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Cover image: Chinese water dragon *Physignathus cocincinus* (© Jeremy Holden). The occurrence of this species and other herpetofauna in Phnom Kulen National Park is described in this issue by Geissler *et al.* (pages 40–63).

# News

## New Master of Science in Sustainable Agriculture

Agriculture forms the backbone of the Cambodian economy and is a priority sector in government policy. To meet future food needs, it is imperative to transform Cambodian agriculture to ensure food security and safety, restore ecosystem services (e.g., carbon sequestration, water quality), sustain economic growth and provide greater opportunities for small-scale farmers.

The Master of Science in Sustainable Agriculture (MSA) was developed by the University of Battambang as part of the *Implementing quality of education & training of the young universities in rural areas of Cambodia* (UNICAM) project which is supported by the European Erasmus+ programme and university partners in Spain, France, Belgium and Italy.

The MSA programme provides students with an opportunity to develop appropriate methods and professional skills in sustainable agriculture development attuned to rural situations in Cambodia. The programme is designed to meet the needs of modern agriculture by equipping students with the necessary skills and practical knowledge to balance the natural resource and the human and economic factors that affect agricultural sustainability. To this end, it emphasizes integrative approaches that can be applied to enhance economically viable, socially supportive and ecologically sustainable agriculture at a national and international level.

The degree is a two-year, part-time (weekend) study programme taught in Khmer (75%) and English (25%). The curriculum combines course work and research work, and includes core, major, elective and research (thesis) components. Teaching staff are experts in sustainable agriculture. Students also have opportunities to undertake internships in Cambodia or overseas countries with collaborating partners. Further details are available at http://unicamedu.com

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## Save Cambodia's Wildlife launches new project to protect forest and biodiversity in Cambodia

Between January 2019 and December 2022, Save Cambodia's Wildlife (SCW) will collaborate with Weltungerhilfe (German Agro Action) and the Cambodian Ministory of Environment to promote forest and biodiversity protection in Cambodia, with financial support from the German Federal Ministry for Economic Cooperation and Development.

The project will establish a natural resource management network comprising 152 Community Protected Areas (CPAs) nationwide. Representatives from each CPA will work with SCW and the Department of Environment and other local authorities to establish by-laws and other regulations to reduce pressures on natural resources.

Over the next four years, the project will support the CPAs through the development of non-timber forest products and eco-tourism services. Because SCW believes in youth as actors for change, the project will also establish a self-sustaining green youth development program where students and young adults can meet to discuss environmental issues and work with local decision-makers to address these.

The project will also raise awareness and understanding regarding climate change and resilience through education activities and piloting of renewable energy initiatives. Eco-clubs will be created in rural schools, where children will learn about nature and recycling and clean up their villages. For renewable energy, SCW will introduce biogas digesters and solar water pumps, which transform cow dung into gas for cooking and improve irrigation options, respectively.

The project will target over 5,500 individuals across the 152 CPAs and indirectly affect over 350,000 people. Increased knowledge through capacity building and youth enabled as actors for change will help ensure that the project outcomes continue beyond its lifespan. The work of SCW (www.cambodiaswildlife.org/) focuses on sustainable natural resource management, climate change and renewable energy, environmental education, alternative livelihoods and social entrepreneurship.

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## Short Communication

# Tiger beetle (Coleoptera: Cicindelidae) records from Kratie Province, Cambodia, with three new country records and an updated checklist for Cambodia

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Cambodia has experienced a surge of interest in its remaining forest ecosystems and associated biodiversity in recent years. Most of the attention has been concentrated on a select number of locations such as the Cardamom Mountains in the southwest and coastal islands, whereas inland lowlands have received little attention. Floodplains in the Mekong Basin are among the most vulnerable areas to environmental pressures associated with rapid economic and demographic development. Thorough documentation of biodiversity is a prerequisite for any conservation efforts in this rapidly changing landscape. Invertebrates are understudied overall, and for even some of the better studied groups such as tiger beetles (Cicindelidae), knowledge is scant. Currently, 53 tiger beetle species have been recorded in Cambodia (Wiesner, 2017) and the most recent additions to the group were by Cassola (2005), Wiesner (2008, 2013, 2014, 2017, 2018) and Matalin (2018a,b).

We report observations of tiger beetles made during a recent survey in central Cambodia, close to the Mekong River (Fig. 1). The "Kdan Mekong 2018 expedition" was coordinated by the Biodiversity Inventory for Conservation initiative and was a biodiversity express survey which sought to update biological knowledge for two regions: Preaek Prasab Wildlife Sanctuary and Sambour Wildlife Sanctuary in Kratie Province, Cambodia. These two regions were identified by WWF Cambodia and the Cambodian Ministry of Environment as requiring field surveys to provide current information on their biodiversity.

We undertook fieldwork at four study sites during the early wet season (between 28 April and 21 May 2018) within the two regions. Four camp locations in the two regions were visited: BC1 Kampi - at an elevation of 55m (12.61862 N, 106.00154 E), BC2 Praek Prasab - at an elevation of 20m (12.56555 N, 105.95080 E), BC3 Koh Klap - at an elevation of 65m (13.01013 N, 106.06539 E) and BC4 Community forest - at an elevation of 69m (13.019582 N, 105.92679 E) (Fig. 1). More information on the expedition and study region can be found in Jocque *et al.* (2018).

Tiger beetles were collected with malaise traps, pitfall traps and opportunistically with a hand net. Specimens were preserved in 70% ethanol. After identification, most of the material was deposited in the Royal Belgian Institute of Natural History (museum accession number 33.901), and part of the material was deposited in the personal collection of Dr Wiesner Jürgen.

A total of 147 specimens representing 16 species were collected (Table 1). All 16 species are first records for Kratie province, whereas three are new records for Cambodia: *Calochroa carissima* (Fleutiaux, 1919), *Cylindera* (*Ifasina*) *spinolae koratensis* Naviaux, 1991 and *Prothyma schmidtgoebeli* Horn, 1895.

*Calochroa carissima* (Fleutiaux, 1919) was almost exclusively collected on sand banks along rivers, both on open

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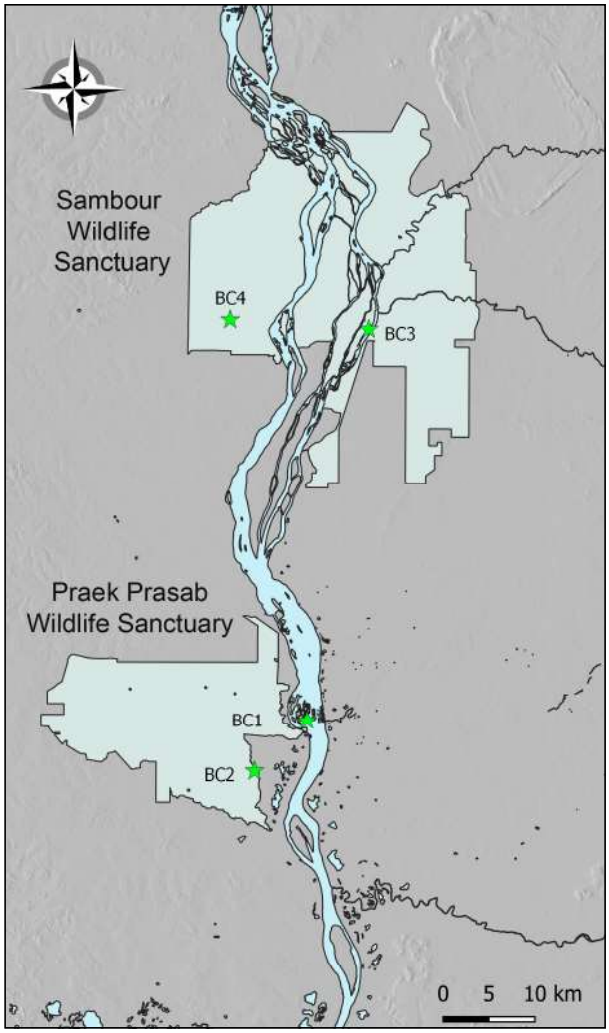


**Fig. 1** Study area including four basecamps (BC1–BC4) where field surveys were coordinated from in Preaek Prasab Wildlife Sanctuary and Sambour Wildlife Sanctuary.

sunny sand bars fringing the Mekong and along the small sandy (1–2 meters wide) edges of a shaded dipterocarp forest river close to BC4. The species is a powerful flyer and difficult to catch during the day. At night, it aggregates on low vegetation about one meter above ground level along these sandy ridges in large numbers, with sometimes over 100 individuals on a single plant (Fig. 2) and can then easily be collected. Tiger beetles from sandy edges of rivers are known to roost on low vegetation at night to avoid predation (Pearson & Anderson, 1985; Bhargav & Uniyal, 2008). *Calochroa carissima* is known from southern Laos mostly along the Mekong, and it is expected to occur all along the Mekong River and its tributaries.

