in acoustic sampling.

Table 5: Ecological traits & status of bat species recorded in Peam Krasop (PK), Koh Kong Province (KK) and adjacent areas.

#	Family / Species	Current Records	Typical Roosts[1]	Foraging Strategy[2]	IUCN Status[3]
	Pteropodidae				
1	*Pteropus hypomelanus*	KK	F	V	NT[4]
2	*Pteropus* sp.	PK	F	V	-
3	*Cynopterus sphinx*	PK / KK	F	IV	LC
4	*Cynopterus brachyotis*	PK / KK	F	IV	LC
5	*Megaerops niphanae*	KK	F	IV	LC
6	*Macroglossus sobrinus*	KK	F	IV	LC
7	*Macroglossus minimus*	PK	F	IV	LC
	Emballonuridae				
8	*Taphozous melanopogon*	PK	A, C	III	LC
	Megadermatidae				
9	*Lyroderma lyra*	KK	A, C	I–II	LC
10	*Megaderma spasma*	KK	A, C, F	I–II	LC
	Rhinolophidae				
11	*Rhinolophus acuminatus*	KK	A, C, F	I	LC
12	*Rhinolophus lepidus*	KK	A, C	I	LC
13	*Rhinolophus malayanus*	PK / KK	C	I	LC
14	*Rhinolophus microglobosus*	KK	C, F	I	LC
15	[*Rhinolophus pearsonii*]	PK	C	I-II	LC
16	*Rhinolophus perniger*	[PK] / KK	C, F	I-II	NA
17	*Rhinolophus pusillus*	[PK] / KK	A, C, F	I	LC
18	*Rhinolophus shameli*	[PK] / KK	C	I	LC
19	*Rhinolophus* cf. *yunanensis*	KK	-	I-II	-[5]
	Hipposideridae				
20	*Hipposideros armiger*	KK	C, F	II	LC
21	*Hipposideros cineraceus*	PK	A, C	I	LC
22	*Hipposideros gentilis*	KK	C, F	I	LC
23	*Hipposideros larvatus* s. l.	PK / KK	A, C	II	-
	Vespertilionidae				
24	*Myotis ater*	PK	F	I-II	LC
25	[*Myotis hasseltii*]	PK	A, C, F	I-II	LC
26	*Myotis horsfieldii*	KK	C	I-II	LC
27	*Myotis muricola*	KK	F	I-II	LC
28	*Pipistrellus coromandra*	KK	A, F	I-II	LC
29	*Pipistrellus paterculus*	KK	A, F	I-II	LC[5]
30	*Hesperoptenus blanfordi*	KK	C, F	I	LC
31	*Murina harrisoni*	KK	F	I	LC[5]
32	*Murina walstoni*	PK / KK	F	I	DD
33	*Kerivoula hardwickii*	KK	F	I	LC
34	*Kerivoula picta*	KK	F	I	NT
	Molossidae				
35	[*Mops plicatus*]	PK	A, C	III	LC

On first impression, areas of *Rhizophora* mangrove within the sanctuary appeared to support relatively few bats which could be speculatively attributed to potentially lower biomass of invertebrates available to bats (due to their intertidal/saline nature) and roost availability (due to possibly fewer tree cavities and crevices relative to mature terrestrial forests). However, this is challenged by analysis of acoustic data which suggest comparable numbers of species may occur in these (Table 4), although the bats registered were skewed towards species which typically forage in semi- to fully open spaces (= strategy II and III taxa).

In a broader context, studies in Vietnam and Thailand have demonstrated dramatic declines in bat abundance between areas with natural and mature forest cover compared to areas with disturbed formations or plantations (Furey et al. 2010, Phommexay et al. 2011). As such, priority should be given to maintaining forest condition and cover within the sanctuary, since the loss of older, larger trees (which typically provide more cavities, hollows and crevices) particularly threatens foliage-roosting species, whereas fragmentation of mature forest stands erodes the foraging effectiveness of forest-interior specialists (= strategy I taxa).

In conclusion, the present work indicates further surveys will reveal additional bat species at Peam Krasop. As multi-year sampling in neighbouring countries indicates that sampling during the dry and wet seasons is critical to inventory completeness (e.g., Furey et al. 2010), such work should ideally encompass both seasons and employ multiple detection methods e.g., live-trapping and acoustic sampling.

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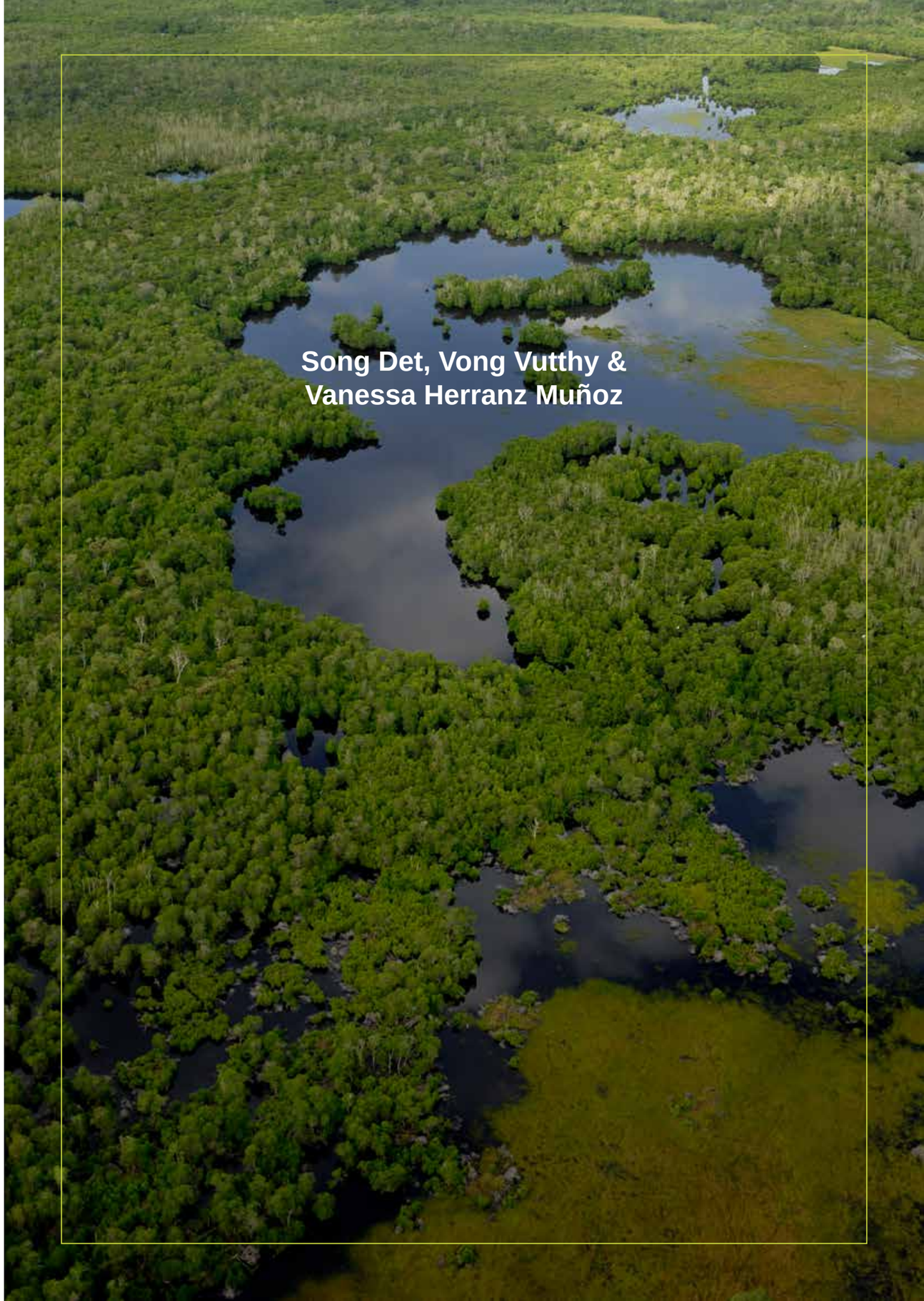
▷ *Pteropus* sp. from the Cambodian coast.

BOTANICAL SURVEY



Song Det, Vong Vutthy &
Vanessa Herranz Muñoz

Title image: Aerial view of Peam Krasop Wildlife Sanctuary.

INTRODUCTION

The protection of intertidal ecosystems is complex because they straddle both the marine and terrestrial realms. This lead to inconsistent characterization as marine and/or terrestrial systems or neither. Vegetated intertidal ecosystems are especially complex to classify because they can have an unclear border with terrestrial vegetation, causing confusion around taxonomy (e.g., mangrove-like plants). This inconsistency and confusion in classification can impact these systems through poor governance and incomplete protection (Rog and Cook 2017). Vegetated intertidal ecosystems also fall under legislation related to native vegetation management, adding a further layer of complexity. While this taxonomic classification may seem trivial, it can have import implications for how species are managed and conserved. Mangrove ecosystem conservation in Cambodia has faced challenges due to a lack of proper identification of mangrove species and documentation of species diversity.

A recent study by Lo et al. (2018) revealed that there are almost 30 distinct species of mangroves and related plants in Botum Sakor National Park (BSNP) an area that is adjacent to Peam Krasop Wildlife Sanctuary (PKWS). However, the study also noted that DNCP (1995) had reported 42 species of true and associated mangroves in Koh Kong province, indicating that there might be more diversity than they recorded, and that more studies should be conducted.

SURVEY AREA & OBJECTIVES

The objective of this study is to review the existing information and assess species plant diversity in the mangrove ecosystem in the Peam Krasop Wildlife Sanctuary. The updated list of plant species in PKWS will provide baseline data for site-specific management and mangrove conservation efforts at the site.

◁ Mangrove forest in Peam Krasop Wildlife Sanctuary.

SURVEY METHODS

Data Collection

Plant species diversity was surveyed using line transects and plots following methods from Sulistyoriniis et al. (2021) & Sreelekshmi et al. (2020) adapted to site conditions. Each line transect ran for a maximum length of 50 m (plots 2-5), and each plot was 5 m^2 . In total, 10 line transects and 30 plots were sampled. The total number of mangrove tree species and associated vegetation was recorded, plus the number of individuals of each species.

All diagnostic features of plants were photographed - including leaves, flowers, fruit, roots, and bark - following Khou (2018). This aided identification to species level. Occasionally, plant specimens were collected for further identification.

To conduct the plant survey, GPS devices were used to record the coordinates of each plot, and a data sheet (Appendix 1) was created to collect information on the plant species found in each plot. To verify the plant species, a mangrove guidebook and checklist were prepared and brought along in the field. For species of particular interest that may require preservation for further study or potentially represent a new species or country record, reading paper and plant presses were utilized. Common plant species were photographed using a digital camera with a ruler scale for size reference.

Data collection of plant species from different sites was systematically recorded in a comprehensive table divided into plot, habitat type and species composition following Ragavan et al. (2016). This table is a tool to present the various plant species in each plot and their habitat associations, which provides valuable information to understand the plant community composition in the mangrove ecosystem.

RESULTS

The present study provides results of plant species diversity in different habitat types surveyed from 10 line transects including 30 plots, covering the seaward to landward mangrove ecosystem in PKWS. The present study recorded 45 plant species, classified into different groups such as trees, vines, shrubs, and palms.

Desk Review

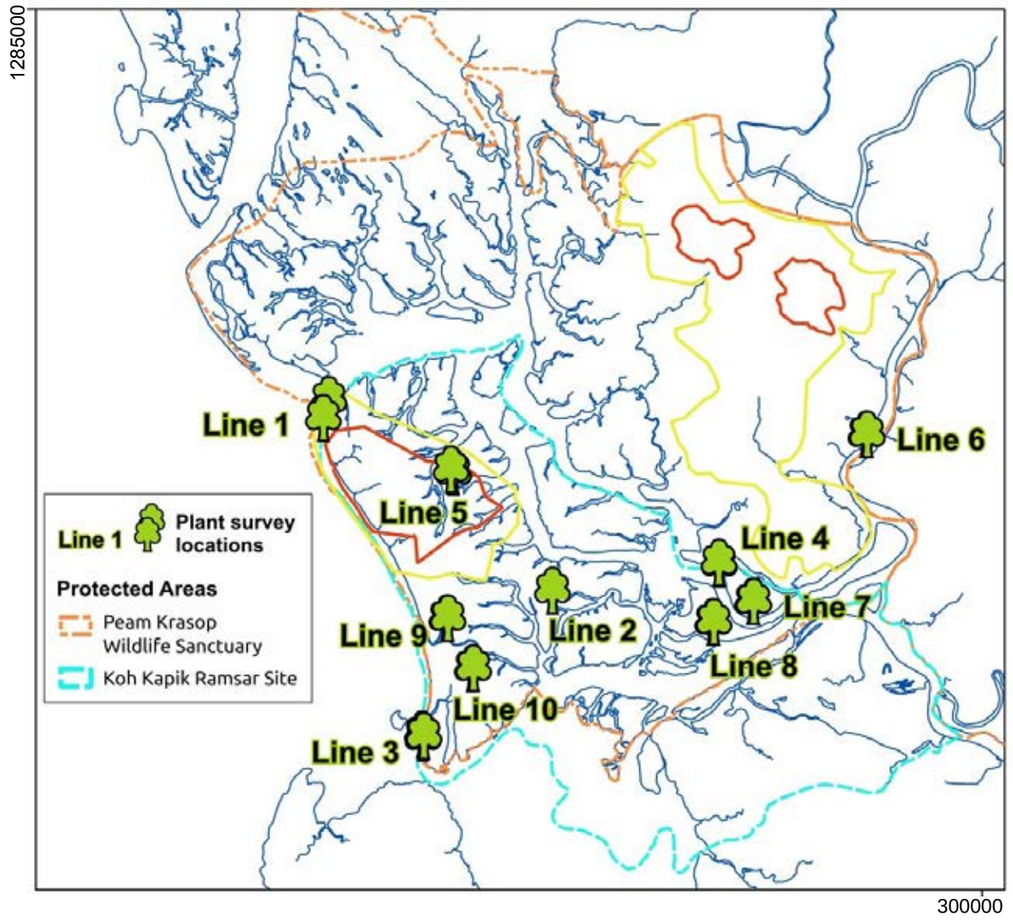
Four reliable sources were consulted to identify and document the mangrove plant species in Cambodia. However, there were notable discrepancies in the number of plant species reported, ranging from 20 to 50 species, as different studies focused on different aspects of the mangrove ecosystem. Therefore, the literature review data cannot provide a comprehensive understanding of the total number of species present in the Cambodian mangrove forest ecosystem. By reviewing the UNEP 2008 report, we estimated there are around 50 species of plant found in Cambodian mangrove habitat. Lo et al. (2018) one of the more recent studies, provides a short list of 26 mangrove species from the peat soil mangroves in Botum Sakor National Park. Other recent studies documented fewer mangrove species, including Khou E. H. (2018) which recorded a total of 35 species of mangrove plants from a limited area within Preah Sihanouk Province. A more general guide of the mangroves of Southeast Asia (Giesen et al. 2006) reported 35 species existing in Cambodia's mangrove forests (Table 1).

Table 1: Mangrove species recorded by different sources: T = True mangrove, A = Associated mangrove.

Species name	Sources reviewed				
	T/A	Lo et al., 2018	UNEP, 2008	Giesen et al., 2006	Khou, 2018
Acanthus ebracteatus	T	*	*	*	
Acanthus ilicifolius	T	*	*	*	
Acanthus volubilis	T		*	*	*
Acrostichum aureum	T	*	*	*	*
Acrostichum speciosum	T	*		*	
Aegialitis rotundifolia	T		*	*	
Aegiceras corniculatum	T		*	*	
Aegiceras floridum	T		*	*	
Aglaia cucullata	A	*	*		
Allophyllus cobbe	A				*
Annona glabra	A				*
Atalantia monophylla	A		*		
Avicennia alba	T		*	*	
Avicennia marina	T	*	*	*	
Avicennia officinalis	T		*	*	
Barringtonia acutangula	A			*	
Barringtonia racemosa	A		*		
Brownlowia tersa	A		*	*	
Bruguiera cylindrica	T		*	*	
Bruguiera gymnorrhiza	T	*	*	*	
Bruguiera parviflora	T		*	*	
Bruguiera sexangula	T	*	*	*	*
Caesalpinia crista	A		*		*
Calamus guruba	A				*
Calycopteris floribunda	A		*		
Casuarina equisetifolia	A				*
Cerbera odollam	A		*		
Ceriops decandra	T		*	*	*
Ceriops tagal	T	*	*	*	
Clerodendrum inerme	A		*		*
Combretum tetralophum	A		*		*
Cordia dichotoma	A				*
Cordia cochinchinensis	A		*		
Cynometra iripa	A				*
Derris trifoliata	A		*		
Excoecaria agallocha	T	*	*		*
Ficus curtipes	A				*
Finlaysonia obovata	A		*		*
Flagellaria indica	A		*		*
Glochidion littorale	A			*	
Gymnanthera oblonga	A				*
Heritiera littoralis	A	*	*	*	*
Intsia bijuga	A	*	*		
Ipomoea maxima	A				*
Kandelia candel	T		*	*	
Lumnitzera littorea	T	*	*	*	*
Lumnitzera racemosa	T	*	*	*	*
Melaleuca cajuputi	A	*			*

Melaleuca leucadendron	A				*
Melanthera biflora	A				*
Melastoma saigonense	A				*
Nypa fruticans	T	*	*	*	*
Oncosperma tigillarium	A	*			
Pandanus tectorius	A		*		*
Phoenix paludosa	A	*	*		*
Pluchea indica	A				*
Premna obtusifolia	A		*		
Rhizophora apiculata	T	*	*	*	*
Rhizophora mucronata	T	*	*	*	*
Scaevola taccada	A		*		
Scyphiphora hydrophyllacea	T	*		*	
Shirakiopsis indica	A		*		
Sonneratia alba	T		*	*	
Sonneratia caseolaris	T	*	*	*	
Sonneratia griffithii	T		*	*	
Sonneratia ovata	T	*	*	*	*
Talipariti tiliaceum	A	*	*		*
Terminalia catappa	A	*			
Thespesia populnea	A		*		
Vincetoxicum carnosum	A				*
Xylocarpus granatum	T	*	*	*	*
Xylocarpus moluccensis	T		*	*	*
Xylocarpus rumphii	T		*	*	
Total Number of Species	**26**	**52**	**35**	**39**	

Fig. 1: Survey lines sampled in Peam Krasop Wildlife Sanctuary.



Species Occurrence

Results showed that the highest numbers of plant species were recorded in the seaward habitat (plots 1, 3 – 5, and 11-13) including approximately 50% of the species recorded during the study. These species include *Allophylus cobbe*, *Ardisia elliptica, Avicennia rumphiana, Bruguiera cylindrica, Bruguiera gymnorrhiza, Casalpinia crista, Casuarina equisetifolia, Chiococa* sp., *Chromolaena odorata, Derris trifoliata, Diospyros* sp., *Heritiera littoralis, Hibiscus tiliaceus, Rhizophora apiculata, Rhizophora mucronata* and others.

Within the landward, riverine area, 12 terrestrial plant species were found, including *Acrostichum ebracteatus, Aglaia cucullata, Bruguiera sexangula, Finlaysonia obovata, Flagellaria indica, Heritiera littoralis, Hibiscus tiliaceus, Intsia bijuga, Planchonella obovata, Rhizophora apiculata, Volkameria* (*Clerodendrum*) *inermis,* and *Xylocarpus granantum*, which were recorded from plots 19-20.

High plant species diversity was also recorded in the back-mangrove habitat areas from plots 6, 7 and 14 -16 by including as the most common species *Ceriops* sp., *Excoecaria agallocha, Derris trifoliata, Heritiera littoralis, Hibiscus tiliaceus, Intsia bijuga, Lumnitzera* sp., *Phoenix paludosa, Rhizophora apiculata* and *Xylocarpus granantum*.

Rhizophora apiculata was found to be dominant, most abundant species in mud creek channels and followed by *Bruguiera cylindrica, Avicennia marina*, and *Xylocarpus rumphiana*. Interestingly, in mud peat habitats only two mangrove species *Ceriops decandra* and *Rhizophora apiculata* appeared to dominate (Table 3).

Plot locations

Table 2: Plot and line locations at the survey site.

Line	Plot	UTM X	UTM Y	Line	Plot	UTM X	UTM Y
Line 1	1	028.0396	12.73737	Line 5	Plot 17	11.499948	103.020835
	2	028.0397	12.73721		Plot 18	11.500595	103.020141
	3	028.0375	12.73719				
	4	028.0360	12.73704	Line 6	Plot 19	11.510496	103.130027
	5	028.0359	12.73682		Plot 20	11.510511	103.130386
Line 2	6	028.7107	12.67787	Line 7	Plot 21	11.471600	103.094219
	7	028.7110	12.67815		Plot 22	11.471236	103.093835
	8	028.7109	12.67833		Plot 23	11.473070	103.094575
	9	028.7085	12.67733				
	10	028.7064	12.6771	Line 8	Plot 24	1 1.466776	103.091370
Line 3					Plot 25	11.462560	103091665
	11	11.431325	103.013038		Plot 26	11.463060	103.093439
	12	11.430417	103.013195				
	13	11.430946	103.013469	Line 9	Plot 27	11.457125	103.020023
					Plot 28	11.456308	103.019904
Line 4	14	11.47641	103.091400				
	15	11.47670	103.09131	Line 10	Plot 29	11.451292	103.022081
					Plot 30	11.451223	103.0
Line 5	16	11.500382	103.020401				

Table 3: Species occurrence by habitat type (p-referred to survey plot).

Species occurrence by habitat and plot									
#	Species	Front peat	Sandy peat	Melaleuca swamp	Mud creek	Peat back mangrove	Peat fresh water	Seaward	Mud peat soil
1	*Acanthus ebracteatus*						p19-20		
2	*Acrostichum aureum*			p23-26	p28	p10, p16,	p19	p12	
						p22, p7,p9			
3	*Acrostichum speciosum*	p24-25	p29	p23,p30	p27	p15-16,	p19		
						p22, p7-8			
4	*Aglaia cucullata*					p15	p19-20		
5	*Allophylus cobbe*	p24						p11	
6	*Ardisia eliptica*	p24						p11, p13	
7	*Avicennia marina*							p2	
8	*Avicennia rumphiana*							p3	
9	*Barringtonia acutangula*	p24							
10	*Bruguiera cylindrica*								
11	*Bruguiera gymnorrhiza*		3			p9			
12	*Bruguiera sexangula*			p23, p26			p19		
13	*Caesalpinia crista*								
14	*Casuarina equisetifolia*								
15	*Causonis trifolia*				p27				
16	*Cerbera odallam*	p24							
17	*Cerbera manghas*			p30					
18	*Ceriops decandra*					p17			p18
19	*Ceriops tagal*	p25				p8			
20	*Chiococca* sp.							p11	
21	*Chromolaena odorata*				p28	p16		p11, p13	
22	*Coco nucifera*			p26					
23	*Combretum tetralophum*					p16			
24	*Dalbergia* sp.	p25	p29	p23, p26		p16, p22			
25	*Derris trifoliata*	p24				p10, p16,	p19-20		
						p6 p8			
26	*Diospyros* sp.	p24	p29	p23-26		p15			
27	*Excoecaria agallocha*	p24-25				p14-15			
28	*Ficus altissima*		p27						
29	*Ficus microcarpa*				p27				
30	*Ficus religiosa*				p27				
31	*Finlaysonia obovata*			p30	p27		p20		
32	*Flagellaria indica*		p29	p23-26, p30		p15-16	p19	p19	
33	*Globba* sp.	p24	p29						
34	*Glochidion littorale*			p30					
35	*Heritiera littoralis*	p24		p23		p22	p19-20	p4	
36	*Hibiscus tiliaceus*	p24-25	p29	p26		p10, p15-16	p19-20	p11-13,	p18
								p3, p5	
37	*Intsia bijuga*	p24				p10, p15	p20		
38	*Licuala spinosa*			p30					
39	*Lumnitzera littorea*	p25				p6-9 p10, p14-15,			
						p17, p22			
40	*Lumnitzera racemosa*			p23		p16-17, p9			
41	*Melaleuca cajuputi*		p29	p23-26,					
				p30					

▽ Front-line tidal mangrove forest at Koh Kapik, Peam Krasop Wildlife Sanctuary.

42	*Morinda citrifolia*	p24							
43	*Nypa fruticans*		p21						
44	*Ochna integerrima*	p26							
45	*Pandanus* sp.	p24	p21						
46	*Phoenix paludosa*	p25				p10, P15-16,			
						p6-7			
47	*Planchonella obovata*	p24-25	p29	p23, p30		p22	p19-20		
48	*Premna serratifolia*	p24	p29	p26, p30	p27			p12	
49	*Rhizophora apiculata*	p24-25	p21	p23	p27-28	p10p14-16,	p20	p1,p13	p18
						p22, p6-7		p2-5	
50	*Rhizophora mucronata*				p27-28			p1, p3,	
								p5	
51	*Samadera indica*					p15			
52	*Scaevola sericea*							p11	
53	*Scyphiphora hydrophyllacea*					p16			
54	*Shirakiopsis indica*					p14			
55	*Smilax* sp.		p29						
56	*Sonneratia alba*							p5	
57	*Terminalia catappa*							p5	
58	*Volkameria inermis*		p29		p27	p14	p19	p3	
59	*Wollastonia biflora*		p29						
60	*Xylocarpus rumphii*							p1, p5	
61	*Xylocarpus granantum*	p24-25	p21			p14-15,	p19		
						p22, p8			
62	*Xylocarpus moluccensis*							p2, p4	

Mangrove habitat species composition

The Seaward

Two line transects were deployed on the seaward habitat (lines 1 and 3). The plant community composition in this area consisted of natural growth including some old, big pioneer plant species, especially *Avicennia* sp. and large-crowned *Xylocarpus* (line 1). The beach (sandy) habitat on line 3 was characterized by tall conifers (*Casuarina equisetifolia*) and big, clumpy woody bushes (*Hibiscus tiliaceus*), which lay as natural windbreaks.

A. Line 1: Plots 1 - 5

The sandy habitat is a natural extension of the coastline, where a dense line of mangrove trees grows in close proximity to the muddy creeks at the back. The ecosystem is composed of several tree species, such as *Avicennia marina*, *Hibiscus tiliaceus, Heritiera littoralis, Bruguiera cylindrica, Terminalia catappa, Xylocarpus rumphii*, and two types of *Rhizophora*: *R. apiculata* and *R. mucronata*. Along with the trees, there are also vines and shrubs growing in the area, mainly *Volkameria inermis* and *Derris trifoliata*, which were found to be widely distributed throughout the site.

B. Line 3: Plot 11-13

Line transects 3, plots 11 - 13 had a higher plant diversity and were covered by grass species, (excluded from surveys), supporting a total of 20 plant species. These plant species were classified into three types; (1) small trees: *Casuarina equisetifolia*, *Hibiscus tiliaceus*, *Bruguiera cylindrica*, *Bruguiera gymnorrhiza* and *Xylocarpus* spp.; (2) shrubs: *Ardisia eliptica, Allophylus cobbe, Chromolaena odorata, Premna serratifolia* and *Scaevola sericea*; and (3) vine climbers: *Caesalpinia crista, Flagellaria indica, Derris trifoliata* and *Caesalpinia crista*.

The Front-line

A. Sandy Mud Peat (Line 7 Plot 21)

On the edge of islets, mangrove tree species, *Rhizophora apiculata, Bruguiera gymnorrhiza*, and *Xylocarpus granantum*, have adapted successfully to grow on the sandy mud substrate. Nipa palm, *Nypa fruticans* were also found in small patches possibly transported by the tide movements.

B. Compact Peat Front (Line 8 Plot 24)

Some islets further inland from the coast support peat soils along their front banks as well as bordering mud areas and harbour a great variety of plant species including both true mangrove and associated species. The high diversity found at this site showed a balanced mixture of species rather than dominance by a few. However, some species of shrub, vine and mangrove fern were abundant including: *Acrostichum speciosum*, *Ardisia* spp., *Allophylus cobbe*, *Hibiscus tiliaceus, Planchonella obovata, Premna serratifolia, Diospyros* spp. and *Morinda citrifolia*. In addition, the tree species recorded ranged from short to tall including *Barringtonia acutangula, Xylocarpus granantum, Intsia bijuga, Cerbera odallam* and *Heritiera littoralis*. The ginger genus,*Globba* spp. was also found to grow on the ground in the peat soil habitat.

The Back Mixed Mangrove

One type of mangrove habitat is the back-water mangrove, which is located behind the front line of the *Rhizophora*-dominated zone. This habitat is more accessible to humans and more vulnerable to anthropogenic disturbances such as illegal land reclamation, including felling of taller trees. These disturbances have negatively impacted the natural regeneration of the mangrove ecosystem and reduced its biodiversity. However, some common plant species have managed to adapt and survive in this habitat and can still be found in this area. A few lines transect were established purposefully to study the characteristics of this habitat type.

A. Line 2 Plot 6-10

After recent clearing of the taller trees in the area, new regeneration of shrub and vine species has occurred in this zone. These include the mangrove ferns *Acrostichum aureum* and *Acrostichum speciosum*, the vine *Derris trifoliata*, and

several kinds of trees such as *Lumnitzera littorea, Lumnitzera racemosa, Rhizophora apiculata, Ceriops tagal, Bruguiera gymnorrhiza, Intsia bijuga* and *Hibiscus tiliaceus.* These species have regrown in this zone and restored some of the vegetation cover. Additionally, one species of palm, *Phoenix paludosa*, can also be found growing in this area.

B. Line 4 Plots 14 - 15

Line 4 was set up in an area that has a similar habitat structure to the back-mix mangrove. This area contained 5 survey plots. The survey found that there are several plant species that have started to regenerate after being disturbed by the clearing activities that took place in recent years. Some of the common tree species that are growing in this site are *Lumnitzera littorea, Rhizophora apiculata, Xylocarpus granantum, Aglaia cucullata* and *Intsia bijuga*. There are also some shrub and vine species that are occupying the space around the site, such as *Diospyros* sp., *Hibiscus tiliaceus, Samadera indica, Shirakiopsis indica* and the mangrove fern *Acrostichum speciosum*. The mangrove fern is especially abundant in this spot.

C. Line 5 Plot 16

Line transects 5, plot 16 was situated behind of mangrove front line, at a spot where charcoal used to be produced in the past. Results of the present study showed different tree species ranging in height 2 - 5 m, such as *Lumnitzera racemosa, Rhizophora apiculata*, and *Hibiscus tiliaceus*. There were also some shrub species that are similar to those found on the previous plots, except for *Combretum tetralophum* and *Scyphiphora hydrophyllacea*, which were unique to this plot. Additionally, there are some vine species that grow around the trees and shrubs, but they could not be identified by the survey.

D. Line 10 Plot 29 and Line 7 Plot 22 (sandy peat back mangrove)

Line transects 10 and 7 were set on sandy mixed peat soil and swampy areas comprised of *Melaleuca* spp. trees and a high diversity plant species. This habitat was found to exhibit a mix of herb plants covering the ground under shady shrub forest connected by vines and lianas. Several tree species were dominant in the area such as *Melaleuca* spp. and *Hibiscus* spp.; while *Premna serratifolia* and *Globba* spp. were the

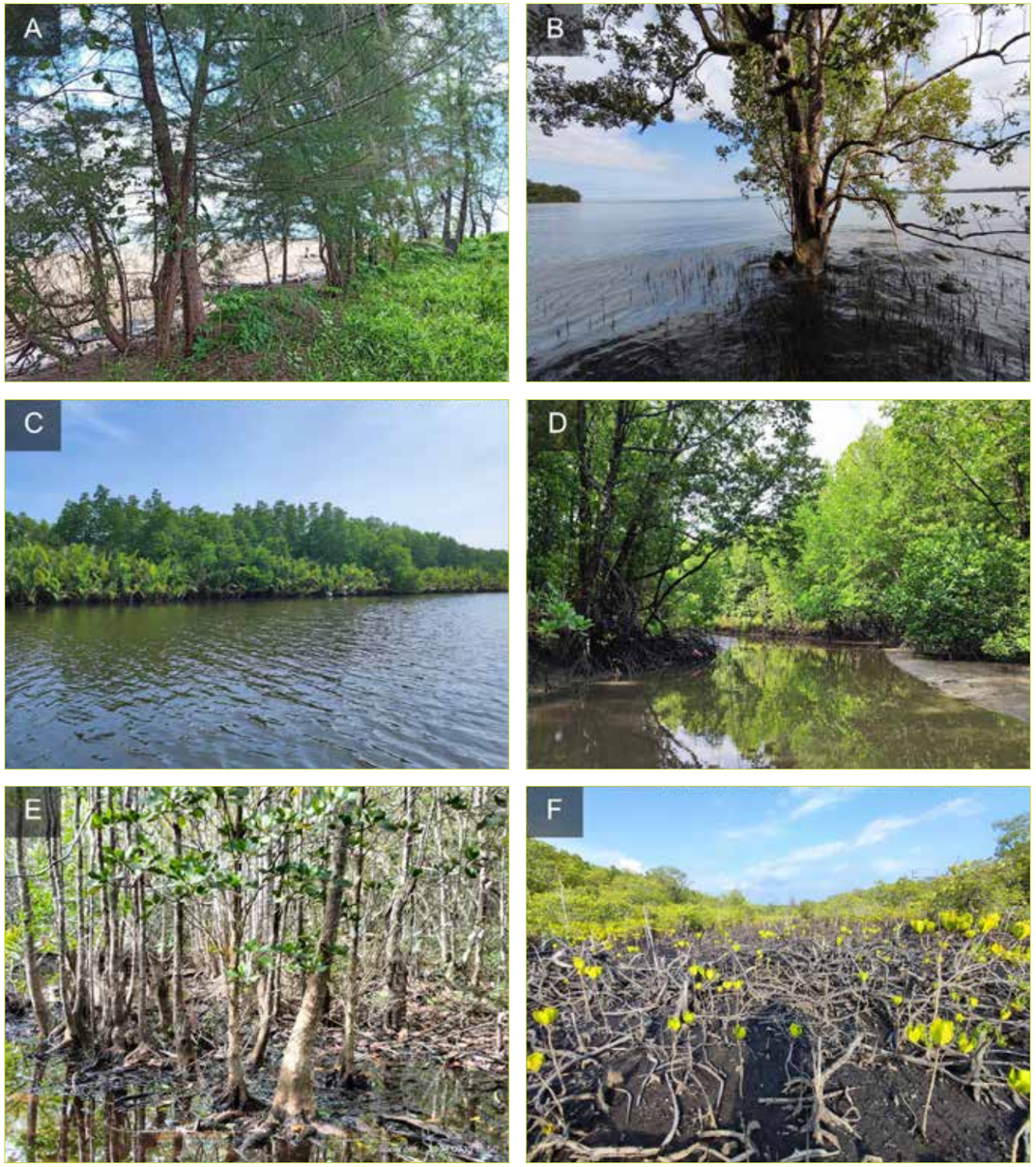


Fig. 2: **A**. Beach front with *Casuarina equisetifolia*; **B**. *Avicennia marina* by the sea; **C**. Islet front with *Rhizophora apiculata* and *Nypa fruticans*; **D**. Creek with *Rhizophora apiculata* and *Avicennia marina*; **E**. Creek with *Bruguiera cylindrica*; **F**. Islet interior with *Ceriops tagal.*

dominant species of herbs and shrubs.

Ceriops and *Lumnitzera* area

This zone is a distinct type of mangrove habitat that is different from the mixed mangrove habitat. It is found in some areas alongside the back-mixed mangrove habitat. Based on direct observation during the survey, the soil in this zone is hard and compact mud, and only 2 to 3 species of true mangroves were found. These species are short-statured, and do not grow taller than 5 meters. They produce knee roots that protrude above the soil surface.

A. Line 5 Plot 17

The habitat on line 5 was dominated by only three mangrove tree species: *Ceriops decandra, Lumnitzera littorea*, and *Lumnitzera racemosa*, showing low plant diversity, as well as dwarf trees, not surpassing 5 m high. Additional species of plant were epiphytic types including orchids, mosses and ferns, which were not included in this study.

B. Line 5 Plot 18

Plot 18 of line 5 was located on the edge of the *Rhizophora* area, where it meets the back-mangrove. The soil in this plot has a layer of mud on top, which is why only some mangrove species were found on the site. The survey found that the most common species in this plot were *Ceriops decandra* and *Rhizophora apiculata*. These two species were distributed unevenly across the plot, but they were the dominant ones forming the main vegetation structure.

Riverine mixed mangrove fresh water (Line 6)

The riverine forest soils were characterized by peat and swampy conditions year-round. The main tree species identified grew to medium height (8 – 10m) including *Heritiera littoralis*, *Xylocarpus granantum, Aglaia cucullata, Intsia bijuga, Rhizophora apiculata, Bruguiera sexangula* and some small trees such as *Hibiscus tiliaceus* and *Planchonella obovata*. There were some shrubs, herbs, and vines such as *Volkameria inermis*, *Acanthus ebracteatus* and *Acrostichum aureum.*

Fig. 3: **A**. Islet front with *Rhizophora apiculata* and *R. mucronata*; **B**. Back mangrove with *Acrostichum speciosum*; **C**. Back mangrove with *Lumnitzera littorea*; **D**. Disturbed area with shrub-dominated regeneration.

Fig. 4: **A**. Melaleuca swamp; **B**. Riverine mixed mangrove fresh water area; **C**. Riverine area with *Xylocarpus granantum*; **D**. Fresh water mixed mangrove stream.

A. Line 7 Plot 23 and Line 8 Plot 26

The *Melaleuca* spp. Tree are the main species providing canopy cover in this zone, growing on sandy soils with seasonal inundation producing swamp conditions. However, below the canopy, and in exposed areas, the dominant species were *Planchonella obovata* (tree and shrub), mangrove fern (shrub) and other species evenly contributed to this habitat including *Diospyros* sp., *Heritiera littoralis, Hibiscus tiliaceus, Flagellaria indica* and *Bruguiera sexangula.*

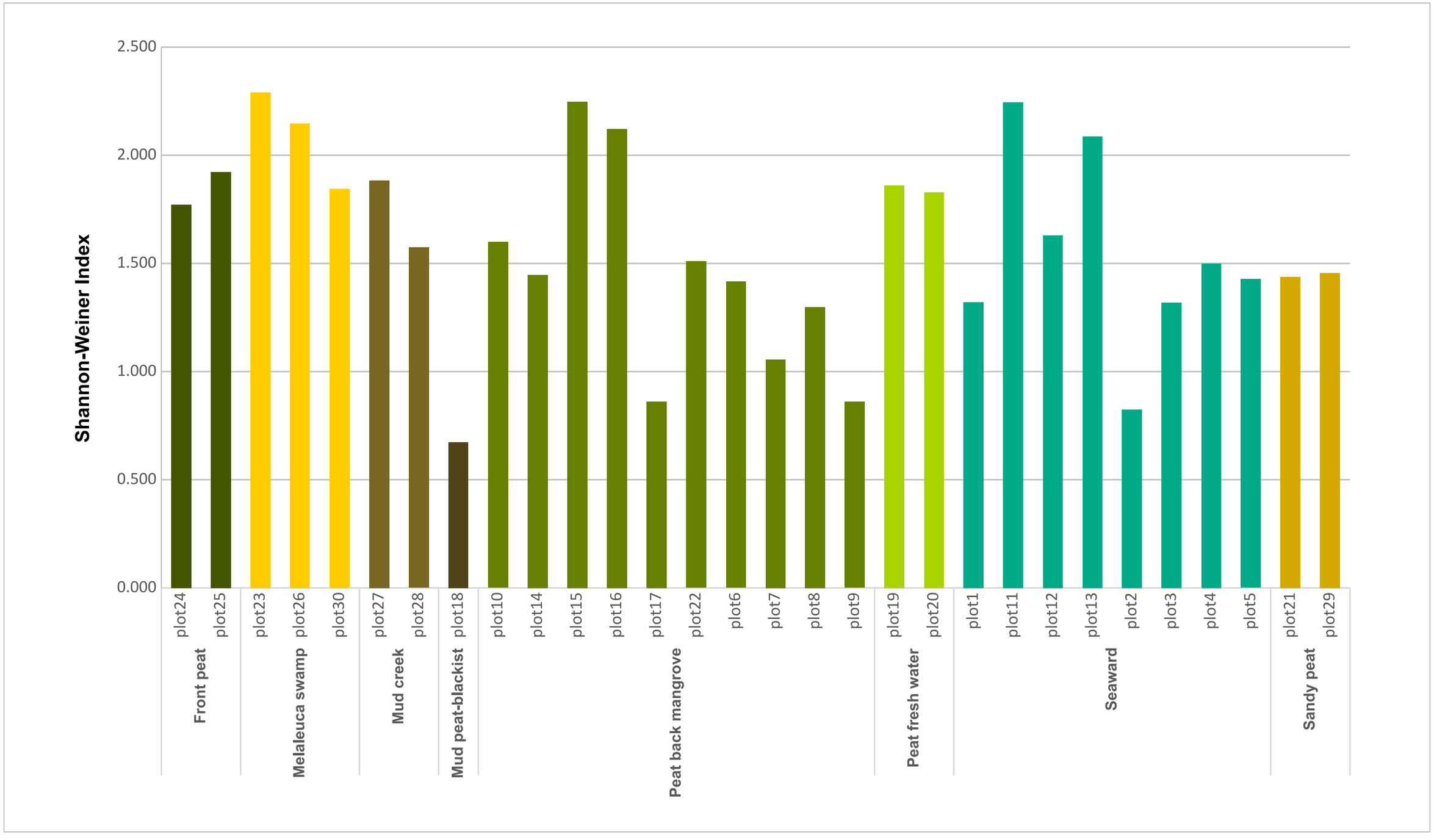
B. Line 10 Plot 30

Line 10 had permanent swamp and sandy peat conditions, and plant species diversity was similar to plot 23 and plot 26, which were classified as Melaleuca mix habitat. Melaleuca trees were found dominant, and along with shrub species such as *Premna serratifolia*, mangrove fern species, *Planchonella obovata* and *Glochidion littorale*, and the palm species *Licuala spinosa.*

Plot Diversity

Shannon diversity indexes were calculated (Fig. 5) for each plot in order to estimate plant diversity levels of different areas derived from the recorded data. In the seaward zone, plot 11 and plot 13 had the most diverse plant species with H’ = 2.246 and H’ = 2.087 respectively. From the back-mix mangrove zone plots 15 and 16 showed most diversity, with H’=2.247 and H’2.21 respectively. Plots from the riverine mangrove areas had similar diversity indexes.

Fig. 5: Shannon-Weiner Index bar graph show plot plant diversity. A higher score means higher diversity, the different colors present different habitats..



DISCUSSION

The present study recorded 62 species of both true mangrove and associated plant species including shrubs and vines. UNEP (2008) recorded 50 plant species in the mangrove ecosystem in Cambodia, whereas a more recent study recorded 39 species (Khou 2018). Our results reflect additional species found in riverine and back mixed mangrove areas that may have been overlooked in previous studies.

The results of the present study provide information on plant diversity in the different habitats of the mangrove ecosystem that is essential to conduct habitat restoration activities.

CONCLUSION

The results of the study suggest that the seaward habitat, riverine mangrove, and back mixed mangrove had the highest species richness, which may indicate a need to prioritize conservation efforts in these habitats.

From a scientific perspective, we suggest that further research and monitoring may be necessary to better understand, protect and restore these habitats. In future studies, it may be beneficial to conduct more extensive surveys in the back-mangrove and riverine brackish water habitats to gather more comprehensive data on plant diversity. Information on plant diversity and zoning should be used to inform restoration activities and guide conservation efforts that protect the ecosystem as a whole. Overall the key the key conservation focus should be on protecting old growth mangrove forest.

Ariel view of flooded Melaleuca forest. ▷

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INVERTEBRATE SURVEY

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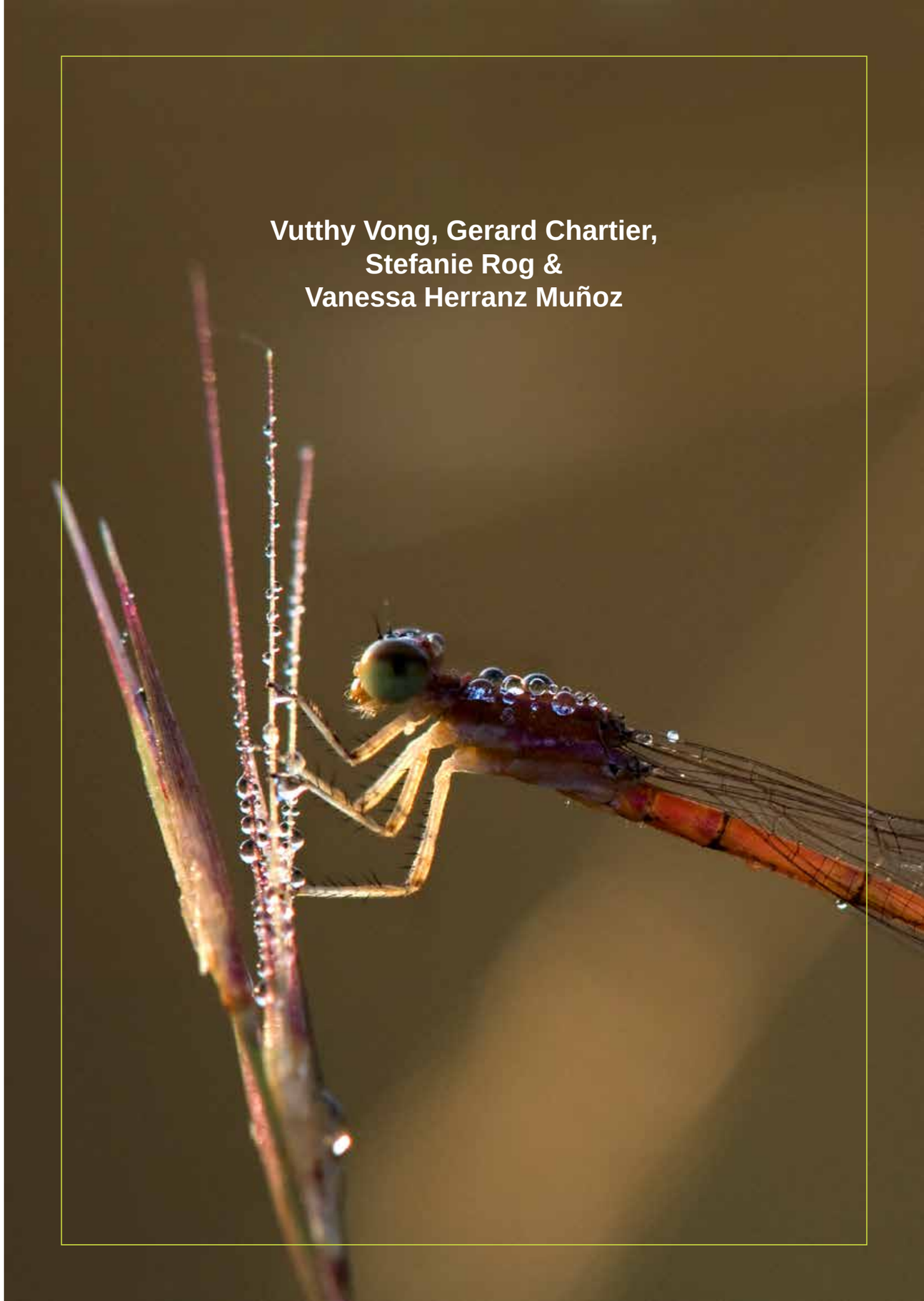


Title image: *Agriocnemis* sp. Peam Krasop Wildlife Sanctuary.

INTRODUCTION

Arthropods (phylum Arthropoda) are invertebrates, such as insects, spiders and scorpions - that fulfil a myriad of ecosystems services, for example nutrient recycling and pollination. However, little is known of their diversity and the function they play in mangrove forests (García-Gómez et al. 2014; Adeduntan et al. 2013).

Insects (class Insecta), which were our main focus in this study, are the most diverse class of organism on Earth. They occupy all habitat types: terrestrial, arboreal, marine and other aquatic ecosystems (Prakhar et al. 2021). Estimates put global insect diversity at approximately 5.5 million species. Despite their incredible diversity, insect populations are declining in many parts of the world. This is due to a combination of factors: habitat destruction, agricultural intensification, invasive species and the effects of the changing climate (Chowdhury et al. 2023; Stork 2018).

Several studies have concluded that the true diversity of the insect fauna of Cambodia is currently under-estimated, especially in comparison to some of its better studied neighbours. It is certain that further studies could significantly increase the number of species recorded from the Kingdom (for example, Chartier & Kosterin 2022; Choi et al. 2022; Maquart et al. 2021; Ascher et al. 2016; Constant et al. 2016; Kosterin et al. 2012).

◁ Odonata habitat in Ka Chat, Peam Krasop Wildlife Sanctuary.

Arthropod diversity in mangrove forests is not well known and often assumed to be low. Yeo et al. (2021) suggested that insects inhabiting mangroves may receive little attention because plant diversity in mangrove habitats is generally low. The assumption is that insect diversity is proportional to plant diversity. However, their study did report a higher diversity within the orders of Diptera and Hymenoptera. These two orders represented over 75% of their collected specimens, which they described as typical for Malaise trap method. By contrast, an earlier study of the mangroves in Singapore by Murphy (1990) focused on insect herbivory, with almost no records of Diptera or Hymenoptera - which are rarely phytophagous. He reported several species of Coleoptera, Hemiptera and Lepidoptera, and speculated that there could be many associated parasitic species of Diptera and Hymenoptera.

A few previous studies have included, at least in part, mangroves in PKWS: Maquart et al. (2022) recorded 34 species of mosquitoes across three locations, all within PKWS; Kosterin & Chartier (2017) recorded 55 species of Odonata in flat marshy coastal areas, with the majority of records from PKWS, Chartier & Kosterin (2022) listed 512 butterfly species in Cambodia, of which 118 are recorded from PKWS.

OBJECTIVES

The main objective of this study was to further the knowledge of diversity of insects (plus other arthropods, if observed) in PKWS.

METHODS

Study site

Ten study sites were selected in PKWS to cover as broad a variety of habitat types as possible during the study period. These included mangrove forest, mixed semi-evergreen forest, coastal shrub forest protecting the area, and more open areas, with various levels of protection and disturbance. Field surveys were conducted twice in the dry season: 28 - 31 March 2023 and 27 -28 April 2023.

Trapping Methods

Arthropods were collected by using different methods: pan traps, sweep netting and light traps.

For pan trapping, 15 pan traps were deployed in five clusters of three, separated by 5 metres, with each cluster comprising three different pan trap colours: white, yellow, and blue. All pan traps contained water with a few drops of detergent to weaken the surface tension, preventing insects from alighting. Pan trapping was employed at three locations: PKWS 01, 04 and 06 (see Table 1).

Sample collection

With the exception of pan trapping, which is an indiscriminate method of collection, our aim was to focus on arthropod groups for which we could make identifications in the field, or for which a known expert willing to accept specimens for detailed examination and identification was available. For example, we made no attempt to collect specimens of ants. For sweep netting and light trapping, insects that could be identified to species level in the field were photographed and then released. In a few cases, for example, with easily identifiable butterflies, records were taken of specimens seen on the wing.

Arthropod specimens from pan traps were filtered through a mesh net and transferred to a jar containing 70% ethanol.

During the first trip, insects were transferred directly to jars containing 70% ethanol. On the second trip, insects were placed in kill jars containing strips of material soaked in acetone, and then transferred to jars with 70% ethanol.

Fig. 1: Methods of arthropod collection. Clockwise from top left: light trap; pan traps, and sweep netting.

Table 1: Sampling locations of arthropods in the PKWS during March-April 2023.

Site Code	Location	Habitats	Collection Methods	Dates
PKWS 01	11°27'05.0"N 103°00'53.8"E	Small open area is located between mangrove forest and disturbed area	Sweep Nets, Pan Trap, Light Trap	28/03/2023 29/03/2023 30/03/2023
PKWS 02	11°27'46.3"N 103°00'46.1"E	Near shrimp pond area in mangrove forest *Rhizophora* sp.	Sweep Nets	28/03/2023
PKWS 03	11°27'23.8"N 103°01'10.4"E	In mangrove forest *Rhizophora* sp.	Light Trap	29/03/2023
PKWS 04	11°28'44.17"N 103°05'32.17"E	Mangrove forest with highly disturbed areas	Pan Trap, Sweep nets	30/03/2023
PKWS 05	11°30'07.9"N 103°01'18.75E	Mangrove forest *Rhizophora* sp. and mixed semi-evergreen forest	Sweep Nets	30/03/2023
PKWS 06	11°25'46.1"N 103°00'47.2"E	Coastal shrub forest with highly disturbed areas	Sweep Nets Pan Traps	29/03/2023
PKWS 07	11°30'40.3"N 103°07'42.6"E	Mangrove forest/semi-evergreen forest with highly disturbed areas	Sweep Nets	31/03/2023
PKWS 08	11°33'45" N 102°59'17" E	Open area with grassland near mangrove forest *Rhizophora* sp.	Sweep Nets, Light Trap	27/04/2023
PKWS 09	11°34'12" N 102°59'39" E	Open area with shrub forest near mangrove forest *Rhizophora* sp. with highly disturbed area	Sweep Nets	28/04/2023
PKWS 10	11°28'37" N 103°6'6" E	Open grassland area near mangrove forest *Rhizophora* sp.	Sweep Nets	28/04/2023

Fig. 2: Images of study sites of arthropods collection in the PKWS.