**Fig. 2** *Calochroa carissima* roosting at night in large numbers on low vegetation (© Justin Clause).

*Cylindera* (*Ifasina*) *spinolae koratensis* Naviaux, 1991 is only known from a limited number of sites, for instance in western Thailand (Naviaux & Pinratana 2001). We recorded the species almost exclusively on dirt roads and dry river beds in patches of lowland dipterocarp forest. *Cylindera* (*Ifasina*) *spinolae spinolae* is more widely distributed and also recorded from Cambodia.

*Prothyma schmidtgoebeli* Horn, 1895 was also only recorded in patches of lowland dipterocarp forest and was commonly observed on dirt roads and dry river beds in the forest. The species is common in the neighbouring countries of Thailand, Laos and Vietnam (Naviaux & Pinratana, 2001) and was expected to occur in Cambodia. Our first country record for the species is indicative of the paucity of information for tiger beetles in Cambodia.

Wiesner (2014) included *Cylindera venosa* in Cambodia tiger beetle fauna in error, as this taxon should be *Cylindera mutata*. *Cylindera mutata* was encountered by Matalin (2018a) and also during our survey on an island in the Kampi area, on the Mekong River (close to BC1).

Our detection of only 16 tiger beetle species reflects the low survey effort and opportunistic nature of our collections. Most of our records were incidental catches at a light trap and in malaise traps. Future surveys of tiger beetles in the region would be most valuable and undoubtedly reveal additional species. For instance, our updated checklist of tiger beetle records in Cambodia brings the national total to 59 species (Appendix 1), which is still very low compared to 133 species in Thailand (Cassola, 2005), 177 species in Vietnam (Wiesner *et al*., 2017) and 143 species in Laos (Wiesner & Geiser, 2016).

**Table 1** Tiger beetles collected during the Kdan Mekong 2018 expedition. Numbers of males (M) and females (F) collected around the four basecamps (BC1–4) are provided. * Indicates a single specimen and ** indicates two specimens deposited in the collection of Dr Wiesner.

| # | Species | BC1 | | BC2 | | BC3 | | BC4 | | Sum |
|---|---|---|---|---|---|---|---|---|---|---|
| | | M | F | M | F | M | F | M | F | |
| 1 | *Calomera angulata* (Fabricius, 1798) | | 1 | 4 | 6 | 3 | 11 | | | 25 |
| 2 | *Calochroa harmandi* (Fleutiaux, 1893) | | | | 1 | 1 | 1 | 9** | 8** | 20 |
| 3 | *Calochroa carissima* (Fleutiaux, 1919) | 1 | | | 1 | 2 | 2 | 3* | 8* | 17 |
| 4 | *Cylindera biprolongata* (Horn, 1924) | | | | | 1 | | | | 1 |
| 5 | *Cylindera khmer* Cassola, 2005 | | | 6** | 1* | 2 | | 2 | | 11 |
| 6 | *Cylindera foveolata* (Schaum, 1863) | | | 1 | 1 | 1 | | 3 | 1 | 7 |
| 7 | *Cylindera minuta* (Olivier, 1790) | 3 | 4 | 1 | 4 | 2 | | | | 14 |
| 8 | *Cylindera mutata* (Fleutiaux, 1893) | 1 | 1 | | | | | | | 2 |
| 9 | *Cylindera spinolae* koratensis Naviaux, 1991 | | | | | 1 | | 4* | 3* | 8 |
| 10 | *Lophyra lineifrons* (Chaudoir, 1865) | | | 1 | | 1 | 3 | 5 | 2 | 12 |
| 11 | *Lophyra fuliginosa* (Dejean, 1826) | | | 2 | | | | | | 2 |
| 12 | *Lophyra striolata striolata* (Illiger, 1800) | | | | 1 | | | 4 | | 5 |
| 13 | *Myriochile sinica* (Fleutiaux, 1889) | | | | 1 | 1 | | | | 2 |
| 14 | *Neocolliris bonelii bonelii* (Guérin-Méneville, 1834) | | | | | 1 | 1 | 1 | | 3 |
| 15 | *Prothyma bouvieri bouvieri* Horn, 1896 | | | | | | | 1 | 1 | 2 |
| 16 | *Prothyma schmidtgoebeli* Horn, 1895 | | | | | | | 8 | 8 | 16 |

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## Appendix 1 Checklist of tiger beetles recorded in Cambodia and their occurence in neighbouring countries

| # | Taxon | Cambodia | | | | | | | | | | | | Reference for Cambodian Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unknown | Siem Reap | Pursat | Koh Kong | Sihanoukville | Kampong Speu | Kampot | Kratie | Stung Treng | Rattanakiri | Thailand | Laos | Vietnam | |
| 1 | *Tricondyla (Tricondyla) pulchripes* White, 1844 | X | | | | | | | | | | | X | X | Cassola 2005, p.14 |
| 2 | *Tricondyla (Tricondyla) stricticeps* Chaudoir, 1864 | | | | X | | | | | | | X | X | X | Matalin 2018a, p.10 |
| 3 | *Tricondyla (Tricondyla) macrodera abruptesculpta* Horn, 1925 | | | X | | | | | | | | | | X | Wiesner 2018, p.21 |
| 4 | *Tricondyla (Tricondyla) annulicornis* Schmidt-Goebel,1846 | | | | X | | | X | | | | X | X | X | Matalin 2018a, p.10 |
| 5 | *Protocollyris probsti* Naviaux, 1894 | | X | | | | | | | | | X | X | | Cassola 2005, p.13 |
| 6 | *Neocollyris (Neocollyris) bonellii bonellii* (Guérin-Ménéville, 1834) | | X | | X | | | | X | | | X | X | X | Wiesner 2008, p.75 |
| 7 | *Neocollyris (Neocollyris) stiengensis* (Horn, 1914) | X | | | | | | | | | | | | X | Cassola 2005, p.14 |
| 8 | *Neocollyris (Neocollyris) moesta* (Schmidt-Goebel, 1846) | | X | | | | | | | | | X | X | X | Cassola 2005, p.13 |
| 9 | *Neocollyris (Neocollyris) impressifrons* (Chaudoir, 1864) | X | | | | | | | | | | | | X | Cassola 2005, p.14 |
| 10 | *Neocollyris (Neocollyris) fuscitarsis* (Schmidt-Goebel, 1846) | | X | | | | | | | | X | X | X | X | Wiesner 2008, p.75 |
| 11 | *Neocollyris (Neocollyris) rufipalpis* (Chaudoir, 1864) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 12 | *Neocollyris (Orthocollyris) crassicornis* (Dejean, 1825) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 13 | *Neocollyris (Leptocollyris) linearis linearis* (Schmidt-Goebel, 1846) | | X | | X | | | | | | | X | X | X | Wiesner 2008, p.75 |
| 14 | *Neocollyris (Leptocollyris) subtilis subtilis* (Chaudoir, 1863) | | | | | | X | | | | | X | X | X | Wiesner 2018, p.21 |
| 15 | *Neocollyris (Leptocollyris) cylindripennis* (Chaudoir, 1864) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 16 | *Neocollyris (Pachycollyris) fasciata* (Chaudoir, 1864) | X | | | | | | | | | | X | | | Cassola 2005, p.14 |
| 16 | *Prothyma (Paraprothyma) exornata* Schmidt-Goebel, 1846 | | | | X | | | | | | | X | X | X | Wiesner 2018, p.22 |
| 18 | *Prothyma (Paraprothyma) schmidtgoebeli* Horn, 1895 | | | | | | | | X | | | X | X | X | This study |
| 19 | *Prothyma (Genoprothyma) heteromalla* (MacLeay, 1825) | | X | | | | | | | | | X | X | X | Cassola 2005, p.16 |
| 20 | *Prothyma (Genoprothyma) bouvieri bouvieri* Horn, 1896 | | X | | | | X | | X | | | X | X | X | Wiesner 1992, p.58 |
| 21 | *Heptodonta eugenia* Chaudoir, 1865 | | X | | X | | | | | | | X | X | X | Wiesner 2008, p.75 |
| 22 | *Calochroa flavomaculata flavomaculata* (Hope, 1831) | | X | | X | | | | | | X | X | X | X | Wiesner 2008, p.76 |

 