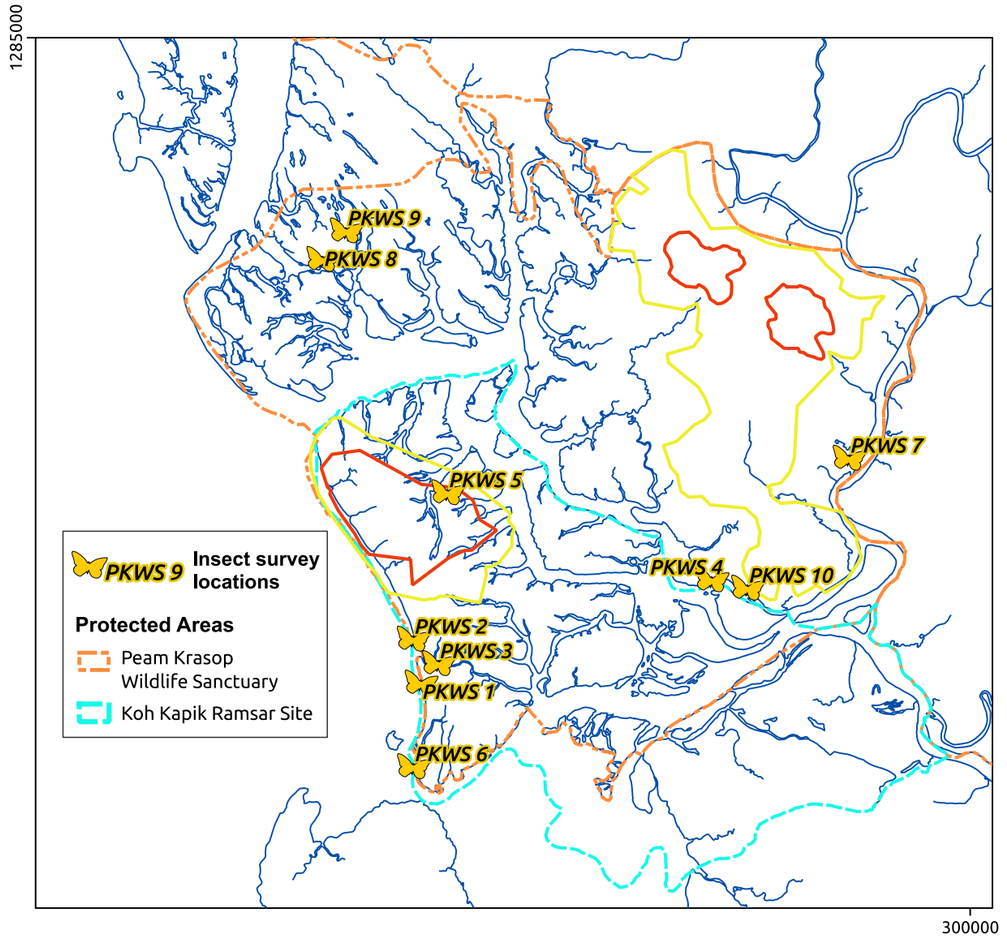


Fig. 3: Study site locations.

Specimen identification

Preliminary identification of specimens was achieved by a combination of authors' knowledge, published keys and descriptions, and expert input. All identifications, so far, have been based on photographs, either in nature, of collected specimens, or both, with no detailed examination of specimens by experts. As a result, many specimens are not yet identifiable to species level. In such cases, taxa have been divided based on clear morphological differences into morphospecies (see Oliver & Beattie 1996).

Where this approach has been applied, the 'species' are labelled with the lowest taxonomic rank that can be applied with confidence, followed by “sp. A”, “sp. B”, etc. This method may introduce errors to the biodiversity analysis. Derraik et al. (2010) found that biodiversity was underestimated by 12% when using morphospecies, compared to using properly identified species from specimens.

Data analysis

Biodiversity indices were calculated using the standard formula; Shannon-Weiner diversity index (H’) (Shannon and Weiner 1949): $H' = -\Sigma p_i \ln(p_i)$, where p_i is the proportion of individuals of each species relative to the total number of individuals.

That is $p_i = n_i/N$, n_i is the number of individuals of species i, N is the total number of individuals. Evenness (J’) was calculated using Pielou’s (1966) formula: $J' = \frac{H'}{ln}$ (S) where S is number of species.

Indices were calculated across taxonomic orders, insect collection methods and collection sites.

All calculations were performed in Microsoft Excel.

RESULTS

During the study we caught 1235 individual arthropods in the mangrove forest of Peam Krasop Wildlife Sanctuary. These comprised of 352 species or morphospecies from approximately 120 families and 17 orders. The overall Shannon-Weiner diversity index was 4.61, with a Pielou’s evenness index of 0.79.

The highest abundance (300 individuals) was recorded for sawflies, wasps and bees; while the true bugs had the highest number of species/morphospecies (62). Abundance and number of species by order are depicted in Fig. 4.

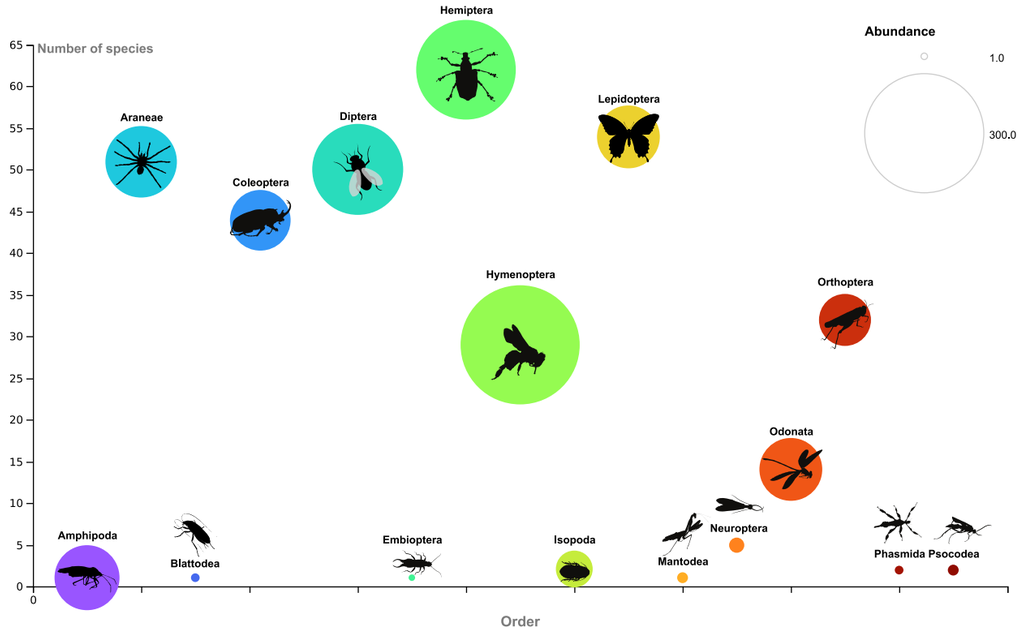


Fig. 4: Number species and abundance of arthropods collection in each order.

Hymenoptera (24.4%) was the most abundant order, followed by Hemiptera (17%), Diptera (13.8%), Araneae (8.6%), Odonata (7.2%), Lepidoptera (6.7%), Coleoptera (6.5%) and Orthoptera (4.6%).

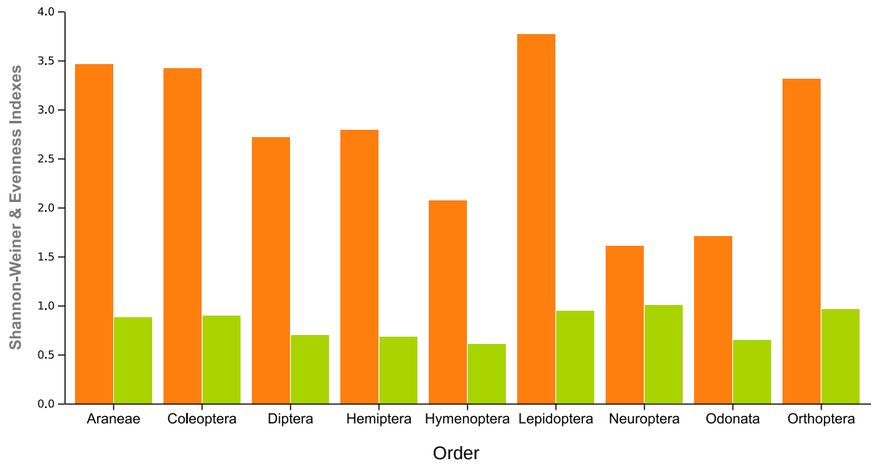
Hemiptera (17.6%) was the most species rich order, followed by Lepidoptera (15.3%), Araneae and Diptera (both 14.2%), Coleoptera (12.8%), Orthoptera (9%), Hymenoptera (8.2%) and Odonata (4%).

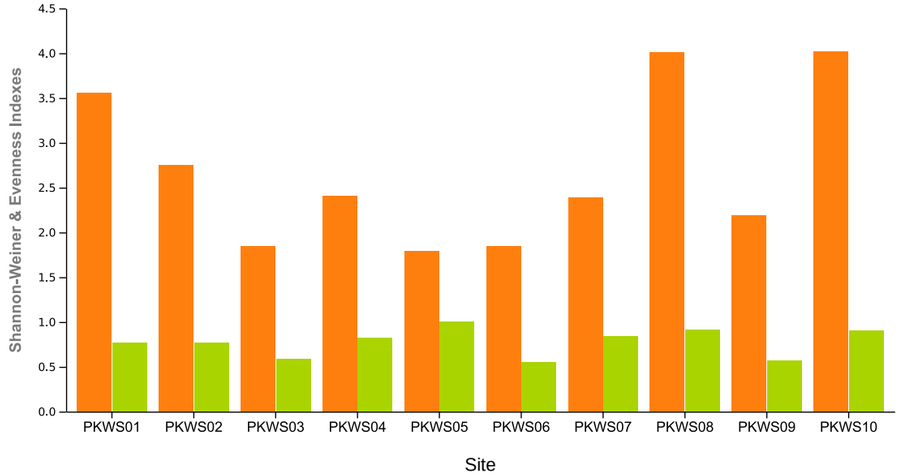
Based on the two diversity indices, Lepidoptera (H'=3.77, J'=0.95) was the most diverse order. Though, Araneae (H'=3.49, J'=0.89), Coleoptera (H'=3.39, J'=0.90), and Orthoptera (H'=3.31, J'=0.96) were all fairly similar. For six orders (Blattodea, Embioptera, Mantodea, Amphipoda, Decapoda and Isopoda) only one species was recorded, resulting in a Shannon-Weiner index of zero.

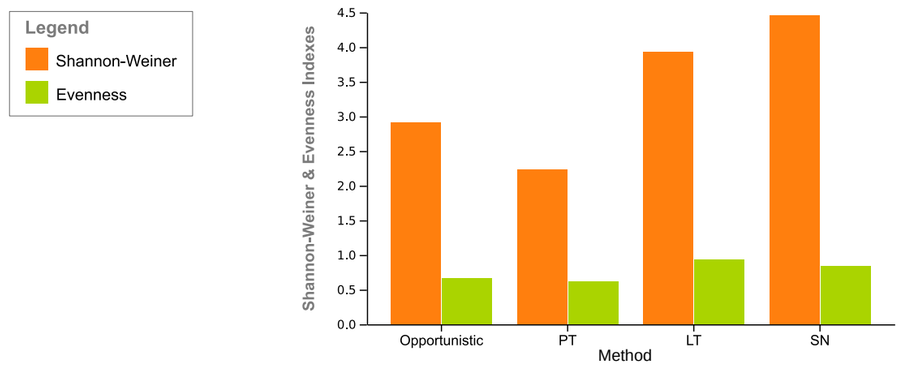
Shannon-Weiner Diversity Index and Pielou's evenness across orders are shown in Fig. 5; by study site in Fig. 6, and by collection method in Fig.7

In terms of sites, PKWS 10 open area with grassland near mangrove forest *Rhizophora* sp. (H'=4.02, J'=0.90, S=89, N=165) and PKWS 08 open area with grassland near mangrove forest *Rhizophora* sp. (H'=4.01, J'=0.91, S=84, J=169) were the most diverse. At PKWS 05 only six individuals were recorded; one each of six different species across four orders. Of the remaining sites, PKWS 03 (H'=1.84, J'=0.59, S=23, J=65) and PKWS 06 (H'=1.84, J'=0.55, S=29, J=161) were the least diverse.

The full list of records is presented in Table 2 and photographs of a selection of specimens are shown in Figs. 8 – 16 in Appendix A.







Figs. 5,6 & 7: Shannon-Weiner Diversity Index and Pielou's evenness across orders.

Fig.: 9 *Neurothemis intermedia atalanta* in Peam Krasop Wildlife Sanctuary.

DISCUSSION

Before discussing the results, it is important to consider the impact that our methods may have had on those results. For comparing the diversity across orders, the chosen methods of collection could have a significant impact on the results. For example, had we employed Malaise traps, we could have expected a higher diversity of Hymenoptera and Diptera (Yeo et al. 2021). In addition, we chose not to record all the alate ants that visited the light traps, given the difficulty in identifying these. Again, that would have increased the diversity of Hymenoptera in our results.

Our choice of light source for trap light traps, while convenient, seemed limited in the diversity and quantity (with the possible exception of alate ants) of the insects it attracted. In addition, there were clear skies and greater than half moon for all light traps during the study, which could have had a significant impact on the on the number and diversity of attracted insects (McGeachie 2002).

In future studies, we could capture specimens more effectively with killing jars using a plaster of Paris base and ethyl acetate as the killing agent.

Our pan traps were fairly shallow plates placed on the ground. The choice of places on the surface, rather than recessed pan traps, could have reduced the number of crawling insects that were collected, though we did record 30 isopods at one pan trap site.

The comparison of diversity between study sites is somewhat difficult because we did not use all of the collection methods at all sites. This was largely due to practicalities. For example, with ten sites, there were not enough nights within the study periods to carry out light trapping at each site. In addition, some sites, in particular PKWS 03 and PKWS 05, where not conducive to sweep netting because of the predominance of *Rhizophora* spp. with their networks of hard aerial roots. When sweep netting, it is natural to gravitate toward vegetation that is softer and offers less resistance to the nets. During this study, this tended to result in sweep netting predominantly in grassy areas and scrubby areas with herbaceous plants.

In addition, the a varied amount of time spent at each site. We spent most time at PKWS 01, which was the only site at which we used all chosen collection methods, and we carried out sweep netting on two occasions. Despite that, its diversity was considerably lower than that of PKWS 08 and 09. This is largely due to the large number of flies in the family Drosophilidae that were collected in pan traps. If they are omitted from the calculation of indices, the results are very similar to those of PKWS 08 and 09. In future studies, a better comparison of sites could be achieved by choosing fewer sites and carrying out all collection methods at each for similar durations.

The highest diversity was found in sites PKWS08 and PKWS10, which might reinforce commonly held beliefs that mangroves areas are less diverse because these sites were the least mangrove-like in the whole study. However, a previous study that have used Malaise traps in mangrove areas have found high diversity of Hymenoptera and Diptera (Yeo et al. 2021). Given that many Hymenoptera and Diptera have very specific parasitic relationships with other arachnid orders, this would suggest also high diversity in those other orders. That the recorded diversity often seems to diminish the closer the study area is to front line mangroves, as in this study, might be the result collection methods, rather than actual lower diversity. As stated above, the front line stands of *Rhizophora* spp. are a hindrance to some collection techniques. In addition, regular tidal inundation prevents pan trapping, or limits it to very short time frames.

Given our choice of collection methods, the results showing Lepidoptera, Araneae, Coleoptera and Orthoptera as the most diverse orders is not surprising. Even with the under-performing light traps, Lepidoptera was still the most diverse order, bolstered by a number of opportunistic records of readily identifiable butterflies (superfamily Papilionoidea). Spiders (Araneae) were recorded almost entirely from sweep netting and opportunistic sightings, with only one spider record from a pan trap. Coleoptera records were mostly from sweep netting and light traps, with just a few each from pan traps and opportunistic sightings. Most records of Orthoptera came from sweep netting and particularly in grassy areas, but with 17.5% from light traps and 7% were opportunistic. If we had used Malaise traps, we would have expected more records of Diptera and Hymenoptera.

In this study, *Nerthra macrothorax* (Fig. 11H) (family Gelastocoridae or toad bugs in the order Hemiptera) is recorded for the first time in Cambodia. *Nerthra macrothorax* was recorded for the first time in the mangrove forest using pain traps.

CONCLUSION

This study found a high level of arthropod diversity in Peam Krasop Wildlife Sanctuary but improved and more varied collection methods would likely return higher values still. There is still a poor understanding of the diversity of the front line mangroves in PKWS. We recommend that further research should be over a longer period, adopting more and consistent collection methods at each site. Studies should also be carried out in both the dry and rainy seasons (this study was predominantly in the dry season). Future studies should aim to identify the importance of insect species richness and abundance and determine insects' roles in predation, parasitism, pollination, and their interaction with the mangrove ecosystem.

Fig. 8: *Rhyothemis obsolescens* in Peam Krasop Wildlife Sanctuary.

APPENDIX A: Detailed Arthropods Records.

Table 2: List of order, family genus, species of arthropods collecting different methods in Peam Krasop Wildlife Sanctuary. **LT**: light trap, **SN**: sweep net, **PT**: pan trap.

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Blattodea				
Ectobiidae			1	1	2
	Coleoptera				
Unknown			1		1
?Curculionidae			2		2
?Gyrinidae				1	1
?Tenebrionidae		1			1
Anthicidae	?*Anthelephila*		2		2
Anthribidae	?*Ozotomerus*	1			1
Attelabidae	?*Auletobius*		1		1
Brentidae	Apioninae		1		1
Buprestidae	?*Endelus*	1			1
Carabidae	?*Tachys*	2			2
Cerambycidae			1		1
Cerambycidae	*Glenea* ca. *vega*		1		1
Cerambycidae	*Tetraglenes* ca. *hirticornis*		3		3
Chrysomelidae		7			7
Chrysomelidae	?*Cryptocephalus*		1		1
Chrysomelidae	?*Erystus quadripunctatus*		1		1
Chrysomelidae	*Lema* sp. A		1		1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Coleoptera				
Chrysomelidae	*Lema* sp. B		1		1
Chrysomelidae	*Tricliona* sp. A	1			1
Chrysomelidae	*Tricliona* sp. B		1		1
Chrysomelidae	*Tricliona* sp. B	0	1		1
Cicadellidae	*?Enantiola hewittii*	1			1
Cicadellidae	*Lophyra*		1		1
Cicadellidae	*Neocollyris*	1			1
Coccinellidae			1		1
Coccinellidae	*?Micraspis discolor*		4		4
Coccinellidae	*Coccinella transversalis*		1		1
Curculionidae	*Entiminae sp. A*		1		1
Curculionidae	Entiminae sp. B	2	2		4
Elateridae			1		1
Lampyridae		1			1
Oedemeridae	Asclerini	2			2
Oedemeridae	Oedemeridae sp. A	2			2
Oedemeridae	Oedemeridae sp. B		1		1
Scarabaeidae	*Adoretus*	1			1
Scirtidae	Scirtidae sp. A	6			6
Scirtidae	Scirtidae sp. B	11	1	2	14
Scirtidae	Scirtidae sp. C	4	1		5
Staphylinidae	Staphylinidae sp. A	1			1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Coleoptera				
Staphylinidae	Staphylinidae sp. B			1	1
Tenebrionidae	*Strongylium erythrocephalum*	1			1
	Diptera				
?	Brachycera sp. A			1	1
?	Brachycera sp. B		1		1
?	Brachycera sp. C		3		3
?	Brachycera sp. D		2		2
?	Brachycera sp. E		2		2
?	Brachycera sp. F		2		2
?	Brachycera sp. G		1		1
?	Brachycera sp. H		1		1
?	Brachycera sp. I		1		1
?	Brachycera sp. J		1		1
?	Brachycera sp. K	1			1
?	Brachycera sp. L			1	1
?	Brachycera sp. M			3	3
?	Brachycera sp. N			1	1
?	Brachycera sp. O			1	1
?	Chironomoidea sp. A		1		1
?	Chironomoidea sp. B			1	1
?	Chironomoidea sp. C			1	1
?	Chironomoidea sp. D			1	1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Diptera				
?	Tipuloidea sp. A		1		1
?	Tipuloidea sp. B		1		1
?	Tipuloidea sp. C		1		1
?Rhiniidae				1	1
?Syrphidae			1		1
?Tachinidae	?Tachinidae sp. A		2		2
?Tachinidae	?Tachinidae sp. B		1		1
?Tachinidae	?Tachinidae sp. C			1	1
?Tephritidae				2	2
Asilidae	Asilidae sp. A		1		1
Asilidae	Asilidae sp. A		1		1
Culicidae			1		1
Culicidae	?*Oculeomyia*	2			2
Dolichopodidae	Dolichopodidae sp. A		3	2	5
Dolichopodidae	Dolichopodidae sp. B		6		6
Dolichopodidae	Dolichopodidae sp. C		2	3	5
Dolichopodidae	Dolichopodidae sp. D		1		1
Dolichopodidae	Dolichopodidae sp. E		1		1
Dolichopodidae	Dolichopodidae sp. F			1	1
Dolichopodidae	Dolichopodidae sp. G			4	4
Dolichopodidae	Dolichopodidae sp. H		4	1	5
Dolichopodidae	Dolichopodidae sp. I			3	3

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Diptera				
Drosophilidae	Drosophilidae sp. A			60	60
Drosophilidae	Drosophilidae sp. B	2		30	32
Drosophilidae	Drosophilidae sp. C	1			1
Hybotidae	?*Elaphropeza*		1		1
Limoniidae	Limoniidae sp. A			1	1
Limoniidae	Limoniidae sp. B			1	1
Micropezidae			1		1
Micropezidae	?*Mimegralla*		1		1
Syrphidae	*Eristalinus*		1		1
	Embioptera				
Oligotomidae		1			1
	Hemiptera				
?	Fulgoroidea sp. A		1		1
?	Fulgoroidea sp. B		2		2
?	Hemiptera sp. A			1	1
?	Hemiptera sp. B			1	1
?	Hemiptera sp. C		1		1
?	Pentatomoidea sp. A		3		3
?	Pentatomoidea sp. B		2		2
?	Pentatomoidea sp. C		1		1
Alydidae	*Riptortus*		1		1
Aphrophoridae			4		4

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Hemiptera				
Cicadellidae		3	2	3	8
Cicadellidae	*Bothrogonia*		8		8
Cicadellidae	*Hishimonus sellatus*	1			1
Cicadellidae	*Maiestas dorsalis*	1			1
Cicadellidae	*Nephotettix*	1			1
Cixiidae	Cixiidae sp. *A*	1	1		2
Cixiidae	Cixiidae sp. *B*	2	7		9
Cixiidae	Cixiidae sp. *C*	1	1		2
Cixiidae	Cixiidae sp. D	1			1
Cixiidae	Cixiidae sp. E	1			1
Cixiidae	Cixiidae sp. F	1			1
Cixiidae	Cixiidae sp. G	1			1
Cixiidae	Cixiidae sp. H		1		1
Coreidae			2		2
Coreidae	*Cletus*		3		3
Coreidae	*Mictini* sp. A		1		1
Coreidae	*Mictini* sp. B		1		1
Delphacidae	Delphacidae sp. A	3			3
Coreidae	*Mictini* sp. A				
Coreidae	*Mictini* sp. B				
Delphacidae	Delphacidae sp. A				

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Hemiptera				
Delphacidae	Delphacidae sp. B		2		2
Dictyopharidae	*Zedochir* ca. *fuscovittatus*		1		1
Dictyopharidae	*Raivuna*		1		1
Flatidae		1			1
Flatidae	*Mimophantia*		2		2
Gelastocoridae	*Nerthra macrothorax*			1	1
Issidae			1		1
Malcidae	*Chauliops*		2		2
Meenoplidae	Meenoplidae sp. A	10	6		16
Meenoplidae	Meenoplidae sp. B	4	0		4
Membracidae	?*Machaerotypus*		2		2
Miridae			1		1
Miridae	?*Creontiades*	1			1
Monophlebidae			1		1
Pachygronthidae	*Pachygrontha*		1		1
Pentatomidae	?*Agonoscelis nubilis*	1			1
Plataspidae	*Brachyplatys*		3		3
Reduviidae	?*Euagoras*		1		1
Reduviidae	*Lisarda*		1		1
Rhyparochromidae	Rhyparochromidae sp. A		1		1
Rhyparochromidae	Rhyparochromidae sp. A	1			1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Hemiptera				
Ricaniidae		1			1
Ricaniidae	*Ricania* ca. *speculum*		2		2
Tettigometridae	*Egropa*		1		1
	Hymenoptera				
?	?Chalcidoidea sp. A		1		1
?	*?*Chalcidoidea sp. *B*		1		1
?	Apoidea		2		2
?	Hymenoptera sp. *A*			3	3
?	Hymenoptera sp. B			1	1
?	Hymenoptera sp. C		1		1
?	Hymenoptera sp. *D*		1		1
?	Ichneumonoidea		3		3
Apidae	*Ceratina* (Ceratinidia)		1		1
Apidae	*Ceratina smaragdula*		1		1
Apidae	*Xylocopa latipes*		3		3
Chalcididae			1		1
Formicidae	*Anoplolepis gracilipes*			3	3
Formicidae	*Camponotus*		1	5	6
Formicidae	*Crematogaster*	15	1		16
Formicidae	*Diacamma*			1	1
Formicidae	*Dolichoderus*		80		80

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Hymenoptera				
Formicidae	*Diacamma*			1	1
Formicidae	*Dolichoderus*		80		80
Formicidae	*Oecophylla smaragdina*	1	91		92
Formicidae	*Polyrhachis* (Cyrtomyrma) sp. A		1		1
Formicidae	*Polyrhachis* (Cyrtomyrma) sp. B		1		1
Pompilidae		1			1
Pompilidae	*Auplopus*			1	1
Scoliidae	*Scolia*		25		25
Sphecidae	*Sceliphron*		1		1
Sphecidae	*Sceliphron deforme*		1		1
Vespidae	Eumeninae		1		1
Vespidae	*Ropalidia* ca. *fasciata*		10		10
Vespidae	*Ropalidia* ca. *stigma*	40			40
Vespidae	*Vespa tropica*		1		1
	Lepidoptera				
Bucculatricidae	*Bucculatrix*	1			1
Crambidae			1		1
Crambidae	?*Piletocera*	1			1
Crambidae	*?Scirpophaga*		2		2
Crambidae	*Bradina*		1		1
Crambidae	Crambinae	1	4		5

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Lepidoptera				
Crambidae	*Euclasta*		1		1
Crambidae	*Pseudocatharylla*	1			1
Crambidae	*Sufetula*	2			2
Crambidae	*Zagiridia*	2			2
Erebidae	?Boletobiinae	1			1
Erebidae	*Gesonia*	1			1
Geometridae	*Comostola quantula*	1			1
Hesperiidae	*Lotongus calathus balta*		1		1
Hesperiidae	Potanthus sp. A		1		1
Hesperiidae	Potanthus sp. B		1		1
Hesperiidae	Potanthus sp. C		2		2
Hesperiidae	Potanthus sp. D		1		1
Hesperiidae	*Suastus gremius gremius*		1		1
Lycaenidae	*Arhopala centaurus nakula*		1		1
Lycaenidae	*Hypolycaena thecloides thecloides*		1		1
Lycaenidae	*Loxura atymnus continentalis*		1		1
Lycaenidae	*Rapala*		1		1
Lycaenidae	*Zizula hylax hylax*		1		1
Noctuidae	?*Xanthodes*		1		1
Noctuidae	*Aucha*	1			1
Nolidae	Nolinae	1			1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Lepidoptera				
Nymphalidae	*Acraea terpsicore*	1			1
Nymphalidae	*Athyma perius perius*		2		2
Nymphalidae	*Cupha erymanthis erymanthis*		1		1
Nymphalidae	*Danaus affinis malayana*		2		2
Nymphalidae	*Danaus melanippus hegesippus*		2		2
Nymphalidae	*Euploea crameri bremeri*		3		3
Nymphalidae	*Junonia atlites atlites*		2		2
Nymphalidae	*Parantica agleoides agleoides*		2		2
Nymphalidae	*Parthenos sylla apicalis*		1		1
Papilionidae	*Graphium sarpedon luctatius*		1		1
Papilionidae	*Papilio polytes romulus*		2		2
Peleopodidae			1		1
Pieridae	*Appias lyncida eleonora*		1		1
Pieridae	*Catopsilia pomona pomona*		9		9
Pieridae	*Delias hyparete indica*		1		1
Pieridae	*Eurema*		1		1
Pieridae	*Hebomoia glaucippe glaucippe*		1		1
Pieridae	*Leptosia nina nina*		1		1
Pieridae	*Prioneris philonome clemanthe*		1		1
Pyralidae	*Emmalocera*	1			1
Pyralidae	Galleriinae	1			1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Lepidoptera				
Sphingidae	*Theretra suffusa*		1		1
Stathmopodidae	*Stathmopoda*	3			3
Tineodidae	*?Cenoloba*	1			1
Tortricidae	Tortricidae sp. A		4		4
Tortricidae	Tortricidae sp. B		1		1
Tortricidae	Tortricidae sp. C		1		1
	Mantodea				
Nanomantidae	*Tropidomantis*		3		3
	Neuroptera				
Mantispidae	*Mantispa*		1		1
Myrmeleontidae	*Ascalaphus placidus*	1			1
Myrmeleontidae	*Ascalohybris* sp. A		1		1
Myrmeleontidae	*Ascalohybris* sp. B		1		1
Myrmeleontidae	*Maezous*		1		1
	Odonata				
Coenagrionidae	*Agriocnemis pygmaea*		5		5
Coenagrionidae	*Ceriagrion cerinorubellum*	2	1		3
Coenagrionidae	*Mortonagrion falcatum*		3		3
Libellulidae	*Brachydiplax chalybea chalybea*		4		4
Libellulidae	*Diplacodes nebulosa*		2		2
Libellulidae	*Diplocaodes trivialis*		9		9
Libellulidae	*Neurothemis fluctuans*	3	45		48

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Odonata				
Libellulidae	*Neurothemis intermedia atalanta*		1		1
Libellulidae	*Orthetrum chrysis*		1		1
Libellulidae	*Orthetrum glaucum*		1		1
Libellulidae	*Orthetrum sabina*		1		1
Libellulidae	*Rhyothemis obsolescens*		1		1
Libellulidae	*Rhyothemis phyllis*		9		9
Libellulidae	*Urothemis signata*		1		1
	Orthoptera				
Acrididae	*Acrida*		2		2
Acrididae	Acrididae sp. A		1		1
Acrididae	Acrididae sp. B		2		2
Acrididae	Acrididae sp. C	1	1		2
Acrididae	Acrididae sp. D		2		2
Acrididae	Acrididae sp. E		1		1
Acrididae	Acrididae sp. F		1		1
Acrididae	Acrididae sp. G		2		2
Acrididae	*Apalacris varicornis*		3		3
Acrididae	*Epistaurus aberrans*		1		1
Acrididae	*Gelastorhinus*		5		5
Acrididae	*Oxya intricata*		6		6
Acrididae	*Phlaeoba*		2		2
Acrididae	*Pseudoxya diminuta*		1		1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Orthoptera				
Acrididae	*Trilophidia annulata*	1			1
Acrididae	*Xenocatantops humilis*		1		1
Gryllidae	*Velarifictorus* ca. *aspersus*	2			2
Gryllidae	*Loxoblemmus* ca. *parabolicus*	1			1
Mogoplistidae	*Ornebius bimaculatus*		1		1
Oecanthidae	*Oecanthus*	2			2
Pyrgomorphidae	*Atractomorpha*		2		2
Pyrgomorphidae	Pyrgomorphidae sp. A		2		2
Pyrgomorphidae	Pyrgomorphidae sp. B		1		1
Pyrgomorphidae	*Tagasta*		1		1
Tetrigidae	Tetrigidae sp. A		1		1
Tetrigidae	Tetrigidae sp. A	1			1
Tettigoniidae	Conocephalinae sp. A		2		2
Tettigoniidae	Conocephalinae sp. A	1			1
Tettigoniidae	*Ducetia*		2		2
Tettigoniidae	*Hexacentrus*		1		1
Trigonidiidae	?*Pteronemobius*	2			2
Trigonidiidae	Trigonidiini		1		1
	Phasmida				
?	Phasmida sp. A		1		1
?	Phasmida sp. B	1			1

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	INSECTA				
	Psocodea				
?	Phasmida sp. A		1		1
?	Phasmida sp. B	1			1
	ENTOGNATHA				
	Symphypleona				
?	Symphypleona		1		1
	ARACHNIDA				
	Araneae				
Araneidae	*Argiope*		1		1
Araneidae	*Argiope catenulata*		1		1
Araneidae	*Cyclosa* ca. *insulana*	2			2
Araneidae	*Cyclosa mulmeinensis*		1		1
Araneidae	*Gea* sp. A		1		1
Araneidae	*Neoscona*		1		1
Oxyopidae	*Oxyopes* sp. A		4		4
Oxyopidae	*Oxyopes* sp. *B*	1	5		6
Oxyopidae	*Oxyopes* sp. *C*		2		2
Oxyopidae	*Oxyopes* sp. *D*		1		1
Oxyopidae	*Oxyopes* sp. E		1		1
Oxyopidae	*Oxyopes* sp. F		3		3
Pholcidae			1		1
Pisauridae	*Nilus*		1		1
Salticidae	?*Evarcha*		14		14

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	ARACHNIDA				
	Araneae				
Salticidae	*?Ligurra*		2		2
Salticidae	*?Menemerus*		1		1
Salticidae	*Carrhotus coronatus*		1		1
Salticidae	*Cosmophasis*		1		1
Salticidae	*Phintella vittata*		5		5
Salticidae	*Rhene flavicomans*		1		1
Salticidae	Salticinae sp. A		1		1
Salticidae	Salticinae sp. B		2		2
Salticidae	Salticinae sp. C		1		1
Salticidae	Salticinae sp. D		1		1
Salticidae	Salticinae sp. E		1		1
Salticidae	Salticinae sp. F		2		2
Salticidae	Salticinae sp. G		3		3
Salticidae	Salticinae sp. H		1		1
Salticidae	Salticinae sp. I		1		1
Salticidae	Salticinae sp. J		1		1
Salticidae	Salticinae sp. K		1		1
Salticidae	Salticinae sp. L		1		1
Salticidae	Salticinae sp. M		1		1
Salticidae	Salticinae sp. N		1		1
Salticidae	*Telamonia festiva*		2		2

Family	Taxon	Collection Method			Total
		LT	SN	PT	
	ARACHNIDA				
	Araneae				
Sparassidae	*Heteropoda venatoria*	2			2
Sparassidae	*Leucauge*		1		1
Sparassidae	*Olios*	1	3		4
Sparassidae	*Thelcticopis*			1	1
Tetragnathidae	*Tetragnatha*	2			2
Tetragnathidae	*Ariamnes*		2		2
Theridiidae	*Ebrechtella* ca. *tricuspidata*		1		1
Thomisidae	*Runcinia*		15		15
Thomisidae	*Thomisus* ca. *labefactus*		2		2
Thomisidae	*Tmarus*		1		1
Thomisidae	*Miagrammopes*	1	1		2
Uloboridae	*Uloborus*		1		1
	MALACOSTRACA				
	Amphipoda				
Talitridae				90	90
	Decapoda				
Sesarmidae	*Episesarma versicolor*	1			1
	Isopoda				
?	Oniscidea			30	30

Fig. 8: Araneae. **A**: *Argiope* sp.; **B**: *Cyclosa insulana*; **C**: *Cyclosa mulmeinensis*; **D**: *Gea* sp. (mature male); **E**: *Neoscona* sp. (mature male); **F**: *Rhene flavicomans*; **G**: *Evarcha* sp.; **H**: *Telamonia festiva*; **I**: *Thiania bhamoensis*; **J**: *Gnathopalystes* sp.; **K**: *Ariamnes* sp.; **L**: *Runcinia* sp.; **M**: *Ebrechtella tricuspidate*; **N**: *Tmarus* sp.; **O**: *Uloborus* sp..

Fig. 9: Coleoptera. **A**: *Ozotomerus* sp.; **B**: *Auletobius* sp.; **C**: *Glenea vega*; **D**: *Cryptocephalus* sp.; **E**: *Lema* sp.; **F**: *Tricliona* sp.; **G**: *Enantiola hewittii*; **H**: *Lophyra* sp.; **I**: *Neocollyris* sp.; **J**: Entiminae sp. **B**; **K**: Lampyridae; **L**: *Asclerini*; **M**: Oedemeridae sp. A; **N**: Staphylinidae sp. A; **O**: Staphylinidae sp. B; **P**: *Strongylium erythrocephalum.*

Fig. 10: Diptera. **A**: Asilidae sp. B; **B**: *Brachycera* sp. C; **C**: *Brachycera* sp. I; **D**: Chironomoidea sp. A; **E**: *Oculeomyia* sp.; **F**: Dolichopodidae sp. D; **G**: Dolichopodidae sp. E; **H**: Dolichopodidae sp. G; **I**: Dolichopodidae sp. H; **J**: Drosophilidae sp. A & B; **K**: *Mimegralla* sp.; **L**: *Eristalinus* sp.; **M**: Tachinidae sp. A; **N**: Tachinidae sp. C; **O**: Tipuloidea sp. B.

Fig. 11: Hemiptera. **A**: *Riptortus* sp.; **B**: *Bothrogonia* sp.; **C**: Cixiidae sp. B; **D**: *Raivuna* sp.; **E**: *Zedochir* sp.; **F**: Flatidae (a nymph); **G**: *Mimophantia* sp.; **H**: *Nerthra macrothorax*; **I**: Issidae; **J**: *Machaerotypus* sp.; **K**: *Creontiades* sp.; **L**: *Egropa* sp.; **M**: Pentatomoidea sp. C; **N**: *Brachyplatys* sp.; **O**: *Euagoras* sp.; **P**: Ricaniidae (a nymph).

Fig. 12: Hymenoptera. **A**: *Ceratina smaragdula*; **B**: *Ceratina* (Ceratinidia) sp.; **C**: Apoidea; **D**: Chalcididae; **E**: *Anoplolepis gracilipes*; **F**: *Crematogaster* sp.; **G**: Hymenoptera sp. A; **H**: Hymenoptera sp. C; **I**: Hymenoptera sp. D; **J**: Ichneumonoidea; **K**: Pompilidae; **L**: *Auplopus* sp.; **M**: *Scolia* sp.; **N**: *Sceliphron deforme*; **O**: Eumeninae; **P**: *Ropalidia fasciata.*

Fig. 13: **A**: *Bucculatrix* sp.; **B**: Crambidae; **C**: *Euclasta* sp.; **D**: *Piletocera* sp.; **E**: *Pseudocatharylla* sp.; **F**: *Sufetula* sp.; **G**: *Zagiridia* sp.; **H**: Boletobiinae; **I**: *Comostola quantula*; **J**: *Suastus gremius*; **K**: *Aucha* sp.; **L**: Nolinae; **M**: *Danaus affinis malayana*; **N**: *Emmalocera* sp.; **O**: *Theretra suffusa*; **P**: *Stathmopoda* sp..

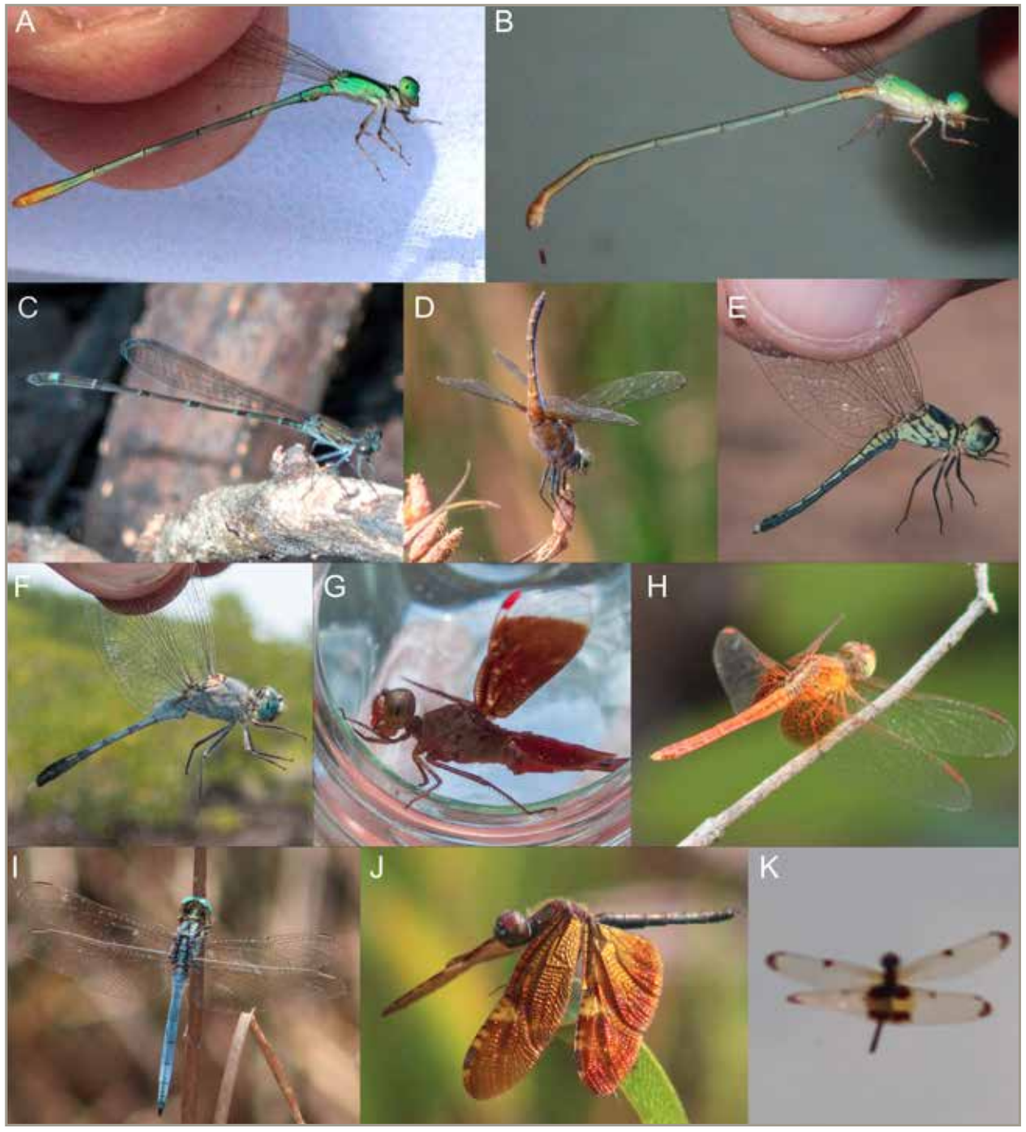


Fig. 14: Odonata. **A**: *Agriocnemis pygmaea*; **B**: *Ceriagrion cerinorubellum*; **C**: *Mortonagrion falcatum*; **D**: *Brachydiplax chalybea*; **E**: *Diplacodes nebulosa*; **F**: *Diplacodes trivialis*; **G**: *Neurothemis fluctuans*; **H**: *Neurothemis intermedia atalanta*; **I**: *Orthetrum glaucum*; **J**: *Rhyothemis obsolescens*; **K**: *Rhyothemis Phyllis.*

Fig. 15: Orthoptera. **A**: *Apalacris varicornis*; **B**: *Epistaurus* sp.; **C**: *Gelastorhinus* sp.; **D**: *Oxya* sp.; **E**: *Phlaeoba* sp.; **F**: *Trilophidia annulata*; **G**: Acrididae sp. A; **H**: Acrididae sp. B; **I**: *Velarifictorus aspersus*; **J**: *Loxoblemmus parabolicus*; **K**: *Ornebius bimaculatus*; **L**: *Oecanthus* sp.; **M**: *Tagasta* sp.; **N**: *Ducetia* sp.; **O**: *Hexacentrus* sp.; **P**: *Trigonidiini.*

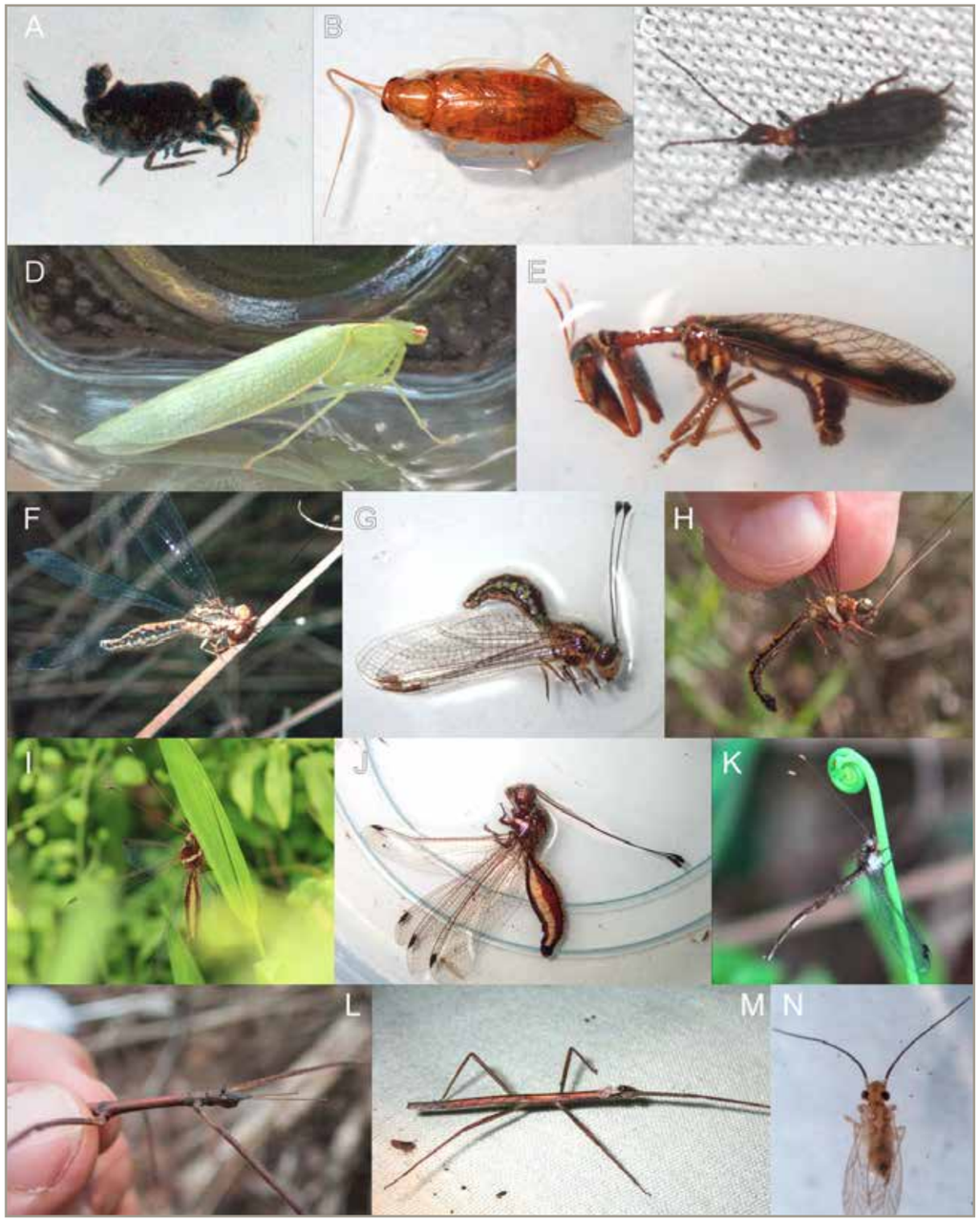


Fig. 16: Other orders. **A**: Symphypleona; **B**: Blattodea, Ectobiidae; **C**: Embioptera, Oligotomidae; **D**: Mantodea, *Tropidomantis* sp.; **E-K**: Neuroptera; **E**: *Mantispa* sp.; **F** & **G**: *Ascalaphus placidus*; **H**: *Ascalohybris* sp. A; **I** & **J**: A*scalohybris* sp. B; **K**: *Maezous* sp.; **L**: Phasmida sp. A; **M**: Phasmida sp. B; **N**: Psocodea, Pseudocaeciliidae.

Fig. 18: Seseramine mangrove crab at Ta Chat feeding on a dead leaf.

Fig. 19: Fiddler crab *Gelasimus vocans* on mudflats at Boeng Kayak.

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HERPETOLOGICAL SURVEY

Title image: Male brackish frog *Fejervarya moodiei* in Peam Krasop.

INTRODUCTION

The term ‘herpetological’ encompasses both reptiles and amphibians. Very little herpetological research has been undertaken in Cambodian mangroves. This is probably due to fact that mangroves cover a relatively small area of the Kingdom and are unlikely to contain much diversity or any endemic forms.

Due to the tidal nature of mangrove forest species living there need to show a degree of salt-tolerance, as is seen in Cambodia’s one euryhaline amphibian species, *Fejervarya moodiei*. Sea, mud and water snakes (Fig. 1) also show this adaptation. Most reptiles and almost all amphibians are not salt-tolerant, therefore the diversity of reptiles and amphibians is expected to be low in the sanctuary.

The purpose of the work was to identify as many reptile and amphibian species as possible. However, given the limited time, greater effort was expended in targeting two species groups - the saltwater-tolerant brackish frog *Fejervarya moodiei*, the Homalopsid mud snakes and the Elaphid sea snakes. At present, there are no records of the mangrove pit viper *Trimeresurus purpureomaculatus* from either Cambodia or the east coast mangroves of Thailand, and no endemic gecko species known from the mangroves in this area. Herpetological searches in Thailand have shown that the eastern side of the peninsular is less diverse than the west. Given the lack of diversity in this context, and the small extent of mangrove in Cambodia, it is unlikely that any new or endemic reptile species occur in Peam Krasop.

The species with the most conservation significance are the brackish frog and the coastal-specific snakes. Both of these rely on mangrove habitat to survive and are not found in terrestrial habitats.

The brackish frog is known from the Boeng Kayak area, but two daytime surveys carried out by the author in May and August 2022 failed to locate this species in its former habitat among the board walk mangroves. Searches in the now much reduced mangrove reserve in Kep in 2022 also failed to find this species. During surveys in the mangroves surrounding Kang Keng Airport near Ream National

◁ **Fig. 1:** Dog-faced water snake *Cerberus schneiderii* on mudflats at Koh Moul.

Park in 2017, local people were seen collecting brackish frogs as fishing bait, although these were probably also collected for consumption. Given the restricted habitat these frogs require, the rapid loss of this habitat, and the targeting of this species for collection, it may be a species vulnerable to future decline in Cambodia.

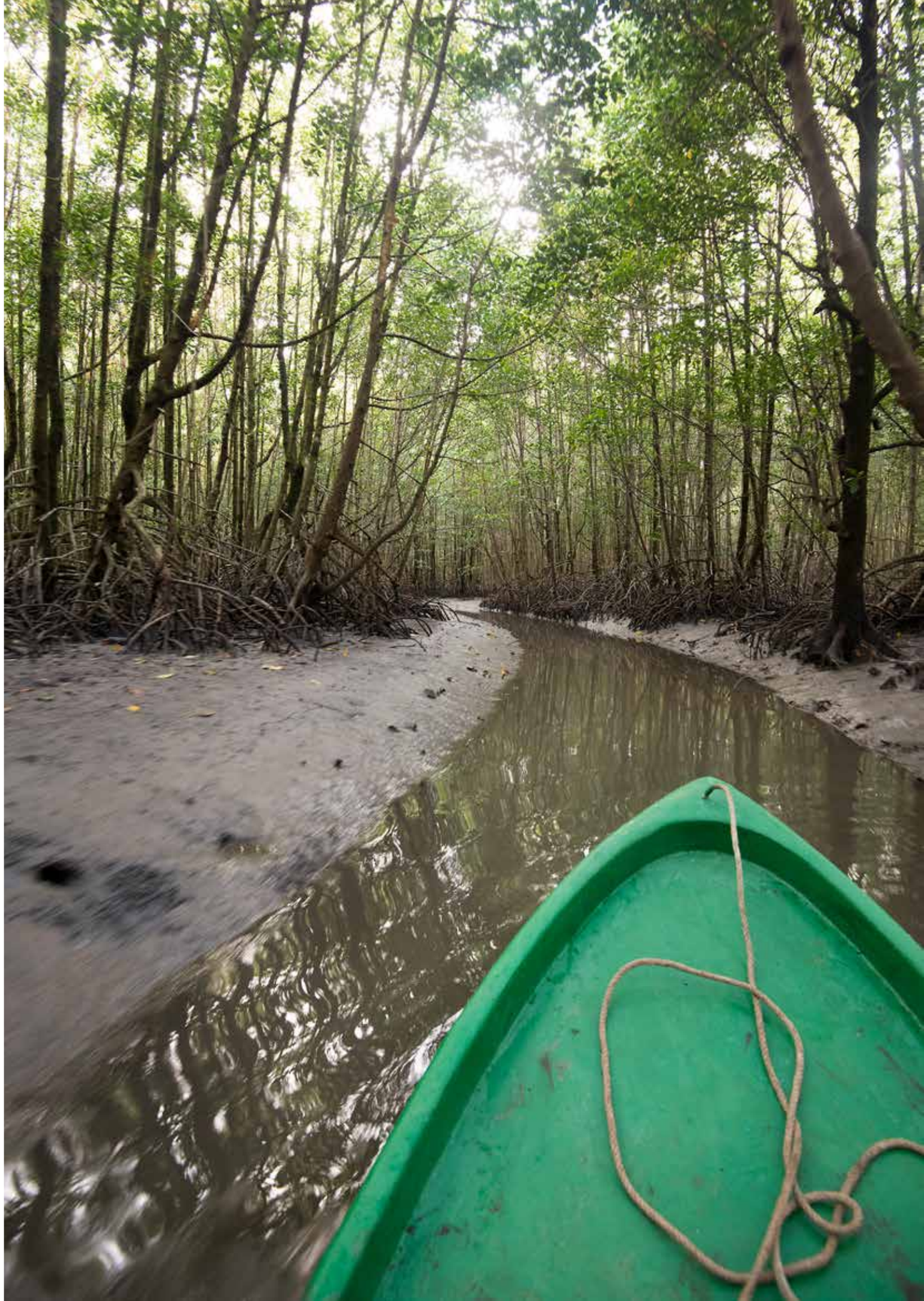
On a previous survey in Peam Krasop in 2012, the author had seen a striped water snake in this Boeng Kayak area. The snake was not captured or identified. Its appearance conformed to a small number of possible species, either a Homalopsid mud snake, such as *Bitia hydroides* (a rare snake of mud flat and estuaries not yet recorded in Cambodia), or one of the Elaphid sea snakes such as *Aipysurus eydouxii* or *Hydrophis klossi,* both of which appear to be recorded in Cambodia.

METHODS

Surveying mangrove forest has a number of unique difficulties, not least of which is the tidal aspect. This means the landscape transitions between dry and inundated over the course of the day. Access is limited and must take into consideration the tide times and the depth of water channels. Even when the tide has receded, the exposed land is often too soft to easily negotiate on foot.

For the purpose of this survey, three approaches we used: night and day surveys by boat through the offshore mangrove forests and channels; foot surveys along the interface between the mangroves at low tide and the surrounding grassland or forest habitat; and searches made from the board walks or around anthropogenic structures within the mangroves.

As most reptiles and amphibians are nocturnal, most search effort was conducted at night. No specialized techniques, such as pit fall or bark traps were used. Instead, searches were made by day and at night, exploring any features that might hold reptiles or amphibians. For amphibians, calls were also used, and some species of frog were identified on the evidence of calls alone. This was a non-destructive survey: specimens were not collected, only photographed in situ and then released.



▷ **Fig. 2:** Boat survey through coastal mangrove channels near Koh Kapik.

Survey Locations

The survey locations covered two principle habitat types: the tidal mangrove forests that are not connected to the mainland or fresh water sources, and transitional zones where mangroves grade into mainland grasslands and Melaleuca forest. No surveys were made in the higher elevation evergreen forest, where it is certain many species that do not occur in the mangrove zone might have been found.