## Appendix 1 Cont'd

| # | Taxon | Cambodia | | | | | | | | | | Thailand | Laos | Vietnam | Reference for Cambodian Occurrence |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Unknown | Siem Reap | Pursat | Koh Kong | Sihanoukville | Kampong Speu | Kampot | Kratie | Stung Treng | Rattanakiri | | | | |
| 23 | *Calochroa carissima* (Fleutiaux, 1919) | | | | | | | | X | | | X | X | | This study |
| 24 | *Calochroa mouhotii* (Chaudoir, 1865) | X | | | | | | | | | | X | X | | Cassola 2005, p.14 |
| 25 | *Calochroa elegantula* (Dokhtouroff, 1882) | | | | | | X | | | | | X | X | X | Wiesner 2014, p.144 |
| 26 | *Calochroa interruptofasciata interruptofasciata* (Schmidt-Goebel, 1846) | | X | | | | | | | | | X | X | X | Cassola 2005, p.17 |
| 27 | *Calochroa interruptofasciata flavolineata* (Chaudoir, 1865) | | | X | | | X | | | | X | X | X | | Wiesner 2008, p.76 |
| 28 | *Calochroa harmandi* (Fleutiaux, 1893) | | | | | | | | X | | | | | X | Wiesner 1992, p.107 |
| 29 | *Calochroa bramani* (Dokhtouroff, 1882) | | X | X | | | X | | | | | X | X | X | Wiesner 2018, p.22 |
| 30 | *Calomera angulata angulata* (Fabricius, 1798) | | | | | X | X | | X | | X | X | X | X | Matalin 2018a, p.14 |
| 31 | *Calomera plumigera scoliographa* (Rivalier, 1953) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 32 | *Calomera funerea funerea* (Macleay, 1825) | | | X | | | | | | | X | X | X | X | Matalin 2018a, p.15 |
| 33 | *Cosmodela juxtata* (Acciavatti & Pearson, 1989) | | | X | X | | X | X | | | X | X | X | X | Wiesner 2008, p.76 |
| 34 | *Cosmodela virgula* (Fleutiaux, 1893) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 35 | *Lophyra (Lophyra) fuliginosa* (Dejean, 1826) | | | | X | | X | | X | | X | X | X | X | Wiesner 2008, p.76 |
| 36 | *Lophyra (Lophyra) cancellata cancellata* (Dejean, 1825) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 37 | *Lophyra (Spilodia) striolata striolata* (Illiger, 1800) | | | X | X | | | | X | | | X | X | X | Wiesner 2008, p.77 |
| 38 | *Lophyra (Spilodia) lineifrons* (Chaudoir, 1865) | | X | X | X | | X | X | X | | X | X | X | X | Wiesner 2008, p.77 |
| 39 | *Naviauxella ramai* Naviaux, 1991 | | X | | | | | | | | | X | X | | Cassola 2005, p.18 |
| 40 | *Naviauxella loebli* Matalin, 2018 | | | | | | | | | | X | | | | Matalin 2018b, p.2 |
| 41 | *Naviauxella labiosa* Naviaux, 1996 | | | | | | | | | | X | | | X | Matalin 2018a, p.12 |
| 42 | *Cylindera (Ifasina) foveolata* (Schaum, 1863) | | X | X | | | X | | X | | X | X | X | X | Wiesner 2008, p.77 |
| 43 | *Cylindera (Ifasina) viduata* (Fabricius, 1801) | | X | X | X | | X | | | | X | X | X | X | Wiesner 2008, p.77 |
| 44 | *Cylindera (Ifasina) khmer* Cassola, 2005 | | X | | | | | | X | | | | | | Cassola 2005, p.18 |
| 45 | *Cylindera (Ifasina) viridilabris* (Chaudoir, 1852) | | | | | | | | | | X | X | | | Matalin 2018a, p.13 |
| 46 | *Cylindera (Ifasina) spinolae spinolae* (Gestro, 1889) | | | | X | | | | | | | X | X | X | Wiesner 2008, p.77 |
| 47 | *Cylindera (Ifasina) spinolae koratensis* Naviaux, 1991 | | | | | | | | X | | | X | | | This study |
| 48 | *Cylindera (Ifasina) decempunctata* (Dejean, 1825) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 49 | *Cylindera (Ifasina) juergenwiesneri* Naviaux, 1991 | X | | | | | | | | | | X | | | Cassola 2005, p.20 |
| 50 | *Cylindera (Eugrapha) minuta* (Olivier, 1790) | | X | | | | X | | X | | | X | X | X | Wiesner 2017, p.44 |
| 51 | *Cylindera (Eugrapha) mutata* (Fleutiaux, 1893) | | | | | | | | X | X | | X | X | X | Matalin 2018a, p.14 |
| 52 | *Cylindera (Eugrapha) biprolongata* (Horn, 1924) | | | | | | | | X | X | | X | X | | Matalin 2018a, p.13 |
| 53 | *Myriochila (Myriochila) sinica* (Fleutiaux, 1889) | | X | X | | | X | | X | | | X | X | X | Wiesner 2018, p.24 |
| 54 | *Myriochila (Myriochila) specularis specularis* (Chaudoir, 1865) | | | | | | X | | | | | X | X | X | Wiesner 2018, p.24 |
| 55 | *Abroscelis tenuipes tenuipes* (Dejean, 1826) | X | | | | | | | | | | | | X | Cassola 2005, p.14 |
| 56 | *Abroscelis tenuipes araneipes* (Schaum, 1863) | | | | X | | | | | | | | | X | Wiesner 2008, p.78 |
| 57 | *Callytron nivicinctum nivicinctum* (Chevrolat, 1845) | X | | | | | | | | | | | | X | Cassola 2005, p.14 |
| 58 | *Callytron andersonii* (Gestro, 1889) | X | | | | | | | | | | X | X | X | Cassola 2005, p.14 |
| 59 | *Enantiola hewittii* (Horn, 1908) | X | | | | | | | | | | | | X | Cassola 2005, p.14 |

# Collection of small-scale artisanal fisheries data using interviews of village fishers on the Sre Ambel River, Cambodia

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## មូលន័យសង្ខេប

ប្រទេសកំពុងអភិវឌ្ឍអាចទទួលផលប្រយោជន៍ពីការរៀបចំឲ្យមានការគ្រប់គ្រងរួមគ្នា (ឧទា៖ សហគមន៍នេសាទ) រវាងទីភ្នាក់ងាររដ្ឋាភិបាល និងអ្នកនេសាទនៅក្នុងតំបន់ ពីព្រោះអ្នកនេសាទគឺជាធនធានមនុស្ស និងសង្គមយ៉ាងសំខាន់សម្រាប់គ្រប់គ្រងធនធានប្រកបដោយប្រសិទ្ធភាព និងការពង្រឹងច្បាប់នេសាទ ក៏ដូចជាចំណេះដឹងអេកូឡូស៊ី និងភាពសម្បូរនៃត្រី និងជលផល។ ទោះជាយ៉ាងណា ការខ្វះព័ត៌មានពីវិសាលភាព និងបញ្ហាជុំវិញការនេសាទអាចរារាំងដល់ការបង្កើតកិច្ចព្រមព្រៀងដែលមានប្រសិទ្ធភាពរវាងសហគមន៍ក្នុងតំបន់ និងទីភ្នាក់ងាររដ្ឋាភិបាល។ ដើម្បីដោះស្រាយគម្លាតព័ត៌មាននៅក្នុងសហគមន៍នេសាទទន្លេដែលបានស្នើនៅក្នុងប្រទេសកម្ពុជាយើងបានប្រើវិធីសាស្ត្រសម្ភាសន៍បែបពាក់កណ្តាលទម្រង់(semi-structured interview) ដែលតម្រូវឲ្យមានការប្រជុំជាសាធារណៈជាមួយនឹងភូមិចំនួន០៦ នៅក្នុងឃុត្តាធិការជលផលនៃប្រព័ន្ធស្ទឹងស្រែអំបិល។ គោលបំណងរបស់យើងគឺ ១) កំណត់ថា តើវិធីសាស្ត្រសម្ភាសន៍បែបពាក់កណ្តាលទម្រង់ផ្តល់ទិន្នន័យជលផលដែលមានសារៈប្រយោជន៍ឬទេ ២) ប្រើទិន្នន័យទាំងនេះដើម្បីផ្តល់យោបល់ដល់អ្នកពាក់ព័ន្ធ សម្រាប់ការអភិវឌ្ឍន៍សហគមន៍នេសាទ។ វិធីសាស្ត្ររបស់យើងបានផ្តល់ទិន្នន័យអំពីប្រជាសាស្ត្រក្នុងតំបន់ និងតួនាទីរបស់យេនឌ័រ(gender roles) គឺអំពីលក្ខណៈសំខាន់ៗនៃនេសាទនិងបច្ចេកទេស និងសក្តានុពលសម្រាប់ការអភិវឌ្ឍវារីវប្បកម្ម និងបានជួយកំណត់បញ្ហាប្រឈមដែលត្រូវដោះស្រាយ។ ត្រី៨៣ប្រភេទ និងភាវរស់ទឹក២០ប្រភេទផ្សេងទៀតត្រូវបានកំណត់អត្តសញ្ញាណថាមានសារៈសំខាន់ខ្លាំងសម្រាប់ការគ្រប់គ្រងនៅក្នុងប្រព័ន្ធស្ទឹងស្រែអំបិល។ បច្ចេកទេសនេសាទរួមមាន ឧបករណ៍នេសាទច្រើនបែប ហើយឧបករណ៍ទាំងនេះ និងកន្លែងនេសាទមានការប្រែប្រួលតាមរដូវ។ ទាំងបុរស និងស្ត្រីបានចូលរួមនេសាទ ហើយជាញឹកញាប់មានតួនាទីបំពេញគ្នាទៅវិញទៅមក។ ឧបសគ្គចម្បងៗដែលបានកំណត់សម្គាល់រួមមាន ការផ្លាស់ប្តូរជម្រក សំពាធនេសាទ និងកង្វះបទបញ្ជា។ វារីវប្បកម្មត្រូវបានកំណត់ថាជាជំណោះស្រាយដែលអាចទៅរួចចំពោះបញ្ហាប្រឈមមួយចំនួន ប៉ុន្តែវាអាស្រ័យទៅលើការប្រើប្រាស់ដី និងទាមទារការគាំទ្រ។ ដោយដែនកំណត់របស់វាត្រូវបានដឹង វិធីសាស្ត្រសម្ភាសន៍បែបពាក់កណ្តាលទម្រង់របស់យើងអាចដើរតួជាគំរូសម្រាប់ការប្រមូលទិន្នន័យ(user-based data) នៅទីជលផលដាច់ស្រយាលផ្សេងទៀត ដែលធនធានចាំបាច់សម្រាប់ប្រមូលទិន្នន័យមិនពាក់ព័ន្ធនឹងជលផល (fishery-independent data) នៅមានកម្រិត។