For the purpose of this survey, four areas were identified, which represented a spectrum of habitat types ranging from tidal mudflats to mainland grassland, with transitional habitat in between (Fig. 3).

The first habitat chosen was the board walk reserve at Boeng Kayak (Figs. 4 & 5). This allowed easy access both day and night, regardless of the tides, to mature mangrove forest. Tidal brackish channels surrounding the mangrove reserve provided the kind of habitat used by salt-tolerant frogs and water snakes. Wooden structures built for tourists within the mangroves offered perfect habitat for gecko species, should any occur. Furthermore, in the adjacent small settlement, local fisherman could be questioned about the occurrence of reptiles and amphibians. this heavily used area was contrasted with more pristine areas deeper in the sanctuary. Access was made by motorbike from Koh Kong town.

The second location was the tourist facility at Ta Chat on the north-east of the sanctuary. Exploring this area gave me access to the transitional habitat between the tidal riverine mangrove (Fig. 6) and the surrounding flooded grasslands and freshwater ditches (Fig. 9). Some buildings situated both in and around the mangrove forest provided good habitat for geckos. Accommodation at this location made it ideal for a three-day survey. UTM: **0289607 1271875**.

The third and fourth locations included the Koh Kapik Ramsar Site and Koh Moul. These gave access to pristine tidal mangrove forest (Fig. 7) that was unconnected to the mainland, and some island plantations that featured freshwater rain pools and ditches. This area was accessed by small motorboat from Boeng Kayak (Figs. 2 & 8).UTM Koh Kapig: **0283456 1267003**; UTM Koh Moul: **0283383 1264687**.

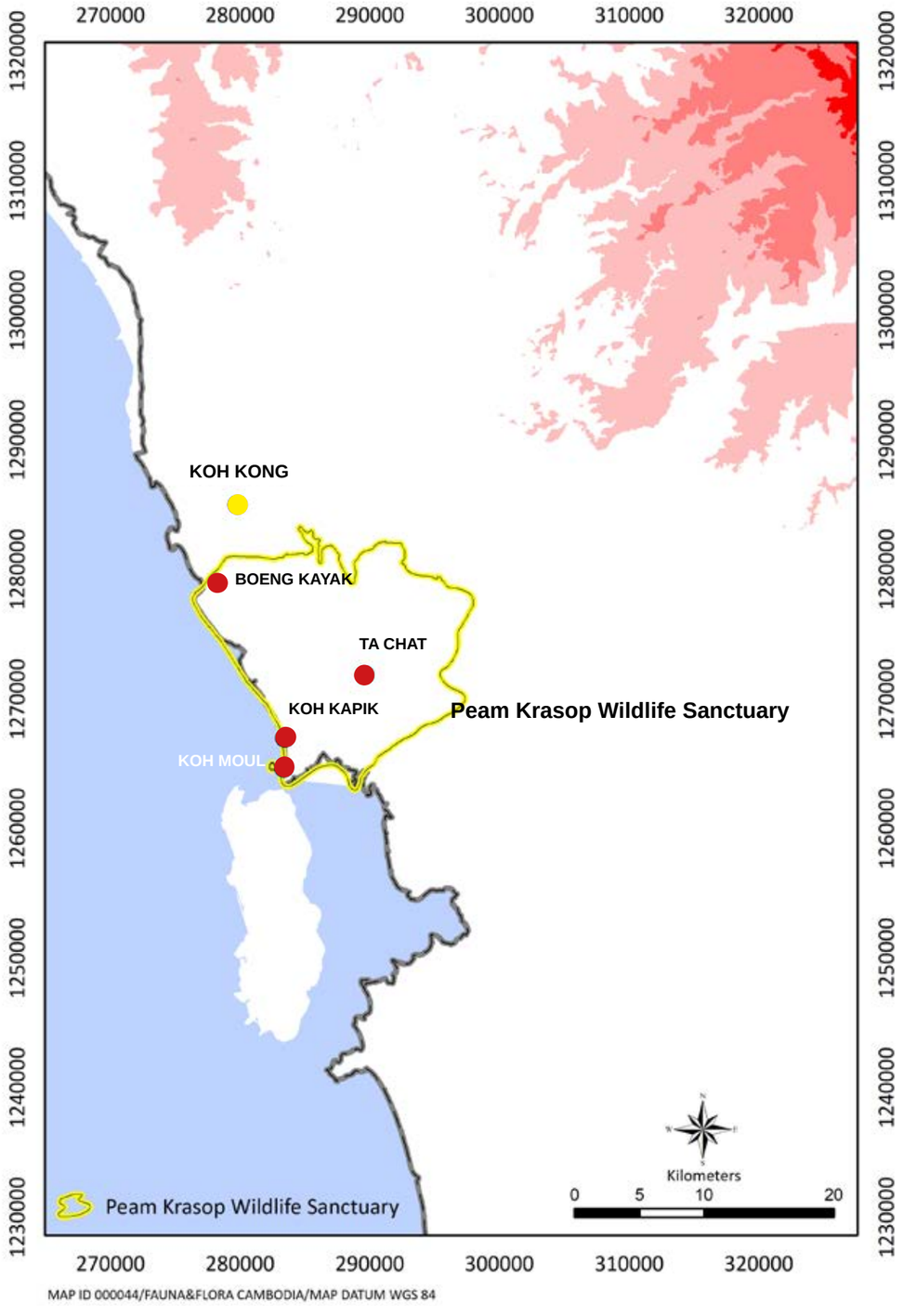


Fig. 3: Survey locations shown in red, Peam Krasop Wildlife Sanctuary.

◁ **Fig. 4:** Mangroves at Boeng Kayak.

Fig. 5: Board walk through the mangrove reserve at Boeng Kayak.

Fig. 6: Riverine mangrove forest at Ta Chat.

Fig. 7: Offshore mangrove forest near Koh Kapik, unconnected to the mainland.

Fig. 8: Accessing offshore mangrove stands by boat.

▷ Fig. 9: Brackish pool in cleared mangroves at Ta Chat.

RESULTS

In total, 17 species of reptile and amphibian were found between 22-28 May (Table 1). These represented 12 species of amphibian and five species of reptile. Only two of these species can be considered mangrove specialists - the brackish frog *Fejervarya moodiei*, and the dog-faced water snake *Cerberus schneiderii.*

Amphibians

The 12 amphibian species seen consisted predominantly of the characteristic fauna of lowland disturbed habitat. Most of these species occur across lowland Cambodia. The one exception is the target species *Fejervarya moodiei.* Formerly, this species was recorded in Cambodia as *Fejervarya cancrivora* (crab-eating frog). Saltwater-tolerant (or euryhaline) frogs of the genus *Fejervarya* Bolkay, 1915, are currently recognised as comprising two species: *F. moodiei*, which occurs from Bangladesh to the Philippines, and *F. cancrivora,* which ranges south from Thailand to the Indonesian archipelago. The two species were recently split from the *cancrivora* complex (Yodthong et al. 2019). Unlike its close relative *F. cancrivora, F. moodiei* shows a greater preference for brackish water and is not found far from mangrove habitat. Although this species has a relatively wide range and is listed by the IUCN as of Least Concern, its particular habitat preference make it vulnerable. It is a species of interest in Cambodia, recorded in only a handful of locations along the Cambodian coast, and not known to occur at any inland sites (Holden 2023).

The first day time search for this species in the mangroves of Boeng Kayak failed to locate it. Interviews with local fishermen living beside the reserve reported that it is still present, but is seasonal in its appearance. In Ream National Park this frog is collected for both fishing bait and local consumption, which makes it likely to also occur at Boeng Kayak. A second visit made at night revealed that locals with spotlights were climbing through the mangrove roots collecting crabs and fish, which might explain why neither frogs nor mudskippers were seen here during either of the surveys.

Table 1: Species found in the four habitat types in Peam Krasop and Koh Kapik.

Location	TC	KKP	KM	BK
Anura				
Duttaphrynus melanostictus	X		X	
Fejervarya moodiei	X	X	X	X
Hoplobatrachus rugulosus			X	
Phrynoglossus martensii			X	
Kalophrynus interlineatus	X			
Kaloula pulchra		X	X	
Microhyla heymonsi			X	
Microhyla mukhlesuri			X	
Hylarana erythraea	X		X	
Hylarana macrodactyla	X			
Chirixalus nongkhorensis			X	
Polypedates leucomystax			X	
Caudata				
Calotes versicolor	X			
Gekko gecko	X			
Gehyra mutilata	X			
Tachydromus sexlineatus	X			
Serpentes				
Cerberus schneiderii		X		

TC: Ta Chat, mangrove transitional with brackish pools and fresh water ditches.

KKP Koh Kapik, tidal mangrove channels and mudflats.

KM: Koh Moul, plantation with brackish and fresh water pools.

BK: Boeung Kayak board walk with mangroves and brackish channels.

Two visits to the reserve in 2022 also failed to locate *F. moodiei,* while a trip in 2012 did find numerous roosting frogs visible from the board walk, indicating that this species is likely in decline at Boeng Kayak.

The species was finally located at Boeng Kayak along brackish drainage channels leading away from the mangroves. Despite perfect conditions (rain) only three individuals were found and no frogs were heard calling. Due to the brackish water, this species was the only amphibian recorded in this area. This fact made the frogs easy to identify. But morphological characteristics, such as body size, tympanum colour, and the presence of two black patches over the vocal sacs of the male frogs (Fig. 10) allowed this species to be confidently distinguished from the superficially similar *Fejervarya limnocharis* - a species that despite being one of Cambodia's commonest frogs, was not encountered during the surveys at Peam Krasop.

Brackish frogs were the one amphibian species found in all of the four study sites. At Ta Chat, small colonies of male frogs were located. None of these were seen in the mangrove forest, but were restricted to brackish pools and channels adjacent to the mangroves. Again, these pools were unused by any other amphibian species. Additional species only began to appear a few hundred metres from the mangrove zone, where freshwater ditches replaced the brackish habitat.

In the tidal mangroves between Boeng Kayak and Koh Kapik, brackish frogs were occasionally seen on the exposed mudflats along the forested channels, but were not common (UTM: **0283943 1266284**). The only other amphibian seen in this area was a single *Kaloula pulchra,* a burrowing species that certainly would be incapable of breeding in this habitat.

By far the largest population of *Fejervarya moodiei* was found on Koh Moul (UTM: **0283383 1264687**) where the frogs were actively breeding in freshwater drainage ditches close to the shore. Male frogs were engaged in noisy choruses, audible from 100 metres or more, that rose and fell throughout the early part of the night.

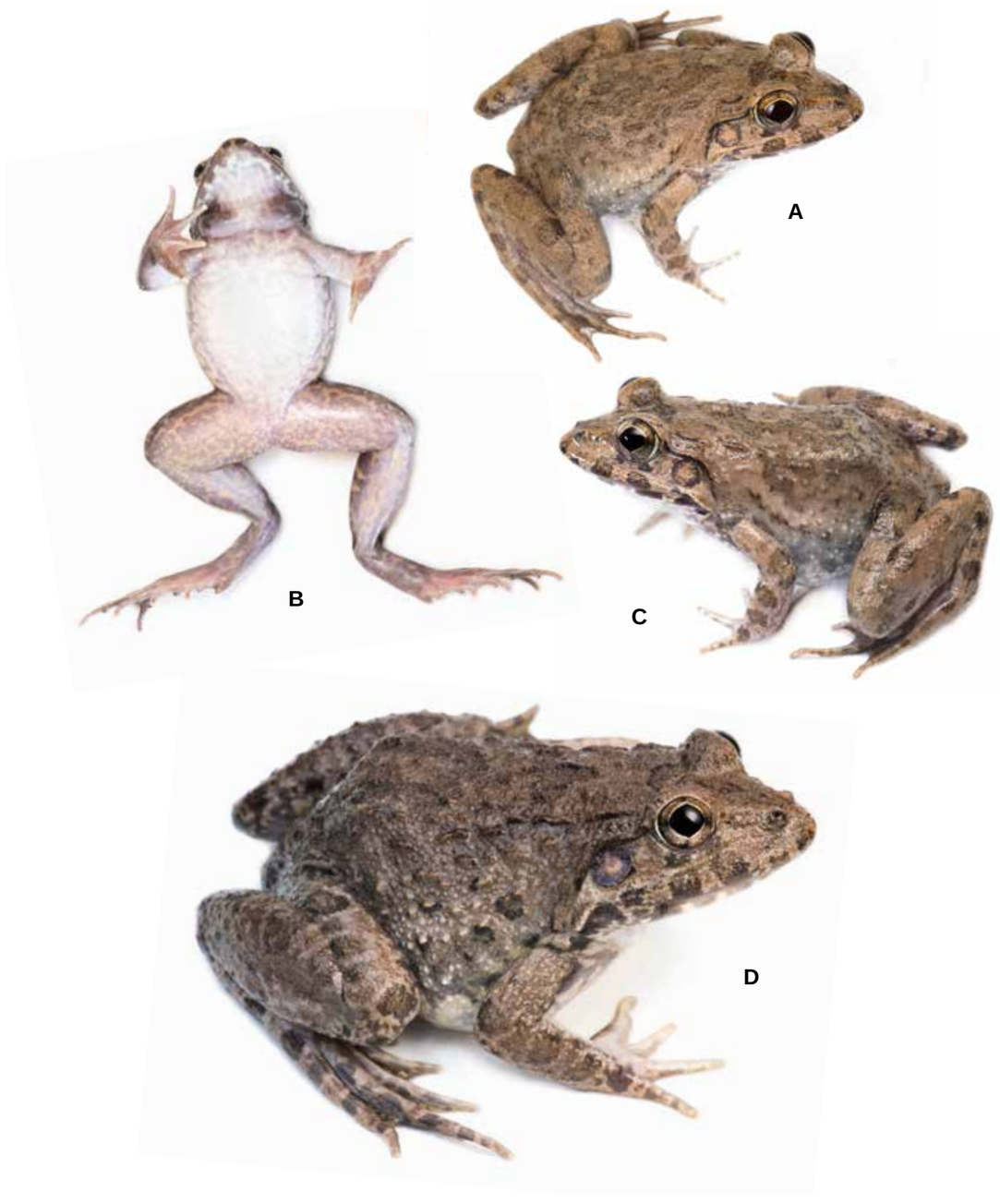


Fig. 10: Specimens of brackish frog *Fejervarya moodiei* found in Peam Krasop Wildlife Sanctuary. **A**: adult male, Ta Chat; **B**: adult male underside showing diagnostic black patches over the vocal sacs, Ta Chat; **C**: adult male, Ta Chat; **D**: larger adult female from Boeng Kayak.

Fig. 11: Mangrove edge at Ta Chat.

Fig. 12: Brackish pool behind mangrove zone at Ta Chat where *Fejervarya moodiei* was first located.

While both the areas exclusively covered by mangroves hosted only brackish frogs, the grasslands around Ta Chat, and the ditches and pools in the coconut plantations on Koh Moul hosted a variety of common lowland frogs of the sort familiar around villages throughout Cambodia.

Six species were found at Ta Chat, including the long-toed grass frog *Hylarana macrodactyla* (Fig. 15) and the sticky frog *Kalophrynus interlineatus,* both of which were not seen in Koh Moul. The three remaining species were the black-spined toad *Duttaphrynus melanostictus*, the green paddy frog *Hylarana erythraea* and the floating frog *Phrynoglossus martensii*. Other common lowland species would almost certainly also occur here but were missed.

Our visit to the plantations of Koh Moul coincided with the threat of heavy rain and as a consequence the frogs were extremely active. This allowed for many species to be identified by sound alone, such as the loud and distinctive call of the rugose frog *Hoplobatrachus rugulosus*. Temporary rain pools in this area contained colonies of various species, including the small treefrog *Chirixalus nongkhorensis*, brown tree frog *Polypedates megacephalus*, painted bull frog *Kaloula pulchra,* floating frog *Phrynoglossus martensii,* green paddy frog *Hylarana erythraea* and two *Microhyla* species, *M. heymonsi* and *M. mukhlesuri*.

The colony of brackish frogs seen breeding here did not share their breeding habitat (a small drainage channel) with any other species, which might mean its water was indeed brackish.

Of the twelve amphibian species recording during the survey (Fig. 13) none were unexpected, with *Fejervarya moodiei* (Fig. 14) an indicator species for mangrove conservation.

Fig. 13: Amphibian species found in Peam Krasop Wildlife Sanctuary: **A**: *Chirixalus nongkhorensis*; **B**: *Hylarana macrodactyla*; **C**: *Polypedates megacephalus*; **D**: *Hoplobatrachus rugulosus*; **E**: *Phrynoglossus martensii*; **F**: *Kalophrynus interlineatus*; **G**: *Microhyla heymonsi*; **H**: *Kaloula pulchra*; **I**: *Microhyla mukhlesuri*; **J**: *Hylarana erythraea*; **K**: *Duttaphrynus melanostictus*; **L**: *Fejervarya moodiei.*

Fig. 14: Brackish frog *Fejervarya moodiei* in mangroves at Ta Chat.

Fig. 15: *Hylarana macrodactyla* at Ta Chat.

Reptiles

The survey discovered very few reptiles, and the majority of these were seen outside of the tidal mangroves and represented common lowland species commensurate with human occupation. In total only five reptile species were recorded between 22-28 May. This low number has two principle reasons: the first is that there are very few reptile species occurring in the tidal mangrove zone. The second was purely down to search effort time being limited.

It is of interest to note that the one snake species seen - dog-faced water snake *Cerberus schneiderii* (Fig.16) was recorded five times in one night. Finding the same species of snake twice in one night is an uncommon occurrence in tropical forests, where snake diversity is high. High encounter frequency of a single species usually indicates a low species diversity.

The remaining four reptile species were all seen in Ta Chat. Two of these were common gecko species - *Gekko gecko* (Fig. 17) and *Gehyra mutilata* - seen on buildings close to the mangroves, and the other two - *Tachydromus sexlineatus*, and *Calotes versicolor* are common grassland species seen in the transitional zone between the mangroves and the lowland forest.

Locals interviewed at Boeng Kayak reported both rat snakes and cobras around the buildings. This is to be expected, as during the gecko search along the board walk and its thatched huts, rats were encountered.

Night surveys of the structures situated within the actual mangrove forests, both in Boeng Kayak and Ta Chat, revealed absolutely nothing. This was surprising, as usually geckos are seen on any rural man-made structure in Cambodia. Clearly, being above saline water was not a draw for these species, which often fall from the trees during territorial fights, or will occasionally move across the ground.

Fig. 16: Dog-faced water snake *Cerberus schneiderii* were common from mangroves and mudflats near Koh Kapik.

CONCLUSION

The results of this brief survey were as expected. Additional species might be expected if conducting longer-term surveys.

It is encouraging to discover that the brackish frog still occurs throughout Peam Krasop and appears to be thriving on the offshore islands, like Koh Moul. Surveys undertaken by the author in 2022 in both Peam Krasop and Kep mangroves had failed to locate this species, which gave rise to concerns that it might have been over-collected. It seems likely that this is indeed the case around Boeng Kayak. These frogs do inhabit holes in the mud banks, and can be found at all times during the year. Local reports said the frogs are commonest, and are sometimes harvested during the ‘wet season’. The fact that brackish frogs were breeding on Koh Moul proves, that as expected, they breed during the wettest part of the year, utilizing pools and ditches that are possibly made less saline by the rain fall. This species is not considered threatened by IUCN, and ranges widely from Bangladesh to Philippines, but in Cambodia, its presence is restricted to a small number of circumscribed areas, and as a country record, the Peam Krasop populations are crucial to its survival in the Kingdom.

The assemblage of amphibian species seen at Ta Chat and the plantation areas of Koh Moul were exactly what might be expected. The presence of *Hylarana macrodactyla* was the single surprise, as this species is not as regularly encountered in anthropogenically modified landscapes as its close relative *Hylarana erythraea* - which occurred in the same habitat near Ta Chat.

◁**Fig. 17:** Tokay geckos *Gekko gecko* were seen only on buildings above dry land at Ta Chat.

Finding a single *Kaloula pulchra* in a tidal mangrove channel was an anomaly, and this record probably relates to a single frog being carried beyond its normal range (This species was heard calling in gardens in Koh Kapik Village after rain). Although this species has been found near mangroves in Singapore, it was not seen near brackish water (Chan & Goh 2010).

Water monitor *Varanus salvator*, the world's second largest lizard, is a salt-tolerant species, and one that we might have expected to find but didn't. Other species we missed were any sea snakes or the unidentified banded snake I observed in Boeng Kayak in 2012.

Despite searching the overhanging branches through the channels, no arboreal snakes were seen. The golden-ringed cat snake, *Boiga melanota*, which is sometimes known as mangrove cat snake, was seen on a earlier survey in Peam Krasop.

Again, beyond some of the scarcer sea snakes or Homalopsid mud snakes, there are no known endemic or rare reptiles that were expected to be encountered.

In terms of habitat quality, the areas between Boeng Kayak and Koh Moul had some excellent mangrove habitat. However, human presence here was high, with constant boat traffic encountered during the day on even the smallest and shallowest channels we used. We did see large mud crabs and mud skippers in this location.

Interview and camera trap data collected by the Fishing Cat Ecological Enterprise recorded a few additional species that were missed by this survey.

Water monitors, which were notably absent during the survey, but certainly expected to occur, were captured on camera traps set in PKWS (Herranz Muñoz pers. comm).

Additional records made by FCEE including the venomous Malayan pit viper *Calloselasma rhodostoma* (Fig. 18). Via the local community, they also recorded reports of king cobra *Ophiophagus hannah* and reticulated python *Malayopython reticulatus* (Fig. 19) - respectively, the largest venomous snake and the largest known snake on Earth. Although reticulated python must certainly occur in the lowland forests of PKWS, there is also the possibility that the individual seen was part of the release programme conducted in the area by Wildlife Alliance.

Fig. 18 : Malayan pit viper *Calloselasma rhodostoma* was recorded by FCEE is common in the drier areas of PKWS.

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◁**Fig. 19:** Reticulated python *Malayopython reticulatus.*

ORNITHOLOGICAL SURVEY

Sophatt Reaksmey &
Vanessa Herranz Muñoz

Title image: Common greenshank *Tringa nebularia* with prawn.

INTRODUCTION

Peam Krasop Wildlife Sanctuary and the Koh Kapik Ramsar Site provide habitats for a range of resident and migratory birds along coastal mudflats, mangrove forests, lowland Melaleuca and evergreen forests. Koh Kapik was designated as a Ramsar site in 1999 under criteria 1 (representative or unique wetlands), criteria 2 (rare and endangered species), and criteria 8 (fish spawning ground, nursery, and/or migration path) (Srey 2012). In addition, PKWS and KKRS have been identified as an Important Bird Area (IBA) by BirdLife International in 2003, highlighting the presence of significant populations of Endangered Nordmann's greenshank *Tringa guttifer* and the Near Threatened Asian dowitcher *Limnodromus semipalmatus*.

In 1996, Wetlands International conducted a bird survey along the Cambodian coast, which would lead to the Ramsar Site designation. During this work over 3000 waterbirds were recorded on the western shore of Koh Kapik alone - the largest number encountered at any of the survey sites. Nordmann's greenshank and broad-billed sandpipers *Limicola falcinellus* occurred in internationally important numbers; while another six species occurred in numbers significant for conservation attention (Table 1). According to this study, the area's extensive, healthy and mature mangrove and *Melaleuca* communities were the best representatives of these habitats in the Gulf of Thailand, and from an ornithological perspective, it had the highest concentration and diversity of waders in Cambodia (Edwards, 1999).

At least 20 species of shorebird occur in KKRS, including several that are globally threatened. In 2014, Critically Endangered spoon-billed sandpiper *Calidris pygmaea* was recorded feeding on low tide pools in KKRS; global population decline may be behind the small number found in the Gulf of Thailand, and the Cambodian wintering population probably larger in the past (Nielsen et al. 2014). Important populations of Endangered great knot *Calidris tenuirostris* and Nordmann's greenshank, Asian dowitcher and Vulnerable Chinese egret *Egretta eulophotes* were recorded in recent surveys at the site (Taing et al. 2018).

◁ Lesser adjutant *Leptoptilos javanicus* feeding in shallow water.

METHODS

In order to describe bird diversity within PKWS/KKRS, this report collates information gathered from several sources: a rapid bird survey conducted in 2023; camera-trapping survey records from 2022, and between 2017-2021, and verified 'research grade' records uploaded to iNaturalist between 2012 and 2022 (Fig. 1).

Rapid surveys were conducted in suitable areas such as mudflats, sandbars, mangrove areas, Melaleuca forests, and mixed mangrove forests from 28-31 March, 2023. The line transect sampling method was used in the survey to identify and scope out potential sites for further survey work. In total, 10 line transects were selected for this purpose (Fig. 2). This method involves systematically walking a pre-determined path or line and recording all of the bird species that are observed within a set distance on either side of the line. This helps to ensure that the survey is conducted in a structured and consistent manner, enabling researchers to compare data accurately over time and across different areas. Using this method, the survey team can identify areas with higher bird densities or greater diversity, providing useful information for conservation and management purposes. A motorized boat was used for the rapid survey and brought us to the sites; as many of these sites could not be accessed easily, we used kayaks to access secluded mangrove channels. Surveys were conducted between 0700hrs and 1500hrs daily over a total of 4 days.

The Fishing Cat Ecological Enterprise (FCEE) and Ministry of Environment (MoE) staff conducted a camera-trapping survey between July and October 2022 of all habitats within PKWS, focusing on obtaining data from all Management Zones (detailed in the Mammals chapter). Additionally, FCEE has been monitoring wildlife at the two sites using camera traps since 2017 - focusing on mangrove and mixed mangrove areas. Bird records obtained during these surveys are presented here.

Data collected by the public through citizen science projects has become increasingly available in recent years (Bonney et al. 2014, Brown and

Table 1: Individual counts of shorebirds recorded on the western shore of Koh Kapik in 1996 (Edwards, 1999).

Species	Scientific Name	Edwards 1999
Nordmann's greenshank	*Tringa guttifer*	13
Broad-billed sandpiper	*Limicola falcinellus*	190
Bar-tailed godwit	*Limosa lapponica*	526
Lesser sand plover	*Charadrius mongolus*	466
Greater sand plover	*Charadrius leschenaultii*	488
Terek sandpiper	*Xenus cinerus*	136
Common greenshank	*Tringa nebularia*	129
Grey plover	*Pluvialis squatarola*	97

Williams 2019), and one widely used platform, iNaturalist[1] has proved to be an important source of biodiversity data, particularly for birds - although a bias for larger species needs to be checked (Callaghan et al. 2021).

For the current report, the map selection tool on iNaturalist[1] was used to select records within PKWS. Only the records tagged 'research grade'[2] were considered, resulting in collection of records obtained from 2012 to 2022, taken by one experienced observer, Gerard Chartier, who is a long-standing collaborator of FCEE and also a local guide and naturalist .

[1] www.inaturalist.org.
[2] Identifications confirmed on the platform by several experienced observers.

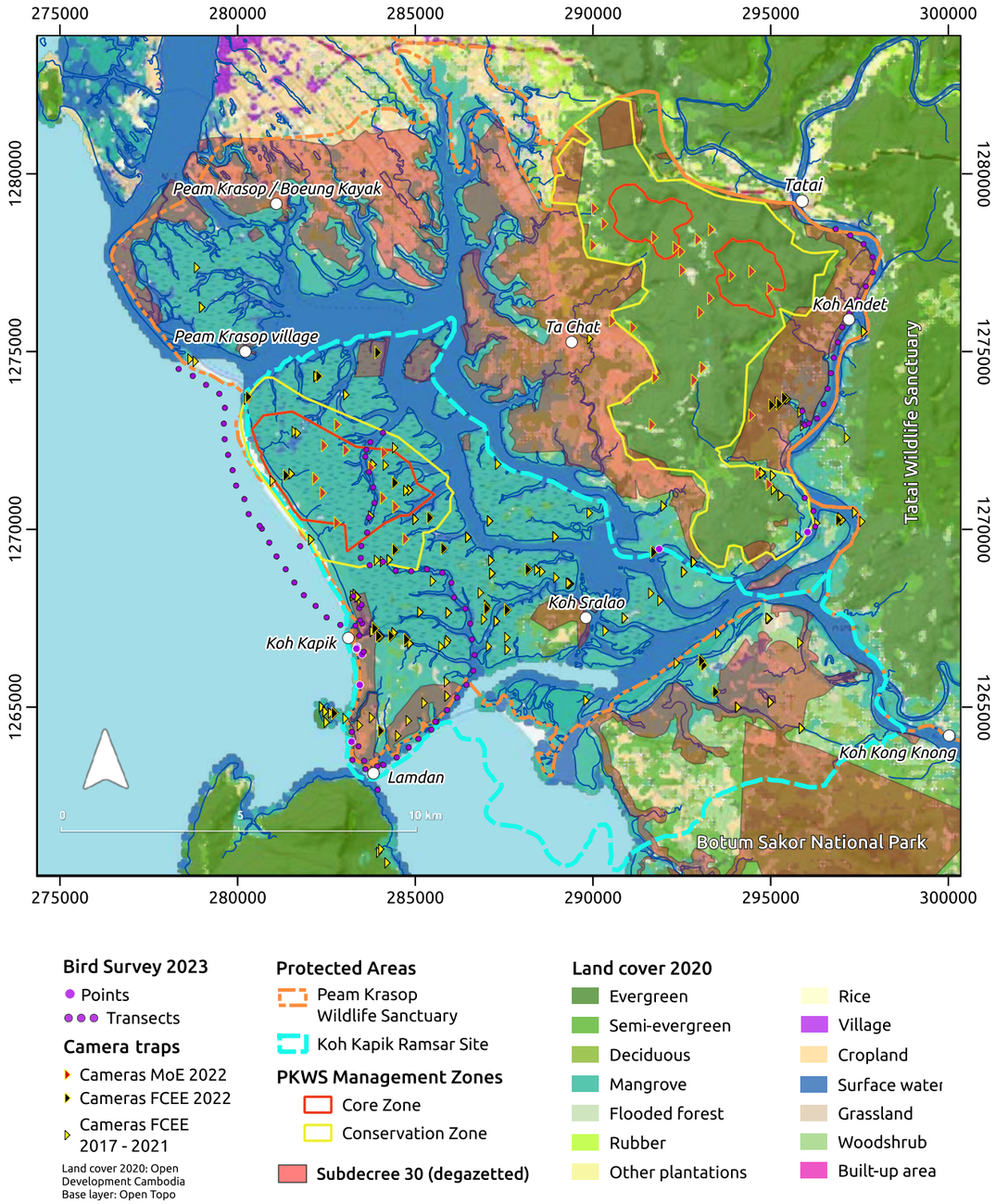

Fig. 1: Locations of the rapid bird survey points and transects, cameras deployed by MoE and FCEE in 2022, and cameras deployed by FCEE between 2017 and 2021.

RESULTS

Overall, a total of 157 bird species, including 15 species listed on the IUCN Red List as Near Threatened to Endangered have been recorded in PKWS/KKRS in recent years (Table 1) rendering the site highly significant for bird conservation. Integrating all data available provides bird diversity information from all areas and habitats present within PKWS: Taing et al. (2018) focused on the western shoreline of KKRS, covering mudflats, sandbanks and beaches, as did the 2023 FCEE rapid survey - in addition to mangrove and mixed mangrove channels; the camera trap survey in 2022 covered mangroves and evergreen forests; camera trap monitoring between 2017 and 2021 spanned mangrove channels, interior and mixed mangrove; and the iNaturalist observations from G. Chartier covered mixed mangroves, Melaleuca forests and semi-evergreen forests.

The data presented here on bird counts along the western shore of Koh Kapik (Taing et al. 2018, and the 2023 rapid survey) is not directly comparable to the previous data from 1996 (Edwards 1999) due to the different survey efforts, however, the vastly different flock numbers suggest a clear decline of the shorebird populations over the last 20 years.

Taing et al. (2018) recorded the presence of 20 shorebird species and several additional seabird species. Not all 20 species were detected during this survey due primarily to the difficulty of accessing certain areas when tidal conditions were unfavourable. Critically Endangered spoon-billed sandpiper *Calidris pygmaea* was not recorded. Only 200 lesser sand plover *Charadrius mongolus* and around 100 greater sand plovers *Charadrius leschenaultii* were observed along both Koh Kapik beach and Peam Krasop beach (Fig. 6). Several great crested terns *Thalasseus bergii* stood atop concrete pillars or water tanks situated within the open sea area facing Koh Kapik Island (Fig. 2); and 20 whimbrels *Numenuis phaeopus* were recorded within mudflats and sandbanks along mangrove channels.

During the 2022 camera trap survey, 35 bird species were recorded. Significant records include Chinese egrets, recorded at five sites within mangrove habitats, and Vulnerable great hornbill *Buceros bicornis*: two individuals foraging for small reptiles were recorded at one site within evergreen forest. Between 2017 and 2021, FCEE deployed cameras mainly throughout the mangrove and mixed mangrove areas of PKWS/KKRS that recorded a total of 39 bird species, including one Endangered green peafowl *Pavo muticus* (Fig. 5) at a mixed mangrove location on the mainland. Near Threatened Eurasian curlews *Numenius arquata* were recorded at eight locations.

Local naturalist Gerard Chartier logged 380 observations of 85 bird species on iNaturalist between 2012 and 2022, including one observation of an great knot, and 16 observations of Vulnerable red-breasted parakeets *Psittacula alexandri,* as well as several interesting observations of wetland species that may have been on migration, including a group of Asian openbill *Anastomus oscitans* in flight, one little grebe *Tachybaptus ruficollis* and one little cormorant *Microcarbo niger.*

Fig. 2: A great crested tern *Thalasseus bergii* stands on a tank in the sea near Koh Kapik.

Table 2: Species recorded in PKWS/KKRS by Taing et al. (2018) and during the rapid survey in 2023 (both showing individual bird counts) number of sites where the species was photographed by camera-traps in 2022 and between 2017 and 2021, and number of observations logged in iNaturalist by G. Chartier between 2012 and 2022.

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
1	Great knot	*Calidris tenuirostris*	EN	7***				
2	Nordmann's greenshank	*Tringa guttifer*	EN	13				
3	Green peafowl	*Pavo muticus*	EN				1	
4	Chinese egret	*Egretta eulophotes*	VU	14	40	5	10	
5	Lesser adjutant	*Leptoptilos javanicus*	VU		1		2	
6	Red-breasted parakeet	*Psittacula alexandri*	VU		5			16
7	Great hornbill	*Buceros bicornis*	VU			1		5
8	Asian dowitcher	*Limnodromus semipalmatus*	NT	1				
9	Bar-tailed godwit	*Limosa lapponica*	NT	41				
10	Black-tailed godwit	*Limosa limosa*	NT	1				
11	Curlew sandpiper	*Calidris ferruginea*	NT	30				
12	Eurasian curlew	*Numenius arquata*	NT	5			8	
13	Grey-tailed tattler	*Tringa brevipes*	NT	7***				
14	Malaysian plover	*Charadrius peronii*	NT	2				
15	Red-necked stint	*Calidris ruficollis*	NT	50				
16	Broad-billed sandpiper	*Calidris falcinellus*	LC	20				
17	Caspian tern	*Hydroprogne caspia*	LC	“a few”				

▽ Following double page: Nordmann's greenshank, a winter visitor to Koh Kapik. © J. Eames.

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
18	Common greenshank	*Tringa nebularia*	LC	2	5			
19	Common redshank	*Tringa totanus*	LC	58				
20	Common sandpiper	*Actitis hypoleucos*	LC	6	15			2
21	Great crested tern	*Thalasseus bergii*	LC	“a few”	14			
22	Greater sand plover	*Charadrius leschenaultii*	LC	160**	100			
23	Grey plover	*Pluvialis squatarola*	LC	40				
24	Gull-billed tern	*Gelochelidon nilotica*	LC	“a few”				
25	Kentish plover	*Charadrius alexandrinus*	LC	75				
26	Lesser crested tern	*Thalasseus bengalensis*	LC	“a few”				
27	Lesser sand Plover	*Charadrius mongolus*	LC	640*	200			
28	Little tern	*Sternula albifrons*	LC	25 pairs				
29	Terek sandpiper	*Xenus cinereus*	LC	20				
30	Whimbrel	*Numenius phaeopus*	LC	70	21		2	
31	White-faced plover	*Charadrius dealbatus*	DD	160**				
32	Ashy minivet	*Pericrocotus divaricatus*	LC		4			
33	Asian brown flycatcher	*Musciacapa dauuria*	LC		1			7
34	Asian koel	*Eudynamys scolopacea*	LC		1			
35	Black bittern	*Ixobrychus flavicollis*	LC		3	1	1	
36	Black-and-red broadbill	*Cymbirhynchus macrorhynchos*	LC		2			4
37	Black-headed oriole	*Oriolus larvatus*	LC		1			
38	Black-shouldered kite	*Elanus caeruleus*	LC		4			
39	Blue-eared kingfisher	*Alcedo meninting*	LC		1			

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
40	Brahminy kite	*Haliastur indus*	LC		10			6
41	Brown strike	*Lanius cristatus*	LC		2			17
42	Brown-throated sunbird	*Anthreptes malacensis*	LC		2			3
43	Buffy fish owl	*Ketupa Ketupu*	LC		2		2	
44	Chestnut-headed bee-eater	*Merops leschenaulti*	LC		5			15
45	Collared kingfisher	*Todiramphus chloris*	LC		25	1		2
46	Common kingfisher	*Alcedo atthis*	LC		11	1	1	3
47	Common tailorbird	*Orthotomus sutorius*	LC		5			1
48	Dark-necked tailorbird	*Orthotomus atrogularis*	LC		15			
49	Greater coucal	*Centropus sinensis*	LC		7	11	44	8
50	Greater racket-tailed drongo	*Dicrurus paradiseus*	LC		5	1	1	2
51	Grey heron	*Ardea cinerea*	LC		4		1	
52	Indochinese roller	*Coracias benghalensis*	LC		3			20
53	Large-billed crow	*Corvus macrorhynchos*	LC		1		2	1
54	Little green bee-eater	*Merops orientalis*	LC		6			
55	Olive-backed sunbird	*Cinnyris jugularis*	LC		4			5
56	Oriental magpie robin	*Copsychus saularis*	LC		4	2	20	8
57	Oriental pied hornbill	*Anthracoceros albirostris*	LC		8	4	4	2
58	Plaintive cuckoo	*Cacomantis merulinus*	LC		2			
59	Pond herons	*Ardeola*	LC		15			6
60	Red-collared dove	*Streptopelia tranquebarica*	LC		4			
61	Ruddy kingfisher	*Halcyon coromanda*	LC		4	2	2	1

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
62	Shikra	*Accipiter badius*	LC		1	1	3	
63	Sooty-headed bubul	*Pycnonotus aurigaster*	LC		7			
64	Spotted dove	*Spilopelia chinensis*	LC		5			19
65	Stork-billed kingfisher	*Pelargopsis capensis*	LC		6		2	2
66	White-breasted waterhen	*Amaurormis phoenicurus*	LC		5	2	25	
67	White-throated kingfisher	*Halcyon smyrnensis*	LC		3			3
68	Yellow bittern	*Ixobrychus sinensis*	LC		1			
69	Yellow-bellied prinia	*Prinia flaviventris*	LC		1			
70	Yellow-vented bulbul	*Pycnonotus finlaysoni*	LC		10			20
71	Barn owl	*Tyto alba*	LC			1		
72	Black drongo	*Dicrurus macrocercus*	LC			1		1
73	Black-capped kingfisher	*Halcyon pileata*	LC			2		3
74	Black-crested bulbul	*Rubigula flaviventris*	LC			1		4
75	Changeable hawk eagle	*Nisaetus cirrhatus*	LC			1		
76	Chinese pond heron	*Ardeola bacchus*	LC			2	2	
77	Collared scops owl	*Otus lettia*	LC			1		
78	Emerald dove	*Chalcophaps indica*	LC			3	5	
79	Indochinese cuckooshrike	*Lalage polioptera*	LC			1		
80	Large-tailed nightjar	*Caprimulgus macrurus*	LC			1		9
81	Lesser coucal	*Centropus bengalensis*	LC			2		
82	Malayan night heron	*Gorsachius melanolophus*	LC			4	1	
83	Racket-tailed treepie	*Crypsirina temia*	LC			1		8

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
84	Ratchet-tailed treepie	*Temnurus temnurus*	LC			1		
85	Red junglefowl	*Gallus gallus*	LC			15	6	
86	Red-headed trogon	*Harpactes erythrocephalus*	LC			1		
87	Siamese fireback	*Lophura diardi*	LC			2		
88	Silver pheasant	*Lophura nycthemera*	LC			1		
89	Spotted wood owl	*Strix seloputo*	LC			1	1	
90	Streak-throated woodpecker	*Picus xanthopygaeus*	LC			3		
91	Striated heron	*Butorides striata*	LC			12	25	2
92	White-rumped shama	*Copsychus malabaricus*	LC			2	1	
93	White-throated fantail	*Rhipidura albicollis*	LC			1		
94	Abbott's babbler	*Malacocincla abbotti*	LC				1	
95	Chestnut-winged cuckoo	*Clamator coromandus*	LC				1	
96	Chinese sparrowhawk	*Accipiter soloensis*	LC				1	
97	Forest wagtail	*Dendronanthus indicus*	LC				3	
98	Great white egret	*Ardea alba*	LC				2	1
99	Green-billed malkoha	*Phaenicophaeus tristis*	LC				3	3
100	Intermediate egret	*Ardea intermedia*	LC				9	
101	Japanese sparrowhawk	*Accipiter gularis*	LC				1	
102	Lesser whistling-duck	*Dendrocygna javanica*	LC				1	
103	Oriental dollarbird	*Eurystomus orientalis*	LC				2	
104	Rufous turtle dove	*Streptopelia orientalis*	LC				2	
105	Slaty-breasted rail	*Gallirallus striatus*	LC				3	

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
106	Slaty-legged crake	*Rallina eurizonoides*	LC				1	
107	Watercock	*Gallicrex cinerea*	LC				1	
108	Ashy drongo	*Dicrurus leucophaeus*	LC					11
109	Asian fairy-bluebird	*Irena puella*	LC					7
110	Asian openbill	*Anastomus oscitans*	LC					1
111	Bar-winged flycatcher-shrike	*Hemipus picatus*	LC					1
112	Barn swallow	*Hirundo rustica*	LC					1
113	Barred buttonquail	*Turnix suscitator*	LC					1
114	Black-headed bulbul	*Brachypodius melanocephalos*	LC					4
115	Black-naped oriole	*Oriolus chinensis*	LC					8
116	Blue-bearded bee-eater	*Nyctyornis athertoni*	LC					2
117	Blue-eared barbet	*Psilopogon duvaucelii*	LC					1
118	Cinnamon bittern	*Ixobrychus cinnamomeus*	LC					1
119	Common flameback	*Dinopium javanense*	LC					5
120	Common hill myna	*Gracula religiosa*	LC					4
121	Common myna	*Acridotheres tristis*	LC					2
122	Copper-throated sunbird	*Leptocoma calcostetha*	LC					4
123	Crested serpent-eagle	*Spilornis cheela*	LC					5
124	Dark-necked tailorbird	*Orthotomus atrogularis*	LC					1
125	Daurian starling	*Agropsar sturninus*	LC					1
126	Golden-fronted leafbird	*Chloropsis aurifrons*	LC					8
127	Gray-faced buzzard	*Butastur indicus*	LC					2

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
128	Great eared-nightjar	*Lyncornis macrotis*	LC					2
129	Greater flameback	*Chrysocolaptes guttacristatus*	LC					1
130	Green imperial-pigeon	*Ducula aenea*	LC					6
131	Green-eared barbet	*Psilopogon faiostrictus*	LC					6
132	House swift	*Apus nipalensis*	LC					2
133	Laced woodpecker	*Picus vittatus*	LC					3
134	Leaf warblers	*Genus Phylloscopus*	LC					1
135	Lesser sand plover	*Charadrius mongolus*	LC					1
136	Little cormorant	*Microcarbo niger*	LC					3
137	Little egret	*Egretta garzetta*	LC					2
138	Little grebe	*Tachybaptus ruficollis*	LC					1
139	Oriental honey-buzzard	*Pernis ptilorhynchus*	LC					8
140	Osprey	*Pandion haliaetus*	LC					1
141	Pacific swallow	*Hirundo tahitica*	LC					1
142	Paddyfield pipit	*Anthus rufulus*	LC					6
143	Peregrine falcon	*Falco peregrinus*	LC					1
144	Pink-necked green pigeon	*Treron vernans*	LC					10
145	Scarlet-backed flowerpecker	*Dicaeum cruentatum*	LC					2
146	Stripe-throated bulbul	*Pycnonotus finlaysoni*	LC					8
147	Taiga flycatcher	*Ficedula albicilla*	LC					1
148	Thick-billed green pigeon	*Treron curvirostra*	LC					2
149	Van hasselt's sunbird	*Leptocoma brasiliana*	LC					12

#	Species	Scientific Names	IUCN Status	Taing et al. 2018	Rapid Survey 2023	Cam. Trap 2022	Cam. Trap 2017-2021	iNAT. OBS. 2012-2022
150	Vernal hanging parrot	*Loriculus vernalis*	LC					4
151	White wagtail	*Motacilla alba*	LC					1
152	White-bellied sea eagle	*Haliaeetus leucogaster*	LC					2
153	White-rumped munia	*Lonchura striata*	LC					1
154	Wreathed hornbill	*Rhyticeros undulatus*	LC					2
155	Zebra dove	*Geopelia striata*	LC					3

Notes from Taing et al. (2018):

*Estimated number from flocks in total approximated 800 sand plover spp., with about 80% representing lesser sand plovers.

**Estimated there are 20% of greater sand plover in 800 sand plover spp.

***6 great knot were detected on January and February survey.

One great knot was observed tagged with a satellite tracking device during the March survey.

Two great knot seen during May survey, but not in breeding plumage. Total count of this species between 7 – 9.

▷ **Fig. 3:** Mosaic of bird species in Peam Krasop Wildlife Sanctuary. Left to right from top row: Racket-tailed treepie; shikra; greater racket-tailed drongo, gold-fronted leafbird; greenshank; black-and-red broadbill; changeable hawk eagle; white-fronted kingfisher; red-breasted parakeet; red turtle dove; black drongo; magpie robin; lesser adjutant; little green bee-eater; Asian brown flycatcher; great hornbill; Oriental pied hornbill; ashy drongo; buffy fish owl; Chinese egret; whimbrel; little egret; common sandpiper and red jungle fowl.

Fig. 4: Endangered great knot at Koh Kapik Ramsar Site. © Porchhay Taing.

Fig. 5: Endangered green peafowl *Pavo muticus* photographed by a camera trap in mixed mangrove habitat on the Peam Krasop mainland in June 2020.

Fig. 6: Flock of lesser sand plover *Charadrius mongolus* and greater sand plover *Charadrius leschenaultii* at a beach near Peam Krasop Village.

Fig. 7: This Critically Endangered spoon-billed sandpiper *Calidris pygmaea* was photographed at Koh Kapik in 2014. © Senglim Suy.

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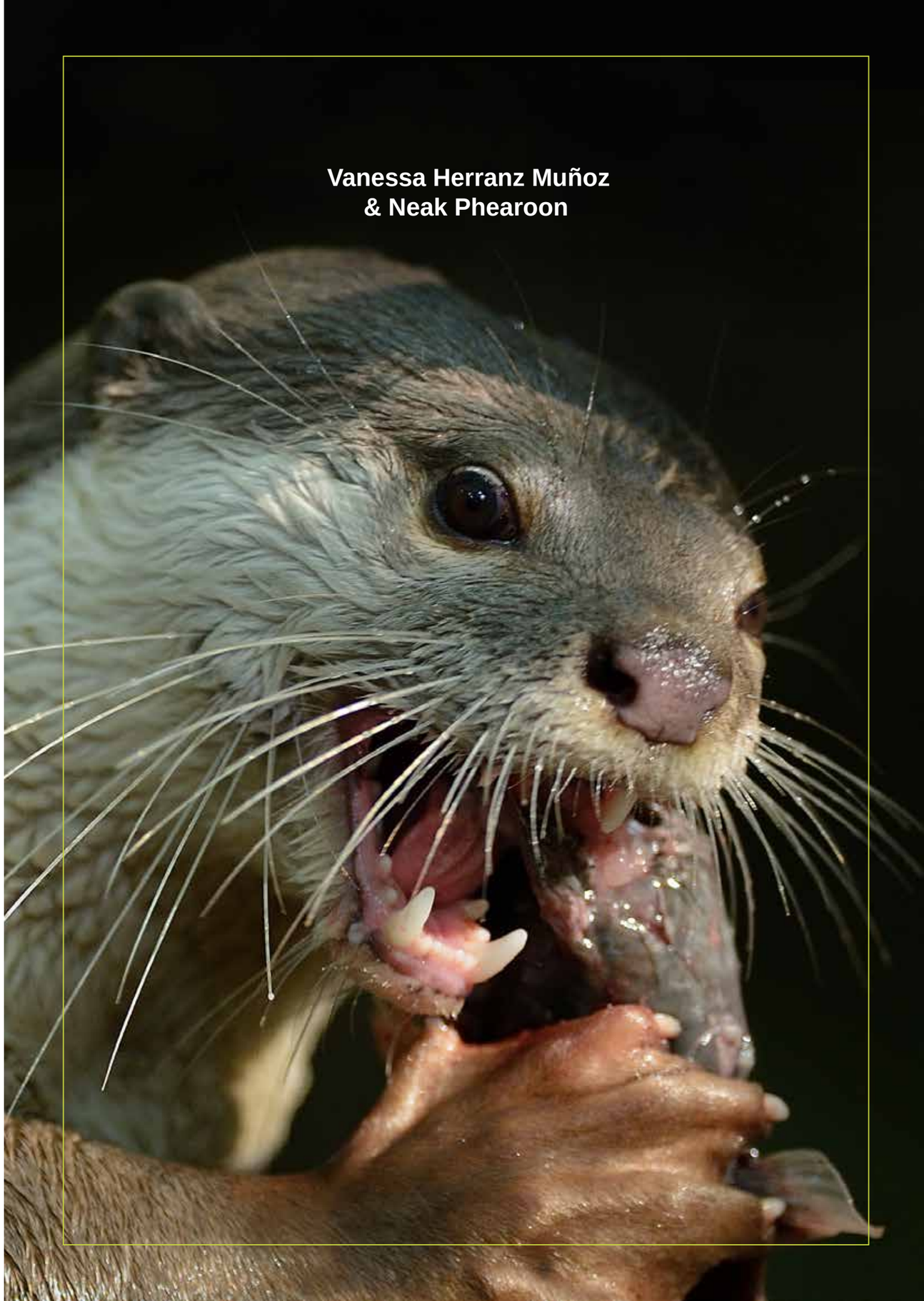
▷**Fig. 8:** Buffy fish owl *Ketupa ketupu* hunting in shallow water.

MAMMAL SURVEY

Vanessa Herranz Muñoz
& Neak Phearoon



Title image: Smooth-coated otter *Lutrogale perspicillata.*

INTRODUCTION

Mangrove forests, can be relatively inaccessible for humans, and may, in some regions, be the most significant remaining habitats for certain threatened species. They are nevertheless neglected in field studies compared to relatively species-rich, terrestrial tropical forests probably, in part, because of the difficulties associated with surveying them (Nowak 2012).

The gradient of continuous habitats found in Peam Krasop Wildlife Sanctuary (PKWS), from coastal mangroves and mixed mangroves, to swamp, semi-evergreen and evergreen forests have the potential to host a great diversity of tropical mammal species. According to local reports, Koh Sralao village was established during World War II, and at that time tigers, elephants and rhinoceros were present in the area (Dara et al. 2009). During the zoning assessment conducted by IUCN between 2008 and 2009 (Ibid.) key informants at five villages provided a list of 24 mammal species that they believed to be present in PKWS (Table 1). Participants also recorded perceived changes in abundance between 1980 and 2008. Absence of species such as leopard *Panthera pardus*, elephant *Elephas maximus*, gaur *Bos gaurus*, banteng *Bos javanicus* and Southern serow *Capricornis sumatraensis* from the lists may suggest that they may lack suitable habitat in the area, or were previously extirpated.

In 2015, the first targeted survey of fishing cat *Prionailurus viverrinus* in Cambodia obtained records of the species in Peam Krasop Wildlife Sanctuary and Ream National Park (Thaung et al. 2018). The survey also recorded the presence of Critically Endangered Sunda pangolin *Manis javanica* and Endangered hog deer *Axis porcinus* in PKWS.

◁ Fishing cat *Prionailurus viverrinus* from Peam Krasop Wildlife Sanctuary.

Table 1: From Dara et al. 2009. Species reported at villages in PKWS: **PK** Peam Krasop Pi; **TC** Ta Chat; **KS** Koh Sralao; **PS** Preak Svay; **KA** Koh Andet.

Mammal Species	Scientific Names	Reporting Villages			
		PK	**PS**	**TC**	**KA**
Long-tailed macaque	*Macaca fascicularis*	*	*	*	*
Pig-tailed macaque	*Macaca leonina*				*
Gibbon sp.	-	*		*	*
Silvered langur	*Trachypithecus* sp.				*
Loris sp.	*Nycticebus* sp.	*		*	
Bear sp.	-	*	*	*	*
Indochinese tiger	*Panthera tigris*	*			
Clouded leopard	*Neofelis nebulosa*		*		
Jungle cat	*Felis chaus*		*	*	
Fishing cat	*Prionailurus viverinnus*	*	*	*	*
Civet sp.	-	*		*	*
Otter sp.	-	*	*	*	*
Hog badger	*Arctonyx collaris*	*		*	
Dhole	*Cuon alpinus*	*		*	*
Wild pig	*Sus scrofa*		*	*	*
Sambar	*Rusa unicolor*	*		*	*
Red muntjac	*Muntiacus vaginalis*	*		*	*
Mouse deer sp.	*Tragulus* sp.	*			
Siamese hare	*Lepus peguensis*	*			
East Asian Porcupine	*Hystrix brachyura*			*	*
Squirrel sp.	-	*			*
Sunda pangolin	*Manis javanicus*	*		*	*
Flying fox sp.	*Pteropus* sp.	*	*		
Dolphin sp.	-	*	*		

Following these findings the Fishing Cat Ecological Enterprise (FCEE) began monitoring fishing cat and other threatened species in the mangroves and lowland areas of PKWS and Koh Kapik Ramsar Site (KKRS) in 2017. The results of this monitoring effort between 2017 and 2023 are currently in prep., however, insights will be discussed here to provide context for the current survey findings.