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## Abstract

Developing countries can benefit from co-management arrangements (i.e., community fisheries) between government agencies and local fishers because the latter can provide social and human capital critical for effective resource management and enforcement of fishing regulations, as well as knowledge on the ecology and relative abundance of fish and fisheries. However, limited information on the scope and issues surrounding fisheries can impede establishment of effective agreements between local communities and government agencies. To address this information gap in a proposed community river fishery in Cambodia, we used a semi-structured interview approach which employed public meetings with six villages within the fisheries jurisdiction of the Sre Ambel River system. Our objectives were to 1) determine if semi-structured interviews could generate useful fishery data, and 2) use these data to make recommendations to stakeholders for development of a community fishery. Our approach provided data on local demographics and gender roles, important fishery characteristics and techniques and potential for aquaculture development and also helped identify challenges to be addressed. Eighty-three fish species and 20 aquatic non-fish species were identified as being of potentially high management importance in the Sre Ambel River system. Fishery techniques included diverse types of gear and these and the areas fished varied seasonally. Men and women were both involved in fishing, often in complementary roles. Potential challenges identified included habitat alteration, fishing pressure and lack of regulation. Aquaculture was identified as a possible solution to some of the challenges, but would depend upon land use and require support. Provided its limitations are understood, our semi-structured interview approach may serve as a model for collecting user-based data in other isolated fisheries where the resources needed to collect fishery-independent data are limited.

## Keywords

Artisanal, Cambodia, co-management, community fishery, semi-structured interview.

## Introduction

Limited availability of information impedes successful management of small-scale fisheries in developing countries. Sound fisheries management depends on accurate information about a fishery, yet management agencies in such countries often suffer from limited human and financial resources for data collection and law enforcement (e.g., Eggert & Greaker, 2009). Absence of coherent, reliable and accessible information on important fish species and fisheries hinders formulation of relevant policies and fishery regulations (e.g., Moffitt *et al*., 2010). As a consequence, small but locally important fisheries receive less government attention in terms of fisheries management and enforcement of existing fisheries laws and regulations (Eggert & Greaker, 2009).

Fisheries in Southeast Asia have experienced declining yields and increasing conflicts which are attributed in large part to habitat alteration (Garces *et al*., 2008; Ngor *et al*., 2018) and increasing fishing pressure (Salayo *et al*., 2006). This is especially true for fisheries in smaller freshwater rivers, which are regionally important yet typically overlooked by management agencies due to limited resources (Hortle, 2007; FAO, 2010, 2012; Welcomme *et al*., 2010; Bartley *et al*., 2015). As a result, local fishing communities and government agencies have sought to establish community fisheries where fishing communities and government agencies share management responsibility and where fishing communities play a significant role in establishing fishing regulations and ensuring adherence to these (Almeida *et al*., 2009). Community fisheries can benefit conservation because local fishers can provide the social and human capital critical for effective fisheries management and law enforcement (Castello *et al*., 2009), as well as valuable knowledge on the biology and ecology of fish and fisheries (e.g., Haggan *et al*., 2007; Moreno, 2007). This facilitates establishment of management approaches that are more culturally and ecologically relevant and may result in greater compliance (King & Faasili, 1999; Crawford *et al*., 2004).

Community fisheries are widely seen as key to improving fisheries management and reducing overexploitation (Sen & Nielsen, 1996; Pomeroy & Berkes, 1997) and hundreds have been established worldwide, primarily in marine environments (Levine & Richmond, 2014). Community fisheries also have been successfully implemented in larger river systems and floodplain lakes (e.g., Armitage *et al*., 2008; Almeida *et al*., 2009), including the Mekong River and Tonle Sap Region in Cambodia (Ratner, 2006; Resurreccion, 2006; Nuon & Gallardo, 2011). Developing an effective community fishery requires establishment of a co-management plan that outlines the goals, responsibilities, cultures, issues,

 

strategies, regulations, and other key components of the agreement (Pomeroy & Rivera-Guieb, 2006). This is particularly difficult in smaller systems where fisheries data have not been compiled and adequate funding and personnel are not available to collect necessary information using traditional sampling.

An alternative to traditional methods for collecting quantitative fisheries information is to collect it directly and qualitatively from the fishers themselves. In systems where routine empirical sampling is not feasible, local fishers are often the most knowledgeable about a fishery and its issues (Haggan *et al*., 2007; Moreno, 2007). The semi-structured interview approach is a powerful tool for obtaining qualitative data directly from people (Rogers, 2001). Semi-structured interviews entail a formal interview where the interviewer uses an interview guide that lists questions and topics to be covered during the conversation, usually in a particular order. It varies from a structured interview in that an interviewer can follow topical trajectories in the conversation that may stray from the guide when deemed appropriate (Rubinson & Asnis, 1989). Although the approach is commonly used in the medical and linguistics fields (e.g., Patton, 1999; Ho, 2006; Alshenqeeti, 2014; Leung, 2015), it is much less common in fisheries management (McGoodwin, 2001).

We used a semi-structured interview approach to address information gaps in a proposed community fishery in Cambodia. Public meetings with villages from within the community fishery jurisdiction were conducted to collect basic data directly from the fishers (user-based approach). Our case study addressed two objectives: 1) To determine if semi-structured interviews in fishing villages could be used to collect basic data on the Sre Ambel River fishery, and 2) To use these data to provide recommendations to stakeholder groups to aid in the development of a community fishery. This approach may have merit as a model for employing a user-based approach for collecting basic fisheries data in other isolated fisheries where the infrastructure to collect fishery-independent data is unavailable.

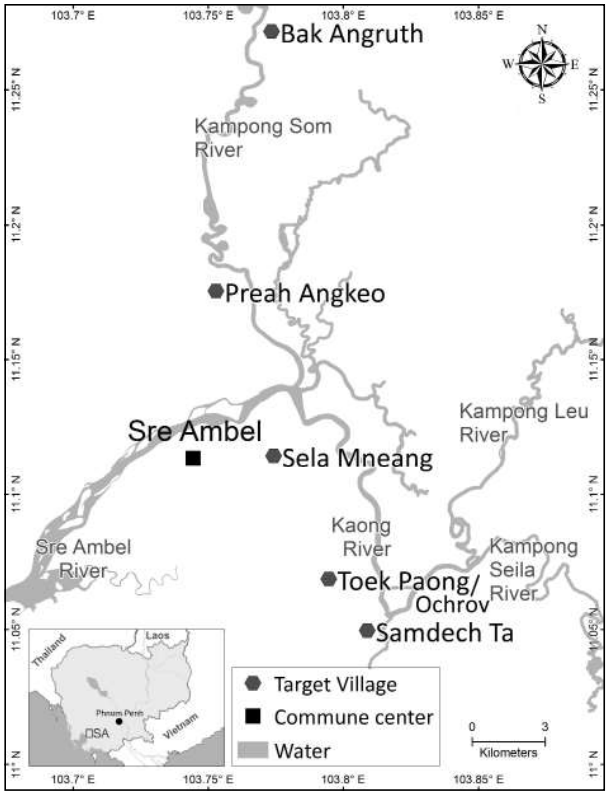


**Fig. 1** The Sre Ambel River system in southern Cambodia.

**Fig. 2** Sre Ambel River.

## Methods

### Study area

The Sre Ambel River system is a complex matrix of lowland rivers and backwaters, flooded forests, and agriculture in Koh Kong Province, Cambodia (Figs 1–2). The river generally flows towards the southwest before emptying into the Gulf of Thailand, with tributaries originating in the Elephant Mountains to the east and foothills of the Cardamom Mountains to the west. At least ten rural villages depend on its fisheries for a substantial portion of their sustenance, livelihoods and cultural continuity. The Fisheries Administration (part of the Royal Government of Cambodia's Ministry of Agriculture, Forestry and Fisheries) has been working with the Wildlife Conservation Society (WCS) and the U.S. Forest Service (USFS) to establish a community fishery with the

 

Sre Ambel River fishing villages. Under this arrangement, a management board composed of village representatives can provide input into fisheries management, regulations and law enforcement.