SURVEY METHODS

Between July and October 2022, FCEE and the Department of Marine and Coastal Zone Management (MoE), conducted a camera trap survey of Peam Krasop Wildlife Sanctuary, focused on the following objectives:

1. Evaluating the adequacy of the currently established Management Zones;

2. Recording biodiversity of all habitats within PKWS.

The survey was designed by FCEE and discussed over training sessions with MoE. A stratified sampling design (Kays et al. 2020) with different scales of grid extent was applied in order to obtain sufficient data from each Management Zone: a 1 km^2 grid was applied to the Core Zones; a 1.5 km^2 grid to the Conservation Zones; and the Sustainable Use Zone was surveyed through long-term monitoring cameras already established by FCEE (Fig. 1). Habitat data was gathered at each location: habitat type, quality, wildlife signs, and threats. The survey covered the full elevation gradient of PKWS (0 – 218 m).

The MoE cameras were deployed by teams composed of Dept. Marine and Coastal Zone Management (MoE), FCEE and Koh Kong PDoE staff (MoE rangers). The teams were instructed to deploy cameras within a 200 m buffer of the planned locations, at the most likely places to be visited or transited by animals, such as trails, streams, and at sites with animal signs. MoE cameras were Bushnell Core DS Low Glow Model #119975C, which were set up to capture 3 images followed by a 10s video upon trigger of the movement sensor, functioning 24h/day. FCEE used several camera models:

(Fig.1) functioning 24h/day. The FCEE work employed several camera trap models: 4 Bolly Guard SG562-D, 8 Browning RF Model BTC-7E-HP4, 15 Panthera IfWildlife V7 and one Moultrie P180i. All cameras were set at approximately 40-60 cm above the ground to target medium-sized mammals. The high tide line point was considered when setting cameras in the tidal mangrove areas. No baits were used during the study.

Fig. 1: Camera traps used in the study. Top row: Bushnell Core DS Low Glow and Moultrie P180i. Bottom row: Bolly Guard SG562-D and Browning RF Model BTC-7E-HP4.

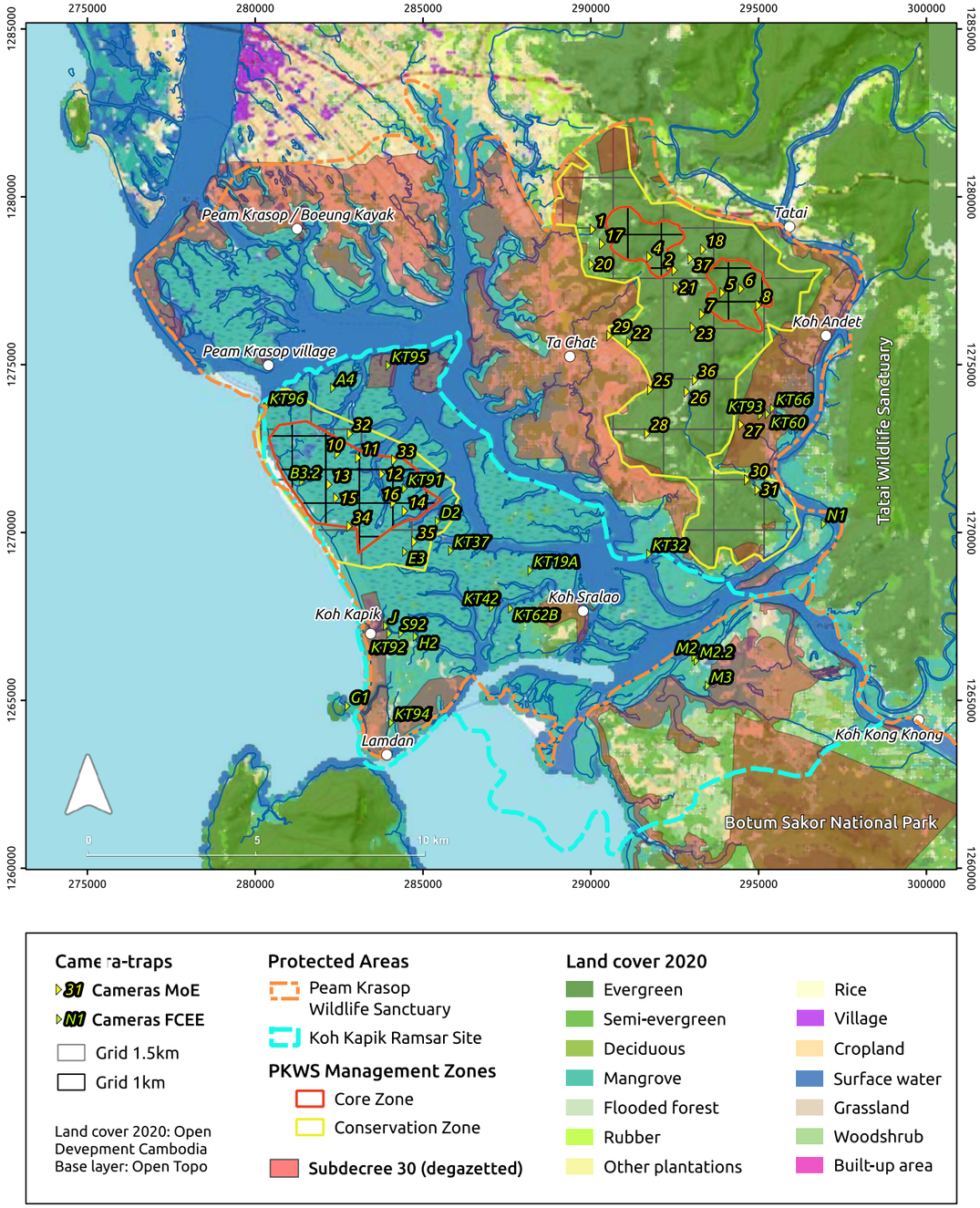


Fig. 2: Map of camera trapping survey locations, PAs, Management Zones, degazetted areas, villages and land cover.

Flooded Melaleuca forest at Koh Sralao.

RESULTS

Survey results provided data from a total of 57 cameras (6 cameras were damaged or produced no results, and one camera was stolen) over 4015.04 camera trap days (CTD) between July and October 2022. Results were obtained from 33 cameras within the Core and Conservation Zones, and 25 cameras deployed in the Sustainable Use Zone (Fig. 2). By habitats: 34 cameras were deployed in the mangroves (2227.53 CTD) and 23 in evergreen forest (1787.51 CTD). Photographic capture events were considered independent when more than 60 minutes had passed between captures of the same species.

A total of 23 species of mammals. Additionally, FCEE recorded another two species of mammals, including one more Endangered species between January and July 2022 (Table 3).

Table 2. Summary of survey results.

Summary of Results	MoE & FCEE July-Oct 22	FCEE Jan-July 2022
Total number of species	61	66
Number of mammals	23	25
Number of birds	36	39
Number of amphibians & reptiles	2	2
Number of threatened species	11	12

Out of 23 mammal species recorded during the survey, nine were classed as Threatened; one as Critically Endangered; three as Endangered, and five as Vulnerable. Additionally, another Endangered species was recorded by FCEE during the previous months of 2022 (Table 2).

Table 3. Summary of survey results. Results for mammal species. Additional species photographed by FCEE in 2022.

						Rate (Captures per 100 CTD)		
Species	Scientific Names	IUCN Status	# Photo Captures	Camera		Overall	Mangrove	Evergreen
				#	%			
Sunda pangolin	*Manis javanicus*	CR	2	2	3.5%	0.05	0.00	0.11
Dhole	*Cuon alpinus*	EN	3	3	6.3%	0.07	0.00	0.17
Hairy-nosed otter	*Lutra sumatrana*	EN	2	2	3.5%	0.05	0.09	0.00
Long-tailed macaque	*Macaca fascicularis*	EN	86	25	43.5%	2.14	3.23	0.78
Fishing cat	*Prionailurus viverrinus*	VU	7	3	5.3%	0.17	0.31	0.00
Greater hog badger	*Arctonyx collaris*	VU	7	3	5.3%	0.17	0.00	0.39
Pig-tailed macaque	*Macaca leonina*	VU	49	14	24.6%	1.22	0.00	2.74
Sambar	*Rusa unicolor*	VU	10	4	7.0%	0.25	0.00	0.56
Smooth-coated otter	*Lutrogale perspicillata*	VU	153	7	12.3%	3.81	6.87	0.00
Asian brush-tailed porcupine	*Atherurus macrourus*	LC	4	1	1.0%	0.10	0.00	0.22
Common palm civet	*Paradoxurus hermaphroditus*	LC	62	21	36.6%	1.54	0.72	2.57
Leopard cat	*Prionailurus bengalensis*	LC	15	10	17.5%	0.37	0.40	0.34
Lesser chevrotain	*Tragulus kanchil*	LC	80	12	21.1%	1.99	0.04	4.42
Red muntjac	*Muntiacus vaginalis*	LC	20	8	14.0%	0.50	0.00	1.12
Spotted linsang	*Prionodon pardicolor*	LC	1	1	1.8%	0.02	0.00	0.06
Malayan porcupine	*Hystrix brachyura*	LC	3	2	3.5%	0.07	0.00	0.17
Wild boar	*Sus scrofa*	LC	90	16	28.1%	2.24	0.04	4.98
Small mammals -1 kg								
Indochinese ground squirrel	*Menetes berdmorei*	LC	163	12	21.1%	4.06	0.00	9.12
Northern smooth-tailed treeshrew	*Dendrogale murina*	LC	5	1	1.0%	0.12	0.00	0.28
Northern treeshrew	*Tupaia belangeri*	LC	3	3	5.3%	0.07	0.00	0.17
Red spiny rat	*Maxomys surifer*	LC	36	1	1.6%	0.90	0.00	2.01
Short-tailed gymnure	*Hylomys suillus*	LC	14	1	1.6%	0.35	0.00	0.78
Variable squirrel	*Callosciurus finlaysonii*	LC	100	15	23.6%	2.49	2.11	2.97
Rat spp.		-	206	31	54.4%	5.13	7.59	2.07
Additional Species Photographed by FCEE Between January - July 2022								
Mammals								
Large spotted civet	*Viverra megaspila*	EN	3	2	2.9%		0.10	
Small Indian civet	*Viverricula indica*	LC	3	1	1.4%			0.10

Amongst the species recorded, only one species could be considered a “large” mammal - the Vulnerable sambar *Rusa unicolor*. Two of the recorded species are considered top predators - the Endangered dhole *Cuon alpinus* in evergreen forests, and the Vulnerable fishing cat *Prionailurus viverrinus* in mangrove forests. The majority of species photographed were medium-sized, and within this survey we identified six species of small mammals (rodents and shrews below 1 kg of body weight), as well as black/gray rat species.

Bears were not photographed during the survey. However, FCEE received one report in 2018 of a sun bear *Helarctos malayanus* swimming across the Tatai River, and it therefore remains a possibility that bears still occur in PKWS. There is a small chance that clouded leopard *Neofelis nebulosa* is also still present, since this species was reported in the past, and has been recorded in both the adjacent Tatai Wildlife Sanctuary and Botum Sakor National Park (Gray et al. 2017). However, PKWS boundaries, delimited by the Tatai River and National Road 48, may represent an barrier for animal movement, and once a species is locally extinct, the possibility of recolonization from the surrounding Protected Areas is less certain than at sites without such barriers.

MANAGEMENT ZONES

The overall numbers of species found in each Zone and habitat including threatened species appears in Fig. 6.

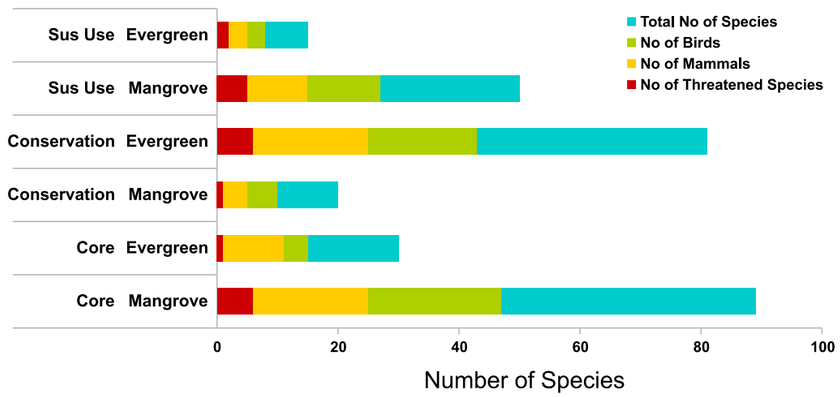


Fig. 6: Raw numbers of species recorded within management zones in evergreen and mangrove habitats.

THREATENED SPECIES

Sunda Pangolin *Manis javanica* (Critically Endangered)

Sunda pangolins were recorded at two mid-elevation semi-evergreen forest locations within the Conservation Zone on the mainland area of PKWS. In 2020, FCEE recorded the species at two lowland mixed mangrove sites within the Sustainable Use Zone, also on the mainland. In 2017 and 2015 (Thaung et al. 2018) the species was recorded in Melaleuca forest sites within the area of overlap between KKRS and Botum Sakor National Park.

The Sunda pangolin is considered highly vulnerable in lowland areas of Cambodia and Viet Nam, since evidence suggests the species may have been already extirpated from low elevation areas in Lao PDR, Myanmar and Thailand (Challender et al. 2019).

In Cambodia, Sunda pangolins were recorded from 11 of 65 randomly set up camera trap stations (across ~8,000 camera trap nights) in the Cardamom Landscape, including our record in northern Botum Sakor, despite no previous records from more than 22,000 camera trap nights previously in the landscape (Gray et al. 2017; Thaung et al. 2018).

This context indicates that detectability of pangolins from large mammal surveys seems to be particularly low (Challender et al. 2019), which is supported by the scarcity of records obtained in PKWS and KKRS between 2017 and 2022 (five in total). Furthermore, we found that careful observation and photo/video editing was necessary to reliably identify the species, and no repeated records were obtained at two locations of long-term monitoring.

These results indicate that PKWS/KKRS, and in particular mid-elevation and lowland habitats may be particularly important for the conservation of this Critically Endangered species and targeted conservation measures should be put in place to ensure its protection.

Fig. 7: Sunda pangolin *manis javanicus* © Jeremy Holden/WA.

Fig. 9: Hairy-nosed otter with pup captured on a camera trap near the Tatai River.

Hairy-nosed otter *Lutra sumatrana* (Endangered)

Hairy-nosed otters were photographed near small mixed mangrove streams within the Sustainable Use Zone near Tatai River at several locations. In the same location in May 2022, FCEE photographed a mother with a hairy-nosed otter pup. We have monitored hairy-nosed otters in this area since 2017, and recorded breeding (two pups) in March 2019. However, the species has not been recorded at any other area within PKWS and it is likely that an important proportion of the local population occupies streams on the western bank of the Tatai River and other small streams within Tatai Wildlife Sanctuary (TWS).

The hairy-nosed otter is considered the rarest and least known otter species in Asia (Sasaki et al. 2021). In Cambodia, hairy-nosed otters have been reported from swamp forest at Veal Veng in the Cardamom Mountains by Holden and Thy (2009); Bassac Marsh along the Mekong River; three areas along the coast, including PKWS and TWS and along the Tatai and Trapeang Rung rivers by

Dong et al. (2010) and Heng et al. (2016); the Tonle Sap wetlands, in Prek Toal Ramsar Site by Wilcox et al. (2016) and in Stung Sen Ramsar Site by Herranz Muñoz and Vong (2022).

The species inhabits peat swamp, Melaleuca and flooded forests, as well as mangroves, and to a lesser degree, tropical forests (Sasaki et al. 2021 and references therein).

Survival of hairy-nosed otters in PKWS and TWS will require active stakeholder engagement in conservation actions to preserve and restore mixed mangrove streams. The Tatai River and its small streams should be established as a priority habitat unit for the conservation of this rare and elusive otter (Fig. 4).

Smooth-coated otter *Lutrogale perspicillata* (Vulnerable)

Smooth-coated otters were photographed throughout the mangrove areas of PKWS. We recorded their presence from the coast, across the mangrove areas, and along the Tatai River and its streams. Individuals and groups may range widely throughout PKWS: a male identifiable due to a missing hand (probably a snare wound) was photographed traveling over 15 km from the mangrove to riverine areas. Smooth-coated otter groups in PKWS are usually composed of 4 – 6 individuals. In the breeding season between April and June, otters aggregate, forming groups of up to 18 individuals, including young. Smooth-coated otters are occasionally camera trapped at the same sites used by hairy-nosed otters, but do not regularly use the same marking sites. The smooth-coated otter is found across South Asia and Southeast Asia, with its range stretching from Indonesia to southern China, then westwards towards India and Pakistan (Khoo et al. 2021).The smooth-coated is the commonest otter species found in Cambodia, with numerous reliable field records from locations throughout the country: Western Siem Pang, Stung Treng Province; Preak Toal and Stung Sen Ramsar Sites in the Tonle Sap Biosphere Reserve (Birdlife International 2013; Willcox et al. 2016; Herranz Muñoz and Vong 2022). The species is also present in Mondulkiri Protected Forest and Seima Protection Forest (WCS Cambodia 2010; Gray et al. 2012) in

Fig. 10: A camera trap image showing five smooth-coated otters in the Sanctuary.

Fig. 11: A camera trap image showing a smooth-coated otter with a missing foot. In all likelihood, this was caused by a wire snare. Animals with amputated limbs has become a common feature in camera trap photographs made recently in Cambodia.

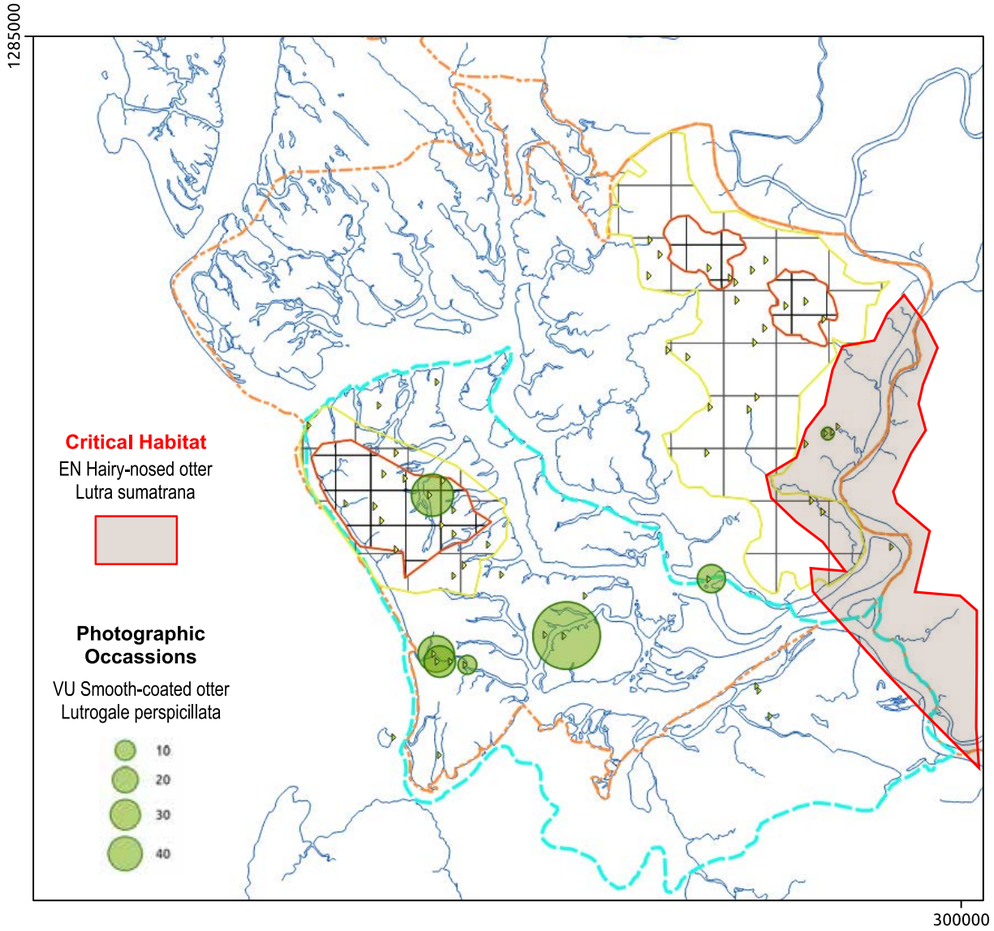


Fig. 12: Hairy-nosed otter critical habitats and Vulnerable smooth-coated otter detections.

Mondulkiri provinces (Theilade and Schmidt 2011). In Koh Kong Province, smooth-coated otters have been recorded in Tatai Krom commune, PKWS and KKRS (Heng and Hon 2007 in Dong et al. 2010; Thaung et al. 2018; Sorn and Veth 2019) Botum Sakor National Park (Royan 2010); Stoeng Koh Pao (A. Starr pers. comm. 2008 in Timmins and Sechrest 2010) and Prek Ta Ok Valley (Timmins and Sechrest 2010). Smooth-coated otters have also been released in Angkor Archaeological Park as part of a re-wilding project (Leroux et al. 2021).

According to our survey results, the extensive mangrove and mixed mangrove areas of PKWS are essential habitats for the local smooth-coated otter population.

Long-tailed macaque *Macaca fascicularis* (Endangered)

During the survey, long-tailed macaques were photographed on 86 occasions at 25 cameras, mainly in the mangrove areas (22 cameras), and only at three cameras within evergreen forests situated below 100 m. Even though these results may indicate that the long-tailed macaque population in PKWS is still relatively abundant and widespread, results of FCEE's long-term monitoring in the mangroves show that the rate of photographic captures of the species has declined sharply in recent years (Fig. 14). The mangrove forests in PKWS represent an optimal habitat for the species,

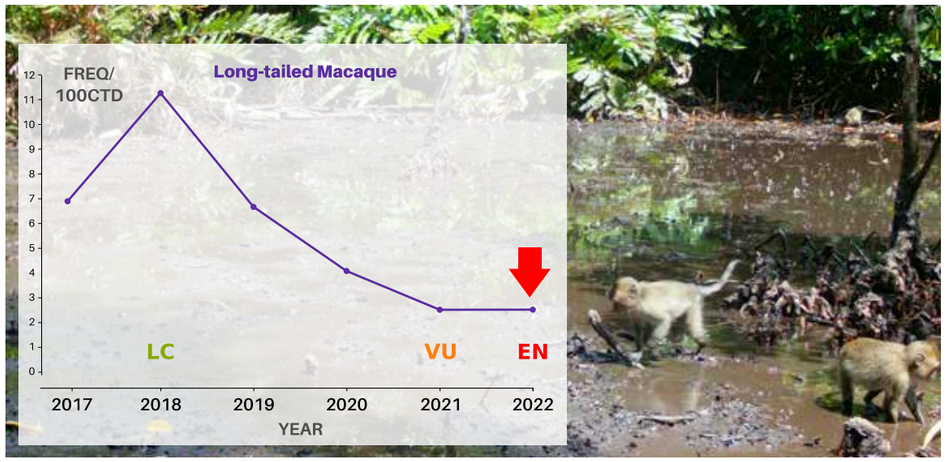


Fig. 14: Frequency of photo-captures of long-tailed macaque.

Northern pig-tailed macaque *Macaca leonina* **(Vulnerable)**

During the study, Northern pig-tailed macaques were photographed on 49 occasions at 14 cameras with evergreen forest cover in the Core and Conservation Zones on mainland PKWS, at altitudes ranging from 91 to 218 m. The species does not appear to use the lower elevations or mangroves, as it had not been previously recorded during FCEE's surveys. At altitudes below 90-100m and in the mangroves, long-tailed macaques are the dominant primate species.

Fishing Cat *Prionailurus viverrinus* (Vulnerable)

Results of the survey showed presence of fishing cat throughout PKWS mangrove habitats within the Core, Conservation and Sustainable Use Zones. The FCEE monitoring of the species since 2017 indicates that mangrove islands are critical for the species since only one record was obtained in mainland areas. Monitoring results suggest that the population has declined during this period. Fishing cats mainly use intermittently flooded back mangrove and flooded mangrove habitats.

The fishing cat range spans throughout South and Southeast Asia, following the patchy distribution of wetlands. While their population is declining but widely distributed in South Asia, scarce records indicate the species is at a high risk in Southeast Asia. Fishing cats are threatened by habitat loss, poaching, persecution and roadkills (Mukherjee et al. 2016).

During the first targeted fishing cat survey in Cambodia (2015) the species was recorded at two coastal Protected Areas: PKWS and Ream National Park (Thaung et al. 2018). Peam Krasop Wildlife Sanctuary is likely the most important stronghold for fishing cats in Cambodia (V. Herranz Muñoz article in prep.).

In Cambodia, the first confirmed records come from captive individuals seen at Phnom Tamao zoo and the Tonle Sap floodplain in the late 1990s (Duckworth et al. 2005). The descendants of these animals today form a captive breeding population still managed at the Phnom Tamao Wildlife Rescue Centre (N. Marx pers. comm.). The first camera-trap record was obtained in 2003, in Kulen Promtep Wildlife Sanctuary (Rainey & Kong 2010), while other claims have since been deemed unreliable or probably misidentification of leopard cat *Prionailurus bengalensis* or large spotted civet *Viverra megaspila* (e.g. Royan 2009). During the first targeted fishing cat survey in Cambodia (2015) the species was recorded at two coastal Protected Areas: PKWS and Ream National Park (Thaung et al. 2018). In 2018, a dead fishing cat was found near the Tonle Sap floodplain (Herranz Muñoz and Vong 2022) suggesting that they still live in the area, and in October 2022, an MoE ranger (Channa Phan pers. comm.) took the first confirmed photograph of a fishing cat in Boeng Tonle Chhmar Ramsar Site within the Tonle Sap Biosphere Reserve. Flooded forests within the Tonle Sap Biosphere Reserve and the Mekong River wetlands including Stung Treng Ramsar Site are also priority areas for surveys to find other populations (Herranz Muñoz et al. 2023).

Fig. 16: Fishing cat *Prionailurus viverrinus* recorded on a camera trap in Peam Krasop.

Other threatened species

Even though they were not photographed during the current survey, results of FCEE's monitoring during 2022 showed evidence of the Endangered large spotted civet within mixed mangrove and Melaleuca forests. Records of the species between 2017 and 2022 are sparse, and they occurred in locations most impacted by habitat destruction and degradation on lowland areas of the mainland and islands.

Fig. 17: Above, sambar *Rusa unicolor* and below, the rarely recorded arboreal civet spotted linsang *Prionodon pardicolor.*

CONCLUSION AND RECOMMENDATIONS

Results of the camera trap survey, as well as insights from FCEE's monitoring of mangrove areas since 2017, indicate that PKWS is probably the most important site for mangrove wildlife in Cambodia, with significant populations of Endangered long-tailed macaques, Vulnerable fishing cats and smooth-coated otters, and presence of Endangered hairy-nosed otters and large spotted civets. The evergreen forests on mainland PKWS are also important for a variety of threatened species such as Critically Endangered Sunda pangolin, Endangered dhole and Vulnerable Northern pig-tailed macaque.

Presence of domestic cats - which could transfer diseases to fishing cats and leopard cats - and dogs which are a threat to all wildlife species, was recorded on the northeast corner of Koh Kapik. Dogs also roam around mangrove forests nearby Koh Kapik Village, where they are might potentially kill fishing cats and otters. Alien, naturalized, rat species *Rattus* spp. are abundant within the mangrove forests, and their generalist foraging habits may hinder mangrove tree regeneration, therefore, protection of predators such as fishing cat, leopard cat and civet species also contributes to control rat populations, and promote mangrove forest growth and regeneration.