### Stakeholder meetings

Personnel from WCS arranged meetings with six of ten identified villages along the Sre Ambel River system from 7 June to 10 June 2018. Village leaders invited their citizens with an interest in the fishery. Attendance was voluntary, and no *a priori* attendance targets were established. All meetings occurred in community centres located in or adjacent to villages. Individual meetings were held with the villages of Bak Angruth, Preah Angkeo, Sela Mneang and Samdech Ta, and a joint meeting was held with the villages of Toek Paong and Ochrov due to their proximity. These six villages were selected by WCS and were assumed to represent all communities in the Sre Ambel River fishery as we could not visit all ten villages in the timeframe available. Each meeting included the village chief, representatives of families associated with fishing, representation from the Fisheries Administration (two individuals including the Interim Community Fisheries Department Director), and representatives from WCS (up to four individuals), USFS (one individual), and Mississippi State University (two individuals, MSU).

Four main categories of information were targeted for collection during stakeholder meetings. These included data on demographics and gender roles, capture fishery characteristics (i.e., who, what, when, where, why, and how) and issues, aquaculture potential and assistance needs. Meetings were initiated by the Fisheries Administration who explained of the importance of developing the community fishery partnership and requested participants to share freely their opinions and concerns. After introductions and general instructions, community members were asked to identify fish and aquatic fauna that they capture or otherwise use via colour pictures on a series of posters displaying the aquatic species of Cambodia. The posters included 532 fish species (freshwater, brackish, and marine) and 57 aquatic non-fish species (i.e., crustaceans, molluscs, reptiles, mammals) potentially inhabiting the region. Species identification was led by WCS staff members (one per group) who had existing relationships with community leaders and were fluent in the native language, Khmer. Villagers were divided into two groups to review the posters, which reduced the number of images reviewed by each group by half. In each instance, the group leader would point to an image and village citizens would reach consensus on whether the species was collected in the fishery. This helped reduce misidentification of species and temper avidity of individual fishers who claimed more species than others in their village. This process lasted about one hour. Concurrent to this activity, demographic information on participants were recorded and the village chief provided village-wide demographic data.

Following species identification, participants were interviewed as a group using a semi-structured interview approach following a series of questions developed *a priori* (Appendix 1). In a semi-structured approach, the questions are predetermined but the order and wording can be modified based on the interviewer's perception of what seems most appropriate (Galletta, 2013). Our questions focused on several themes, including fishing techniques, purpose of fishing, distance to fishing areas, times of year when fishing occurs, issues or challenges related to the fishery, possible actions or regulations that could be implemented, aquaculture, fish use and processing, gender roles in fishing, technical expertise desired and funding needs. MSU staff posed the questions and WCS staff provided translations between English and Khmer. Participants were also given the opportunity to provide unsolicited input and then the meeting was adjourned.

### Data management

A common meeting was arranged for the villages of Toek Paong and Ochrov due to proximity. Logistical concerns required that the villages jointly participate in fish identification; thus, the total number of fish identification sessions was five. However, these villages were interviewed separately to provide greater data resolution, yielding six semi-structured interview sessions.

Information collected was entered into Microsoft Excel, where data were synthesized into frequencies of responses from villages. Species of fish from posters were verified for family, genus, species and common names using www.fishbase.org, whereas other aquatic species from posters were verified using www.gbif.org. To determine species most often collected by village fishers and in need of further research and management, each species was ranked by the number of villages identifying it as being collected or otherwise part of their fishery. Species with no villages or only one out of five villages (≤20%) identifying it as collected were considered of low research and management need (low importance), at least in the context of the fishery. These are species which are likely uncommon in the fishery or potentially misidentified. Species identified by two or three villages (40–60%) were considered of medium research and management need (medium importance) and species identified by four or all five villages (≥80%) were considered of potentially high importance to the fishery and likely represent confirmed, common catches in village fishing activities. Although these species may or may not be important to subsistence or commercial success, they

represent species impacted by fishing activities and in need of management and research attention.

### Recommendations

Recommendations for development of a community fishery were derived from the synthesis of data from the villages interviewed. Interviewees were assumed to be representative of the fishery community of each village and providing uninhibited answers, although the information was obtained through language translators and village authorities and a government fisheries official were present during the process. Participation was dependent on community connections that were previously established. To ensure quality of data for making generalizations to the entire fishery community, only repeated, similar answers from multiple villages were considered to be common truths (Yach, 1992). Repeated themes from at least half (≥ 50%) of villages interviewed were distilled into pertinent recommendations. In addition, recommendations also included perspectives important to the success of co-manageed fisheries (e.g., Wilson *et al*., 2003). Recommendations followed data collection categories, namely demographics and gender roles, capture fishery characteristics, aquaculture potential and perceived challenges.

## Results

### Demographics and gender roles

The six villages interviewed contained from 134 to 510 families with 626 to 2,291 people per village and a total population of 7,231 people. Female and male participants were present at meetings and a total of 48 adult females and 39 adult males attended these (Table 1).

Both men and women were involved in fishing, with men described as leading fishing efforts (i.e., where, when and how to fish) and women supporting fishing by holding boats in place while men fished. Women undertook primary responsibility for sorting, processing and selling fish at market. Older adults described traditional roles of men and women commonly fishing together as couples; however, with declining catch rates in recent years, men were said to go further, fish longer and catch less than in the past, and women assisted with fishing less frequently as a result.

### Capture fishery characteristics

Village interviewees indicated that many families were involved in fishing for subsistence or small-scale commercial purposes, although the number of families or percentage of the village community was not reported. In general, people noted trying to capture fish to meet family needs and minimize purchasing fish from markets, or small-scale sale of fish to purchase other cooking ingredients. Commercial fishing was also present in most villages, but meeting participants indicated fewer families participated in commercial fishing than subsistence fishing. Fishing occurred throughout the year, with best fishing generally occurring during low water periods in the dry season or between the wet and dry seasons when fish migrate, but not all fishers fished all year around. Villagers reported that, when not fishing, many farmed fruit and vegetables (indicated by five out of six villages), produced rice (five), collected and sold forest products (three), left the village to work on construction in larger cities (three) or made natural charcoal to sell (one).

**Table 1** Demographics of villages and participants of community meetings held in June 2018 in the Sre Ambel River system, Cambodia.

| Demographic | Villages | | | | | | Totals |
|---|---|---|---|---|---|---|---|
| | Bak Angruth | Preah Angkeo | Toek Paong | Ochrov | Sela Mneang | Samdech Ta | |
| Number of families | 310 | 510 | 134 | 164 | 375 | 135 | 1628 |
| Total people | 1,400 | 2291 | 672 | 681 | 1561 | 626 | 7231 |
| Male | | 1166 | 324 | 327 | 750 | 292 | 2859 |
| Female | | 1125 | 348 | 354 | 811 | 334 | 2972 |
| Meeting attendees | | | | | | | |
| Male | 8 | 4 | 4 | 2 | 5 | 16 | 39 |
| Female | 18 | 13 | 3 | 7 | 7 | 0 | 48 |

 

All six villages fished nearby (<3 km) their villages, and most fished longer distances (>3 km) when necessary. Fishers reported having to travel farther to fish during the dry season than the wet season, and attributed this to increased salinity in the lower river during periods of lower flow. However, catch rates were often greatest during this period for fishers willing to travel because fish tended to concentrate upstream. Fishing areas often overlapped locations of other villages along the river. Fishing gears included passively fished gears (gill nets, bamboo pound nets, trotlines) and actively fished gears (hook and line, fish traps, cast nets, hand trawls, basket nets, gigs/spears; Fig. 3). Use of spears and gigs tended to occur during the dry season when water levels were low and water clearer, making fish more concentrated and visible.

Eighty-three fish species from 24 families were identified by at least 80% of villages. These were designated as being of potentially high importance for the fishery (Appendix 2). Another 141 fish species in 36 families were identified as being of medium importance (Appendix 3). For non-fish aquatic catch, 20 species from 9 families were also determined as being of high importance (Appendix 4). Almost all species captured were utilized as food or sold to live markets in the town of Sre Ambel. In addition to primary river channels and connected backwaters, fishers identified rice fields and floodplain forests as important regions for the fishery. Rice fields and forests composed primarily of the genus *Melaleuca* are inundated during the wet season and provide additional habitat for fish, allowing lateral movement from the river to the floodplain. Flooded forests were identified as being important spawning areas for many fish. Villagers also noted the importance of ponds within the forests for providing habitat for fish during the dry season.

Villages identified what they perceived as the primary issues facing the fishery. All six villages interviewed noted that catch rates were declining due to poor management and irresponsible fishing practices. Two villages described a 50% to 80% decline in catch over the past 15 years, while the remaining four simply stated that catches had declined. Villages placed much of the blame on the use of illegal fishing gears or techniques by outsiders, although other villages and occasionally local fishers from within the village were also blamed. Illegal fishing gears reported included electric fishing, chemical poisoning of fish, use of scare tactics to push fish into traps, and spearfishing at night using lights and underwater breathers during the dry season.