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JUVENILE FISH SURVEY

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Title image: *Toxotes jaculatric, Lutjamus russellii* and *Leiognathus equula.*

INTRODUCTION

Mangrove forests are the most important and productive habitats of estuarine ecosystems, supporting high fish abundance and diversity (Muzaki et al. 2017). Many of estuarine and marine aquatic animals depend on mangrove forest habitats as parts of their life cycle such as for feeding, breeding, spawning, and nursery grounds (Kurniawan et al. 2020). Mangrove areas composing of the canopy and root structure complexity provide excellent shelter from predators, and food availability for fish larvae and juveniles to increase their survival, growth, and recruitment for their stock (Laegdsgaard and Johnson 2001; Robertson and Duke 1987).

Larval and juvenile fish occurrence and distribution greatly vary in mangrove estuaries depending on precipitation, estuary morphology, tidal dynamics, current velocity, and the availability of food resources (Badú et al. 2022). The distribution, occurrence, density, movement and growth of fish larvae and juveniles are heavily influenced by environmental factors such as light, current, tide, moon phase, salinity, temperature, and different habitat types (Hoq and Nazrul Islam 2007, Lima et al. 2016, Muzaki et al. 2017, Purnomo et al. 2020).

Despite the importance of mangroves as nursery habitats in the life history of fish, studies on the early life stages, biology, and ecology of estuary fish in mangrove forests are poorly known in Cambodian coastal waters. Therefore, this study fills the gap by establishing the baseline information on abundance, distribution, and diversity of estuary fish larvae and juveniles for coastal fishery management and conservation planning in the Peam Krasop Wildlife Sanctuary. Furthermore, this research will highlight the hotspot of fish larval and juvenile diversity for zoning in the Peam Krasop Wildlife Sanctuary.

OBJECTIVE

The study’s objective is to describe fish larval and juvenile diversity and assemblage structure in the Peam Krasop Wildlife Sanctuary.

◁ Mangrove channel in Peam Krasop Wildlife Sanctuary.

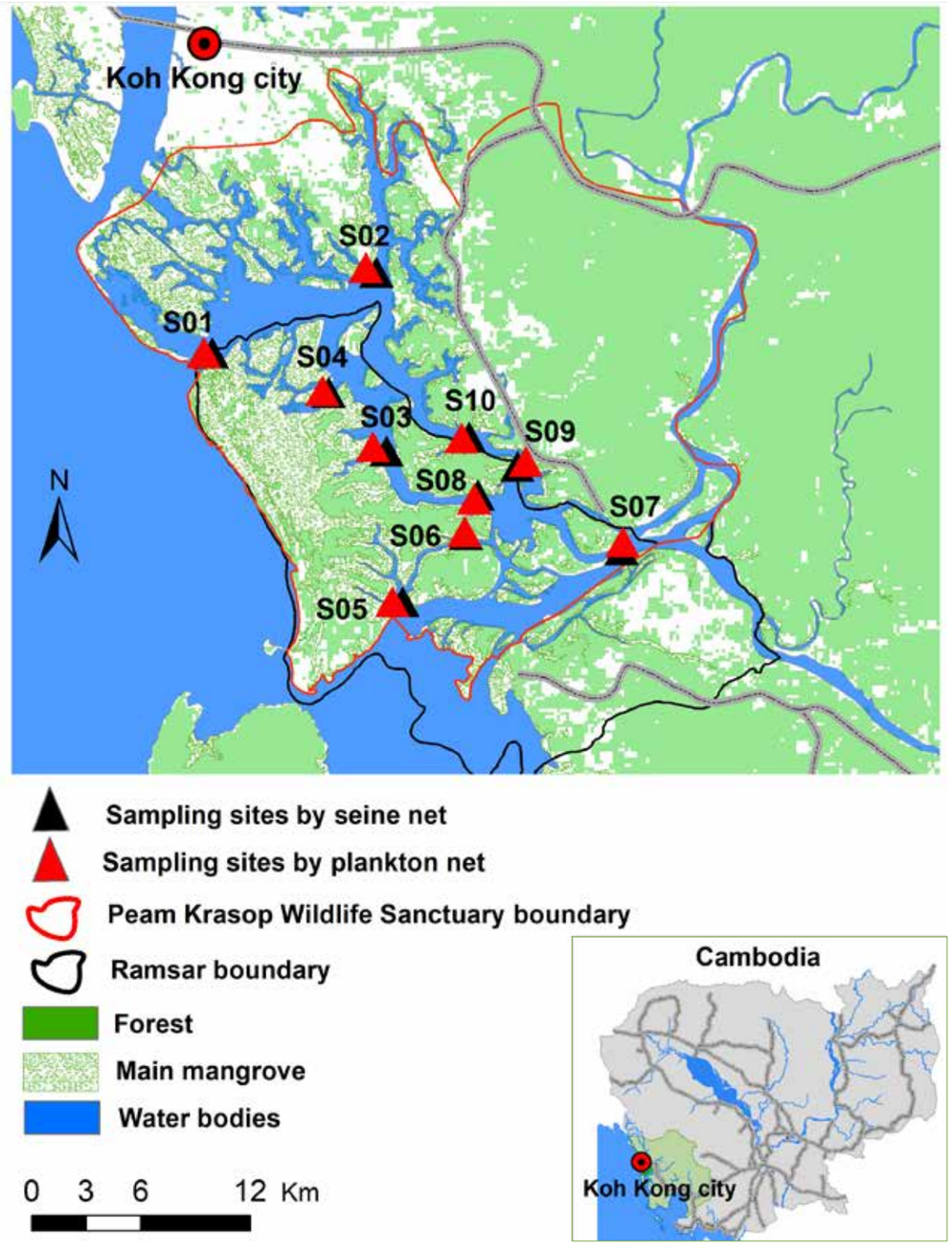


Fig. 1: Map showing sampling sites in Peam Krasop Wildlife Sanctuary.

METHODS AND MATERIALS

Study Sites

This study was carried out in mangrove forest channels in the Peam Krasop Wildlife Sanctuary (PKWS) located in Koh Kong province (Fig. 1). Ten study sites were selected for the sampling as indicated from S01 to S10 on the map below (Fig. 1 and Table 1) to understand the fish larval and juvenile diversity and its distribution patterns. The sites are located in the mangrove forests of the Peam Krasop Wildlife Sanctuary spatially covering the lower part of the sanctuary. Characteristics of the sampling sites are shown in Fig. 3.

Fish larval and juvenile collection

Larval and juvenile fish samples were collected by plankton net (Fig. 2a) with a mesh size of 1 mm, 1 m diameter, and 5 m length. The net was dragged at a depth of about 0.5 to 1 m from the surface using a boat against the tidal flow along mangrove channels. The flow metre is attached to the mouth of the net to measure the water volume filtering through the plankton net for water volume measurement. A small seine net (Fig. 2b) with 1 mm mesh size, 5 m length, and 2 m depth were dragged by two persons along the mangrove channels. Sampling was carried out three times at each site during the day time between 3-7 June 2023, and each sampling time took 3 minutes or about 50 m for seine net and 5 minutes for plankton net. Larvae and juveniles were collected from the codend of the net, and seine net. Then, all samples were immediately preserved with 5% formalin in plastic jars. Next, samples were transferred in 70% ethanol. All samples were brought to the laboratory of Faculty of Fisheries and Aquaculture (FiFA) Royal University of Agriculture (RUA) for processing, identification, photographing and analysis.

Fig. 2: Fish larval and juvenile collection by (left) plankton and (right) small seine nets in Peam Krasop Wildlife Sanctuary.

Fish larval and juvenile processing and analysis in laboratory

In the laboratory, larval and juvenile samples were sorted and separated under a dissecting microscope. Fish larvae and juveniles were identified to possible family or species level using fish identification guides for Southeast Asia and Cambodia (Kimura et al. 2018, Konishi 2007, Konishi et al. 2012, SEAFDEC 2007, Yoshida et al. 2013). The number of individuals per species were counted from the entire sample.

Table 1: Sampling sites and date using plankton and seine nets in Peam Krasop Wildlife Sanctuary, Koh Kong Province.

Sampling Date	Seine net			Plankton net	
	Sites	Latitude (°N)	Longitude (°E)	Latitude (°N)	Longitude (°E)
3-Jun-23	S01	11.521103	102.987293	11.520948	102.989651
3-Jun-23	S02	11.545870	103.034580	11.544494	103.037679
4-Jun-23	S03	11.493570	103.036630	11.492310	103.040700
4-Jun-23	S04	11.509830	103.021900	11.509400	103.023730
5-Jun-23	S05	11.448340	103.042430	11.448250	103.045350
5-Jun-23	S06	11.468694	103.063454	11.468000	103.063800
6-Jun-23	S07	11.465800	103.109711	11.463430	103.109300
6-Jun-23	S08	11.478170	103.066210	11.479500	103.067270
7-Jun-23	S09	11.489170	103.081376	11.487840	103.078930
7-Jun-23	S10	11.496080	103.062640	11.496420	103.064800

Figs. 3 & 4: Characteristic habitat in sampling site 03, Peam Krasop Wildlife Sanctuary.

RESULTS

Total 3798 individuals of fish larvae and juveniles collected using plankton and seine nets belonging to 74 species, 53 genera, 31 families and 15 orders (see Table 2) were recorded from Peam Krasop Wildlife Sanctuary from between 3 to 7 June, 2023. Eight orders represent 99.51% of the total abundance, including Perciformes (79.02%, 3001 individuals), Atheriniformes (6.13%, 233 ind.), Gobiiformes (6.56%, 249 ind.), Kurtiformes (2.37%, 90 ind.), Carangiformes (2.19%, 83 ind.) Beloniformes (1.26%, 48 ind.), and Clupeiformes (1.11%, 42 ind.), and Acanthuriformes (0.87%, 33 ind.). Ten families represents 95.47% of the total abundance, including Ambassidae (62.98%, 2392 ind.), Leiognathidae (8.32%, 90 ind.), Gobiidae (2.20%, 5.79 ind.), Gerreidae (5.50, 209 ind.), Atherinidae (4.16%, 158 ind.), Apogonidae (2.37%, 90 ind.), Carangidae (2.19%, 83 ind.), Phallostethidae (1.97%, 75 ind.), Zenarchopteridae (1.24%, 47 ind.) and Toxotidae (0.95%, 36 ind.).

Table 2: List of fish larval and juvenile taxa using plankton and seine nets from Peam Krasop Wildlife Sanctuary from 3-7 June 2023.

No.	Order	Family	Genus	Scientific Names	Common Names
1	Acanthuriformes	Drepaneidae	*Drepane*	*Drepane punctara*	Spotted Sicklefish
2	Acanthuriformes	Scatophagidae	*Scatophagus*	*Scatophagus argus*	Spotted Scat
3	Acanthuriformes	Siganidae	*Siganus*	*Siganus guttatus*	Orangespotted Spinefoot
4	Acanthuriformes	Siganidae	*Siganus*	*Siganus javus*	Streaked Spinefoot
5	Acanthuriformes	Siganidae	*Siganus*	*Siganus sp.*	Rabbitfishes
6	Atheriniformes	Atherinidae			Silversides
7	Atheriniformes	Atherinidae	*Atherinomorus*	*Atherinomorus* sp.	Silversides
8	Atheriniformes	Atherinidae	*Hypoatherina*	*Hypoatherina* sp.	Sumatran Silverside
9	Atheriniformes	Phallostethidae	*Neostethus*	*Neostethus lankesteri*	Priapiumfishes
10	Atheriniformes	Phallostethidae	*Neostethus*	*Neostethus* sp.	Priapiumfishes
11	Beloniformes	Belonidae	*Strongylura*	*Strongylura* sp.	Needlefishes
12	Beloniformes	Zenarchopteridae	*Zenarchopterus*	*Zenarchopterus* sp.	Halfbeak
13	Blenniiformes	Blenniidae			Blennies
14	Blenniiformes	Blenniidae	*Omobranchus*	*Omobranchus* sp.	Blennies
15	Callionymiformes	Callionymidae	*Repomucenus*	*Repomucenus sagitta*	Dragonets
16	Carangiformes	Carangidae	*Alepes*	*Alepes* sp.	Jacks
17	Carangiformes	Carangidae			Jacks
18	Carangiformes	Carangidae	*Carangoides*	*Carangoides praeustus*	Brownback Trevally
19	Carangiformes	Carangidae	*Carangoides*	*Carangoides* sp.	Jacks
20	Carangiformes	Carangidae	*Scomberoides*	*Scomberoides lysan*	Doublespotted queenfish
21	Carangiformes	Carangidae	*Scomberoides*	*Scomberoides* sp.	Jacks
22	Clupeiformes	Clupeidae			Herrings (Sardines)
23	Clupeiformes	Clupeidae	*Escualosa*	*Escualosa* sp.	Sardines
24	Clupeiformes	Dorosomatidae	*Hilsa*	*Hilsa kellee*	Kelee shad
25	Clupeiformes	Dorosomatidae	*Sardinella*	*Sardinella albella*	White Sardinella
26	Clupeiformes	Engraulidae			Anchovies
27	Clupeiformes	Engraulidae	*Stolephorus*	*Stolephorus dubiosus*	Thai Anchovy
28	Clupeiformes	Engraulidae	*Stolephorus*	*Stolephorus indicus*	Indian anchovy
29	Clupeiformes	Engraulidae	*Stolephorus*	*Stolephorus* sp.	Anchovies
30	Clupeiformes	Engraulidae	*Thryssa*	*Thryssa hamiltoni*	Hamilton's Thryssa
31	Elopiformes	Elopidae			Ladyfishes
32	Gobiiformes	Butidae	*Butis*	*Butis butis*	Duckbill Sleeper
33	Gobiiformes	Butidae	*Butis*	*Butis sp.*	Sleepers
34	Gobiiformes	Gobiidae	*Acentrogobius*	*Acentrogobius* sp.	Gobies
35	Gobiiformes	Gobiidae	*Brachygobius*	*Brachygobius* sp.	Gobies
36	Gobiiformes	Gobiidae	*Drombus*	*Drombus globiceps*	Kranji drombus
37	Gobiiformes	Gobiidae	*Drombus*	*Drombus triangularis*	Brown drombus
38	Gobiiformes	Gobiidae	*Glossogobius*	*Glossogobius sparsipapillus*	Linecheek tank goby
39	Gobiiformes	Gobiidae	*Glossogobius*	*Glossogobius sp.*	Gobies

No.	Order	Family	Genus	Scientific Names	Common Names
40	Gobiiformes	Gobiidae			Gobies
41	Gobiiformes	Gobiidae	*Gobiopterus*	*Gobiopterus chuno*	Gobies
42	Gobiiformes	Gobiidae	*Mugilogobius*	*Mugilogobius* sp.	Gobies
43	Gobiiformes	Gobiidae	*Papuligobius*	*Papuligobius* sp.	Gobies
44	Istiophoriformes	Sphyraenidae	*Sphyraena*	*Sphyraena pinguis*	Red barracuda
45	Kurtiformes	Apogonidae	*Apogon*	*Apogon fleurieu*	Flower Cardinalfish
46	Mugiliformes	Mugilidae			Mullets
47	Perciformes	Ambassidae	*Ambassis*	*Ambassis interrupta*	Long-spined glass perchlet
48	Perciformes	Ambassidae	*Ambassis*	*Ambassis kopsii*	Singapore Glassy Perchlet
49	Perciformes	Ambassidae	*Ambassis*	*Ambassis* sp.	Glassfishes
50	Perciformes	Ambassidae	*Ambassis*	*Ambassis vachellii*	Vachell's Glass Perchlet
51	Perciformes	Gerreidae			Mojarra
52	Perciformes	Gerreidae	*Gerres*	*Gerres erythrourus*	Deepbody Silverbiddy
53	Perciformes	Gerreidae	*Gerres*	*Gerres oyena*	Common Silverbiddy
54	Perciformes	Gerreidae	*Gerres*	*Gerres* sp.	Mojarra
55	Perciformes	Haemulidae	*Pomadasys*	*Pomadasys kaakan*	Javelin Grunt
56	Perciformes	Haemulidae	*Pomadasys*	*Pomadasys* sp.	Grunt
57	Perciformes	Leiognathidae	*Leiognathus*	*Leiognathus equula*	Common Ponyfish
58	Perciformes	Leiognathidae	*Leiognathus*	*Leiognathus* sp.	Slipmouths
59	Perciformes	Leiognathidae	*Nuchequula*	*Nuchequula gerreoides*	Decorated ponyfish
60	Perciformes	Leiognathidae	*Nuchequula*	*Nuchequula* sp.	Ponyfishes
61	Perciformes	Leiognathidae			Slipmouths
62	Perciformes	Leiognathidae	*Secutor*	*Secutor megalolepis*	Bigscaled Ponyfish
63	Perciformes	Leiognathidae	*Secutor*	*Secutor* sp.	Ponyfishes
64	Perciformes	Lutjanidae			Snappers
65	Perciformes	Lutjanidae	*Lutjanus*	*Lutjanus russellii*	Russell's Snapper
66	Perciformes	Lutjanidae	*Lutjanus*	*Lutjanus* sp.	Snappers

No.	Order	Family	Genus	Scientific Names	Common Names
67	Perciformes	Monodactylidae	*Monodactylus*	*Monodactylus argenteus*	Silver moony
68	Perciformes	Polynemidae	*Eleutheronema*	*Eleutheronema tetradacrylum*	Fourfinger threadfin
69	Perciformes	Sillaginidae	*Sillago*	*Sillago aeolus*	Oriental Sillago
70	Perciformes	Sillaginidae	*Sillago*	*Sillago sihama*	Silver Sillago
71	Perciformes	Toxotidae	*Toxotes*	*Toxotes jaculatrix*	Banded archerfish
72	Pleuronectiformes	Cynoglossidae	*Cynoglossus*	*Cynoglossus puncticeps*	Speckled tonguesole
73	Tetraodontiformes	Tetraodontidae	*Lagocephalus*	*Lagocephalus* sp.	Puffers
74	Tetraodontiformes	Triacanthidae	*Tripodichthys*	*Tripodichthys blochi*	Longtail Tripodfish

Common species:

In this survey we encountered the following common species as adults and juveniles (caught as sea or in the mangrove estuaries): *Ambassis vachellii*, *Ambassis kopsii*, *Apogon fleurieu*, *Butis butis*, *Carangoides praeustus*, *Drombus globiceps*, *Leiognathus equula*, *Neostethus lankesteri*, *Neostethus* sp., *Toxotes jaculatrix*, *Lutjanus russellii*, *Atherinomorus* sp. (see Figure 5).

Species with threat status:

In this survey we encountered the following species which have an IUCN threat status: Spotted Seahorse *Hippocampus kuda* (see Fig. 6). It is noted that the species (Fig. 7) was found in the catch from a fisherman fishing in between site S05 and S06 in Peam Krasop Wildlife Sanctuary.

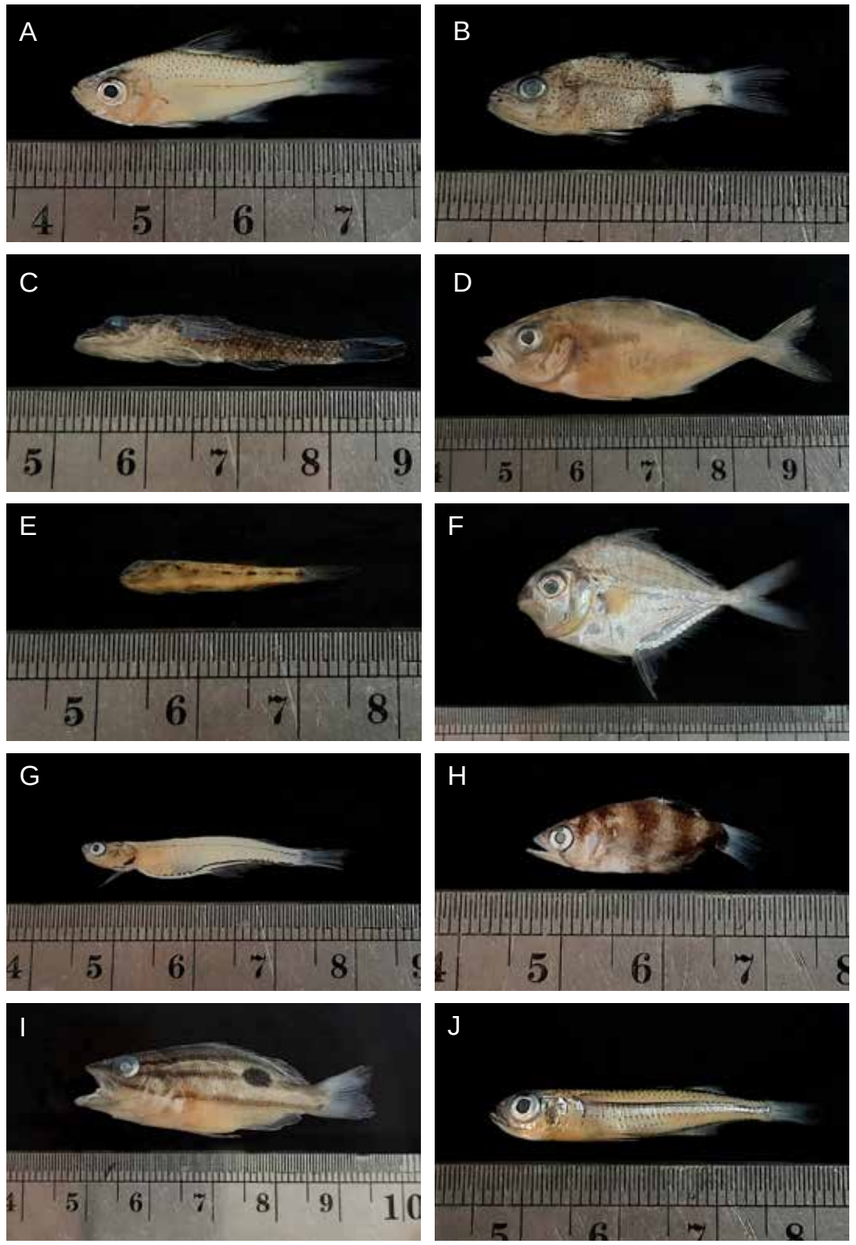
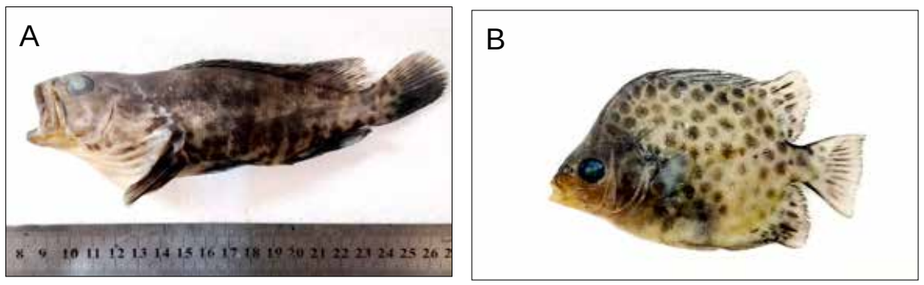


Fig. 5: Common juveniles of (a) *Ambassis vachellii* (24.3 mm SL), (b) *Apogon fleurieu* (21.58 mm SL), (c) *Butis butis* (30.13 mm SL), (d) *Carangoides praeustus* (31.97 mm SL), (e) *Drombus globiceps* (18.59 mm SL), (f) *Leiognathus equula* (27.07 mm SL), (g) *Neostethus* sp. (12.14 mm SL), (h) *Toxotes jaculatrix* (19.83 mm SL), (i) *Lutjanus russellii* (37.59 mm SL), and (j) *Atherinomorus* sp. (28.68 mm SL) in Peam Krasop Wildlife Sanctuary.

Fig. 6: Threatened species of *Hippocampus kuda* in Peam Krasop Wildlife Sanctuary.

Species of economic importance:

In this survey we encountered the following species with (high) economic value as juveniles and adults (caught at sea or in the mangrove estuaries): *Epinephelus coioides*, *Moolgarda cunnesius*, *Nibea soldado*, *Herklotsichthys dispilonotus*, *Carangoides praeustus*, *Scomberoides lysan*, *Lutjanus russellii*, *Scatophagus argus*, *Siganus guttatus*, *Sillago aeolus*, *Sillago sihama*, *Eleutheronema tetradactylum*, *Sardinella albella*, *Sphyraena putnamae* (see Fig. 7). It is noted that the species shown in Fig. 7 (a) and Fig. 7 (g) were taken from fisherman's catches made between site S05 and S06.



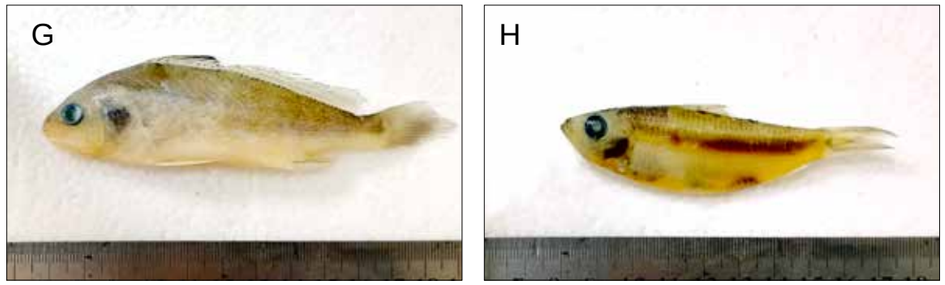


Fig. 7: Economic valued species of (a) *Epinephelus coioides* (154 mm SL), (b) *Scatophagus argus* (68 mm SL), (c) *Sphyraena putnamae* (185 mm SL), (d) *Siganus guttatus* (67 mm SL), (e) *Moolgarda cunnesius* (119 mm SL), (f) *Sillago sihama* (117 mm SL), (g) *Nibea soldado* (112 mm SL), (h) *Herklotsichthys dispilonotus* (73 mm SL) in Peam Krasop Wildlife Sanctuary.

CONCLUSION AND RECOMMENDATIONS

This study represents the preliminary assessment of diversity, and spatial distribution of fish larvae and juveniles in Peam Krasop Wildlife Sanctuary in Koh Kong province on one occasion from 3-7 June, 2023. Totally, 74 larval and juvenile taxa belonging to 53 genera, 31 families and 15 orders were found in Peam Krasop Wildlife Sanctuary. The most dominant fish families/taxa in the sanctuary were Ambassidae, Leiognathidae, Gobiidae, Gerreidae, Atherinidae, Apogonidae, Carangidae, Phallostethidae, Zenarchopteridae and Toxotidae. This indicates that the mangrove forest in coastal waters provide an excellent shelter for feeding and nursery grounds of many estuarine and marine fish species including species that are commercially important and high conservation status (threatened) in the IUCN Red List. This information reaffirms the necessity to protect the mangrove forests in support of fish biodiversity conservation and the local community livelihoods in the area and beyond.

From this rapid assessment, we would also like to suggest future research be done as follows:

- Should do monthly or bimonthly fish larvae and juvenile collection to investigate spatial and temporal/seasonal fish larval and juvenile assemblage to generate necessary information in support of conservation planning as well as to measure the effect of management and conversation planing in the Peam Krasop Wildlife Sanctuary.

- Adult fish composition, diversity and catch, and other aquatic animals should be studied to provide further information necessary for effective fisheries conservation and management in Peam Krasop Wildlife Sanctuary.

- Annotated checklist on fish and aquatic animal diversity should be inventoried to support biodiversity monitoring/assessment and a scientifically sound fisheries management and conservation initiatives of this sanctuary.

- Awareness raising should be conducted among the Fisheries Administration staff and local community fishers on the fishing gear restrictions, the access and seasonal closures to conservation zones and this sanctuary.

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