All six villages reported habitat degradation as a serious concern. More specifically, sand mining (indicated by five out of six villages), deforestation (five), and loss of spawning habitat (five) were implicated. Sand is harvested using hydraulic vacuums from sand bars within the river and deposits on inner river bends. Riparian forest is bulldozed to provide access to sand

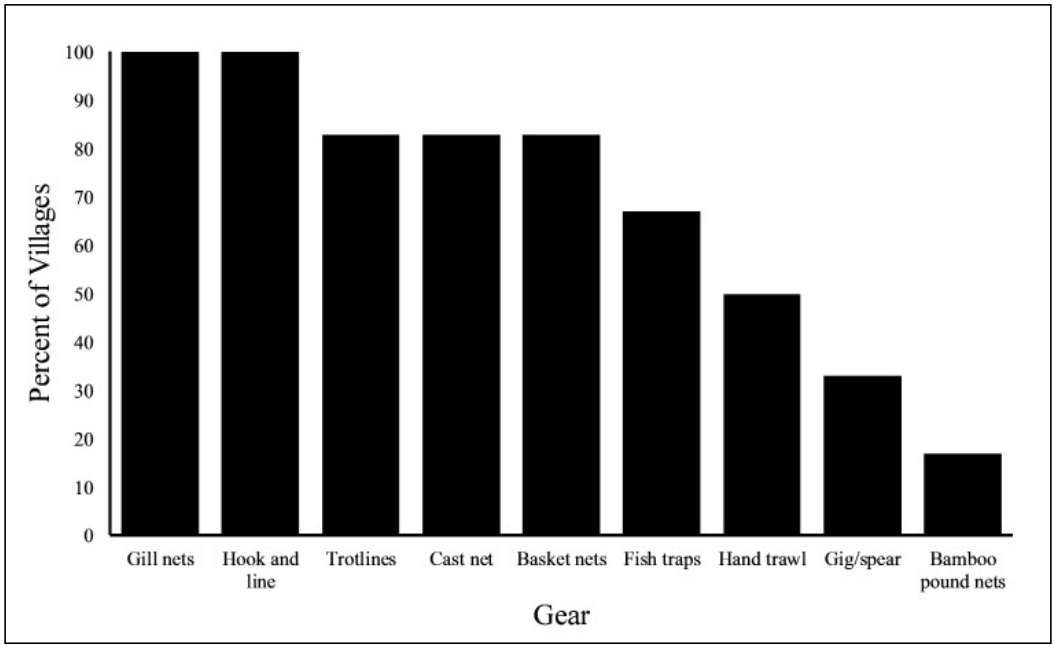


**Fig. 3** Passive and active fishing gears used by villages in the Sre Ambel River system.

deposits. This activity is illegal because it is conducted outside of permitted areas and occludes river navigation due to the large hoses laid across the river surface. Sand mining appears to be removing most of available sand bar habitat, which is particularly problematic for conservation of the critically endangered royal turtle *Batagur affinis*. This species is designated as the National Reptile in Cambodia and currently only occurs in the Sre Ambel River system (Seimon *et al*., 2017). Additional impacts include changes in river hydrology, loss of fish habitat, sedimentation, and deteriorating water quality. Similarly, villagers noted that removal of riparian forest habitat for alternative land development and lumber was altering river hydrology and fish spawning.

Several other concerns were reported to a lesser extent. Half of the villages noted that privatization of waterfront property has reduced fishing access and that historic fishing grounds are no longer accessible. This is true for the Sre Ambel River and its tributaries, adjacent floodplain forests and isolated ponds and lakes on newly privatized lands. One village noted concerns with changing climate, whereas one noted increasing human populations in the area and interviewees from Toek Paong village noted that a commercial pig farm had been constructed near the river with little regard to effluent control. Effluent was draining into ponds and the river reach fished by the villagers and had affected drinking water, with increased reports of illness after exposure.

### Aquaculture potential

Aquaculture is not commonly practiced by villages in the Sre Ambel River system, although all villages were interested in the potential for adding aquaculture to their livelihoods. Perceived constraints to this included lack of available land, cost to construct ponds, cost and availability of fingerling fish to stock ponds, availability of feed and technical expertise. Some villages included members that had constructed one or more ponds that they stock with small wild fish captured from the river. Fish are raised using offal from harvested chickens and discarded food or termites from the forest. Other villages reported that people had attempted to culture fish such as tilapia *Oreochromis* spp., pangasid catfish *Pangasius* spp. or other species but had either failed or had only temporary success due to lack of technical expertise or problems with flooding and escape of cultured animals.

Species that were identified as being desirable for culture included climbing perch *Anabas testudineus*, snakeheads *Channa* spp., tilapia, catfish *Pangasius* spp. and *Clarias* spp., carp (Cyprindae), eel (family not specified), and in areas with saline waters, barramundi *Lates calcarifer* and mud crabs *Scylla* spp. Ponds were the desired method of aquaculture, as cage culture was not perceived as a good method by several villages in the Sre Ambel River system due to the potential for theft. Villages reported that the primary market is for live fish with little demand for freshly dead whole or cleaned fish. Fish not sold or consumed immediately could be fermented, turned into a fish paste called prahok, dried, or in some instances smoked for long-term storage.

### Assistance needs

The six villages interviewed requested technical expertise and strategic funding assistance from WCS, USFS, and MSU personnel. Technical expertise for wild capture fisheries included help with development of a community fishery and information and guidance for developing an ecotourism strategy. All six villages expressed interest in developing ecotourism, including recreational fishing, wildlife viewing, rural cottage rentals and marketing local goods and crafts. Requests for technical expertise for aquaculture included pond design and general husbandry assistance. Two villages also requested technical expertise on vegetable and poultry farming. Funding was requested to help finance pond construction, improve aquaculture fingerling supply and support fishery enforcement, including funds to purchase a boat for enforcement and to hire conservation officers.

### Recommendations

Common themes in responses to each data category (i.e., demographics and gender roles, fishery characteristics, aquaculture potential and challenges) were identified from at least half of the villages surveyed. This provided nine recommendations encompassing common themes important to the establishment of the community fishery for the villages surveyed, but also of potential relevance for the application of these techniques elsewhere. The recommendations comprised: 1) Create an inclusive community fishery council, 2) Determine vulnerable river areas in need of protection, 3) Define allowable fishing gears and techniques, 4) Strengthen enforcement capacity, 5) Visually display regulations on the river, 6) Develop plan to protect and restore riparian forests, 7) Establish an enforceable sand mining/resource extraction policy, 8) Implement a standardized evaluation program, 9) Develop an aquaculture outreach programme.

## Discussion

Our use of a semi-structured interview approach at community meetings with stakeholders provided valuable and substantial information on the Sre Ambel River fishery. Village fishers provided data on species importance, techniques and gears employed, disposition of catch and identified key issues facing the fishery. These

 

data will be essential in developing the community fishery and preliminary fishing regulations.

We identified 83 species that were collected by at least 80% of the villages interviewed. These were collected during fishing activities or otherwise used or observed by fishers in each village. These data represent potential species occurrence and suggest that these fish are collected in the fishery and may require management actions for conservation. However, the data do not represent abundance or indicate the importance of a given species to the fishery in the Sre Ambel River system. Further, the data are only as accurate as the villagers' ability to identify fish to the species level (O'Donnell et al., 2012). We employed a group consensus approach, allowing participants to discuss a species among themselves when opinions differed, which should have reduced false positives to some degree. However, future research should include specimen collection and ichthyological expertise to confirm species identifications.

Several species were identified as being particularly important to villagers for consumption and small-scale commercial sale. These included the climbing perch *Anabas testudineus*, several snakehead species (*Channa* spp.), and several catfish species (*Pangasius* spp. and *Clarias* spp.). Prawns *Macrobrachium* spp. were also of particular importance, especially during the wet season in flooded *Melaleuca* forests. Initial management efforts could focus on these species while targeted research identifies additional management needs in the fishery. Fishers expressed concerns with declining catch rates and size for these and other species and suggested that recruitment overfishing may be eliminating fish before they have the opportunity to spawn. Further, loss or degradation of spawning habitat was indicated by all villages interviewed, which is a commonly reported issue in stream fisheries elsewhere (e.g., Goldstein & Meador, 2011; Winemiller *et al*., 2012).

A major concern expressed during interviews was illegal fishing by outsiders. Artisanal and small-scale commercial fisheries in Cambodia and worldwide are under increasing pressure from overfishing (Gordon, 1954; McManus *et al*., 1992; Worm *et al*., 2009), often due to increasing harvest by more sophisticated mobile fishers from outside of the local fishing community (Almeida *et al*., 2009). Artisanal fishers rely on local resources, therefore declining fish harvest can lead to food insecurity, cultural stress and poor economic performance manifested as poverty in their communities (Andrew *et al*., 2007; Bene *et al*., 2007; de Graaf *et al*., 2011). Further, competition for limited resources may put small-scale local fishers in conflict with larger-scale external fishing enterprises (Pauly, 2006) and act as a barrier to economic advancement in local communities.

Despite the value of the semi-structured interview approach for collecting basic information when no data or a mechanism for collecting data are available, several authors have addressed methodological concerns allied to the use of interviews in qualitative social science research (e.g., Potter & Hepburn, 2005; Ho, 2006; Myers & Newman, 2006; Alshenqeeti, 2014). A major challenge with the semi-structured interview is ensuring that data are valid and reliable (e.g., Leung, 2015). Because interviewers can modify questions as a conversation progresses, the interview process is less systemized and standardized than a structured interview, which can increase information variance (Segal & Coolidge, 2003). In other words, it can increase the chances that different interviewers will elicit different information from the same individual or group. To minimize this possibility, we used the same interview team for all village meetings.

Conversely, allowing flexibility in the interview process has been shown to improve rapport between the interviewer and subjects compared to more formal and structured interviews (Rubinson & Asnis, 1989; Rogers, 2001). This flexibility also promotes greater response depth by providing the interviewer with an opportunity to probe and expand on an interviewee's responses (Rubin & Rubin, 2011). At no time during our community meetings was there a sense of tension or distrust between the participants and the interview team. All participants appeared to be excited to share their knowledge. This of course might lead to avidity bias, as individuals attending meetings were the most interested in the state of the Sre Ambel River fishery. However, we were not trying to characterize each village as a whole. We were simply trying to collect basic information on the fishery. In that regard, having the most avid fishers should have ensured that the data collected were more accurate and valid.

Data accuracy and validity can be a concern when it is collected qualitatively via interview (Bernard *et al*., 1984). The quality and credibility of derived data can depend largely on the audience and research purposes (Patton, 1999). Criteria for determining the quality and credibility depend on the purpose and outcomes of the research (Patton 1997); that is, one must weigh the potential benefits of the data against the consequences of being wrong. O'Donnell *et al*. (2012) compared fisher interviews to fisher logbooks and independent landings data and found that interviews should be used cautiously to inform specific catch targets, but also concluded that interviews were a reasonable proxy for more costly research methods. For the Sre Ambel River fishery, we did not estimate specific harvest parameters and the consequences on misidentifying a fish species or overemphasizing a perceived issue are relatively minor given

the need for preliminary data to develop a co-management agreement.

Our consultations with the villages helped us to identify the following preliminary recommendations for development of the co-management agreement. These would not have been possible prior to our study due to limited information on the fishery. We offer for consideration the following nine recommendations, which are similar to co-management challenges in small-scale fisheries elsewhere (Rettig *et al*., 1989; Wilson *et al*., 2003; Salas *et al*., 2007).

1. *Create an inclusive community fishery council*. Representative, knowledgeable and sustainable management is imperative to the success of co-managed and small-scale fisheries (Jentoft *et al*., 2003). It was evident that many villages fished beyond their local reach of river, particularly during the dry season. The co-management agreement will need to create a framework that addresses use of regions by multiple villages. The governing body (council) will require representation of all villages to ensure compliance with agreed fishing regulations.
2. *Determine vulnerable river areas in need of protection*. Areas where fish may be more vulnerable to fishing pressure due to aggregations, spawning and so forth are important to regulate (Jul-Larsen *et al*., 2003). River zonation such as no-take areas may be necessary to protect sensitive areas from overharvest. Village fishers and/or directed research can be used to identify important areas for reproduction, staging, migration corridors or other life history bottlenecks that make overharvest more likely. The community fishery council will need this information when establishing fishing regulations for the river and its tributaries.
3. *Define allowable fishing gears and techniques*. Diverse gear-use is a challenge in establishing restrictions on small-scale fisheries (Salas *et al*., 2007). Additional gear restrictions may be necessary to maintain a viable fishery. Current gear restrictions include bans on electric fishing, chemical fishing, certain high-volume traps, and a few other techniques. Gill nets are currently legal, and are highly effective in catching many fish species, especially mobile species and non-target species such as the royal turtle. Mesh size largely determines the size of captured fish. Minimum mesh size restrictions could be used to allow smaller fish to evade capture, preventing recruitment overharvest by allowing juveniles to escape. Elimination of gill nets entirely, as implemented in the community fisheries of the Amazon (Almeida *et al*., 2009), should also be considered for long-term sustainability. Almeida *et al*. (2009) found that this excluded commercial fishing by outsiders and resulted in a 48% increase in catch for community fishers.
4. *Strengthen enforcement capacity*. Enforcement capacity poses a challenge to community fisheries in Cambodia (Ratner, 2006). The current use of illegal gears and non-sustainable harvest techniques concerns villages and needs to be addressed in the co-management agreement. The agreements should include local and national law enforcement agencies and explicitly state expectations and responsibilities. Some enforcement authority should be given to community representatives, but primary enforcement (confiscation of gears, arrests) needs to rest with enforcement agencies. Additional funding may be required to provide vessels and other equipment for enforcement, and potentially to hire conservation officer(s) to work on enforcement of community fishery laws and regulations.
5. *Visually display fishery regulations on the river*. Five out of six villages remarked that ignorance of the laws was often to blame for illegal fishing and agreed that well-placed signs on the river would help curb illegal activities. These signs could be placed on cables crossing river channels and indicate boundaries of the community fishery jurisdiction and protected zones within it. The signs could include easily understandable visuals for illiterate fishers.
6. *Develop plan to protect and restore riparian forests*. Protection of fisheries habitat is essential to a successful co-management plan (Pinkerton, 1989). On the Sre Ambel River system, floodplain habitat and particularly *Melaleuca* forest, appears to be important for the fishery in providing spawning and juvenile habitat during the wet season and pond refugia for brood stock during the dry season, as well as fishing opportunities during inundation. A sustainable policy for forest use and development is needed.
7. *Establish an enforceable sand mining/resource extraction policy*. Habitat destruction as a result of sand mining is a primary concern for fisheries and conservation of species such as the royal turtle in the Sre Ambel River system. The practice should be eliminated where possible. If allowed to continue, sand mining operations need to be better designed to minimize direct within-river impacts. This may include protection of riparian buffers and restrictions on mining of critical habitats, such as sand bars utilized by turtles for nesting, while allowing harvest of sand deposits further from the river bank. Following completion of mining activities at a location, habitat should be restored or created to benefit fish and other wildlife species. The responsibility and costs of restoration should be assigned to the extraction operation during the permitting process.
8. *Implement a standardized evaluation program*. Community development is only successful if demonstrable improvements are achieved. To demonstrate success, data must be collected before and after programme implementation. This requires ongoing assessment and could be achieved using a scientist-led or stakeholder-led approach. For the stakeholder-led approach, fishing logs could be created and distributed to village fishers with instruction on data recording. Fishers would record harvest data through time, allowing assessment of changes in catch associated with implementation of the community fishery and adherence to regulations.
9. *Develop an aquaculture outreach programme*. All villages were interested in aquaculture but did not have the financial means or expertise to get started. Development of educational programming could bridge the knowledge gap and facilitate aquaculture development in these communities. Further, a demonstration facility for aquaculture would be invaluable to educate and train interested villagers. The facility would need to be simple, inexpensive and replicable, with 2–3 gravity-fed ponds and easy to grow, readily available species. It could be constructed in a centrally located village, but should be used to train people from any village interested in aquaculture.

These recommendations address many of the issues identified during our community consultation process. While additional issues and concerns will undoubtedly arise during implementation of the community fishery, our approach has provided an important starting point

 

by generating basic fishery data where these did not exist and where traditional sampling methods were not feasible. We contend that the data provided by the Sre Ambel fishing villages are reasonably reliable and provide a valuable boost to the preliminary database for managing the fishery. Fisheries management is largely an adaptive process, composed of multiple iterations of trial and error, with each iteration learning from mistakes made previously (Neal, 2015). This is because natural fisheries are dynamic systems with a great deal of associated uncertainty. Managers rarely have enough information to make the best possible decisions for the stakeholders and the resource, and so must proceed with the information at hand.

Management uncertainty is exacerbated in developing countries such as Cambodia, where managers lack the funding and/or personnel to collect the data necessary for managing small-scale fisheries. In such situations, a user-based approach such as the one we employed can generate a significant amount of data with minimal investment, while simultaneously empowering local ownership and long-term planning to conserve important resources. Because our approach involved all primary stakeholders, including the fishers, researchers, collaborators, and the management authority, these data may be used to form initial objectives and management recommendations, which can be refined over time as newer data become available.

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## Appendix 1 General questions posed during village stakeholder meetings in the Sre Ambel River system, Cambodia

| Category | Audience | General Question Format |
|---|---|---|
| Demographics | Village chief | How many households/families in the village? |
| | | Total number of people? |
| | | Number of men? Women? |
| Poster Identification | All villagers | Which fish species are captured or otherwise important to the village? |
| | | What other species are captured or otherwise important to the village? |
| Capture Fisheries | All villagers | Where do people fish? Does this change seasonally? |
| | | How many people in village fish? Is fishing seasonal? |
| | | When not fishing, what employment? |
| | | Is fishing subsistence or small-scale commercial? |
| | | What are the roles of men and women in fishing? |
| | | What fishing gears are used? |
| | | How are fish handled after capture? Is processing involved? |
| | | What are the issues/challenges facing the fishery? |
| | | Is outsider fishing or illegal fishing an issue? |
| | | Is enforcement adequate? |
| Aquaculture | All villagers | Does aquaculture currently occur in the village? What species? |
| | | Is there interest in developing aquaculture? |
| | | What species and techniques? |
| | | What are the limitations to aquaculture? |
| Assistance | All villagers | What do you need to be successful? |
| | | How can we help? |

## Appendix 2 Freshwater, estuarine and marine fish species designated as high importance to villages in the Sre Ambel River system, Cambodia

| # | Species |
|---|---|
| | **Ambassidae** |
| 1 | *Ambassis buruensis* (Bleeker 1856) Buru glass perchlet |
| 2 | *Ambassis kopsii* (Bleeker 1856) Singapore glassy perchlet |
| 3 | *Parambassis siamensis* (Fowler 1937) |
| | **Anabantidae** |
| 4 | *Anabas testudineus* (Bloch 1792) |
| | **Ariidae** |
| 5 | *Hexanematichthys sagor* (Hamilton 1822) Sagor catfish |
| | **Bagridae** |
| 6 | *Hemibagrus filamentus* (Fang & Chaux 1949) |
| 7 | *Hemibagrus nemurus* (Valenciennes 1840) Asian redtail catfish |
| 8 | *Mystus albolineatus* (Roberts 1994) whiteline catfish |
| 9 | *Mystus rhegma* (Fowler 1935) |
| 10 | *Mystus wolffi* (Bleeker 1951) |
| 11 | *Pseudomystus siamensis* (Regan 1913) Asian bumblebee catfish |
| | **Belonidae** |
| 12 | *Xenentodon cancila* (Hamilton 1822) freshwater garfish |
| | **Channidae** |
| 13 | *Channa gachua* (Hamilton 1822) walking snakehead |
| 14 | *Channa lucius* (Cuvier 1831) |
| 15 | *Channa micropeltes* (Cuvier 1831) Indonesian snakehead |
| 16 | *Channa striata* (Block 1793) striped snakehead |
| | **Clariidae** |
| 17 | *Clarias batrachus* (Linnaeus 1758) Philippine catfish |
| 18 | *Clarias macrocephalus* (Günther 1864) bighead catfish |
| 19 | *Clarias nieuhofii* (Valenciennes 1840) slender walking catfish |
| | **Clupeidae** |
| 20 | *Anodontostoma chacunda* (Hamilton 1822) Chacunda gizzard shad |
| | **Cyprinidae** |
| 21 | *Barbodes aurotaeniatus* (Tirant 1885) |
| 22 | *Barbodes rhombeus* (Kottelat 2000) spotted barb |
| 23 | *Barbonymus altus* (Günther 1868) red tailed tinfoil |
| 24 | *Barbonymus gonionotus* (Bleeker 1849) silver barb |
| 25 | *Barbonymus schwanenfeldii* (Bleeker 1854) tinfoil barb |
| 26 | *Crossocheilus atrilimes* (Kottelat 2000) |
| 27 | *Cyclocheilichthys apogon* (Valenciennes 1842) beardless barb |
| 28 | *Cyclocheilichthys armatus* (Valenciennes 1842) white eye barb |
| 29 | *Desmopuntius johorensis* (Duncker 1904) striped barb |
| 30 | *Discherodontus ashmeadi* (Fowler 1937) |
| 31 | *Esomus longimanus* (Lunel 1881) Mekong flying barb |
| 32 | *Esomus metallicus* (Ahl 1923) flying minnow |
| 33 | *Labiobarbus siamensis* (Sauvage 1881) |
| 34 | *Laubuka laubuca* (Hamilton 1822) Indian glass barb |
| 35 | *Mystacoleucus marginatus* (Valenciennes 1842) |
| 36 | *Opsariichthys bidens* (Günther 1873) |
| 37 | *Osteochilus lini* (Fowler 1935) |
| 38 | *Osteochilus microcephalus* (Valenciennes 1842) |
| 39 | *Osteochilus vittatus* (Valenciennes 1842) bonylip barb |
| 40 | *Osteochilus waandersii* (Bleeker 1853) |
| 41 | *Paralaubuca riveroi* (Fowler 1935) |
| 42 | *Poropuntius normani* (Smith 1931) |
| 43 | *Puntigrus partipentazona* (Fowler 1934) tiger barb |
| 44 | *Rasbora amplistriga* (Kottelat 2000) |
| 45 | *Rasbora aurotaenia* (Tirant 1885) pale rasbora |
| 46 | *Rasbora borapetensis* (Smith 1934) blackline rasbora |
| 47 | *Rasbora dusonensis* (Bleeker 1850) rosefin rasbora |
| 48 | *Rasbora hobelmani* (Kottelat 1984) Kottelat rasbora |
| 49 | *Rasbora paviana* (Tirant 1885) sidestripe rasbora |
| 50 | *Rasbora rubrodorsalis* (Donos-Büchner & Schmidt 1997) |
| 51 | *Rasbora tornieri* (Ahl 1922) yellowtail rasbora |
| 52 | *Scaphognathops stejnegeri* (Smith 1931) |
| | **Datnioididae** |
| 53 | *Datnioides polota* (Hamilton 1822) four-barred tigerfish |
| 54 | *Datnioides undecimradiatus* (Roberts & Kottelat 1994) Mekong tiger perch |
| | **Eleotridae** |
| 55 | *Butis koilomatodon* (Bleeker 1849) mud sleeper |
| 56 | *Oxyeleotris marmorata* (Bleeker 1852) marble goby |
| | **Gerreidae** |
| 57 | *Gerres filamentosus* (Culvier 1829) whipfin silver-biddy |
| | **Hemiramphidae** |
| 58 | *Hyporhamphus limbatus* (Valenciennes 1847) congaturi halfbeak |
| | **Latidae** |
| 59 | *Lates calcarifer* (Bloch 1790) barramundi |
| | **Mastacembelidae** |
| 60 | *Macrognathus circumcintus* (Hora 1924) |
| 61 | *Macrognathus maculatus* (Culvier 1832) frecklefin eel |
| 62 | *Macrognathus semiocellatus* (Roberts 1986) eyespot spiny eel |
| 63 | *Macrognathus siamensis* (Günther 1861) peacock eel |
| 64 | *Mastacembelus armatus* (Lacepède 1800) zig-zag eel |
| 65 | *Mastacembelus erythrotaenia* (Bleeker 1850) fire eel |
| 66 | *Mastacembelus favus* (Hora 1924) tire track eel |

## Appendix 2 Cont'd

| # | Species |
|---|---|
| 67 | *Nandus nandus* (Hamilton 1822) Gangetic leaffish |
| | **Notopteridae** |
| 68 | *Notopterus notopterus* (Pallas 1769) bronze featherback |
| | **Osphronemidae** |
| 69 | *Betta splendens* (Regan 1910) Siamese fighting fish |
| 70 | *Osphronemus exodon* (Roberts 1994) elephant ear gourami |
| 71 | *Osphronemus goramy* (Lacepède 1801) giant gourami |
| 72 | *Trichopodus pectoralis* (Regan 1910) snakeskin gourami |
| 73 | *Trichopodus trichopterus* (Pallas 1770) three spot gourami |
| 74 | *Trichopsis vittata* (Cuvier 1831) croaking gourami |
| | **Pristolepididae** |
| 75 | *Pristolepis fasciata* (Bleeker 1851) Malayan leaffish |

| # | Species |
|---|---|
| | **Scatophagidae** |
| 76 | *Scatophagus argus* (Linnaeus 1766) spotted scat |
| | **Siluridae** |
| 77 | *Ompok urbaini* (Fang & Chaux 1949) |
| 78 | *Wallago micropogon* (Ng 2004) |
| | **Synbranchidae** |
| 79 | *Monopterus albus* (Zuiew 1793) Asian swamp eel |
| | **Tetraodontidae** |
| 80 | *Dichotomyctere ocellatus* (Steindachner 1870) eyespot puffer |
| 81 | *Pao cambodgiensis* (Chabanaud 1923) |
| 82 | *Pao cochinchinensis* (Steindachner 1866) |
| | **Toxotidae** |
| 83 | *Toxotes chatareus* (Hamilton 1822) spotted archerfish |

## Appendix 3 Freshwater, estuarine and marine fish species designated as medium importance to villages in the Sre Ambel River system, Cambodia

| # | Species |
|---|---|
| | **Ambassidae** |
| 1 | *Parambassis apogonoides* (Bleeker 1851) iridescent glassy perchlet |
| 2 | *Ambassis gymnocephalus* (Lacepède 1802) bald glassy |
| 3 | *Ambassis vachellii* (Richardson 1846) Vachelli's glass perchlet |
| | **Ariidae** |
| 4 | *Arius maculatus* (Thunberg 1792) spotted catfish |
| 5 | *Arius venosus* (Valenciennes 1840) veined catfish |
| 6 | *Cryptarius truncatus* (Valenciennes 1840) |
| 7 | *Hemiarius stormii* (Bleekeri 1858) armoured sea catfish |
| 8 | *Nemapteryx caelata* (Valenciennes 1840) engraved catfish |
| 9 | *Netuma thalassina* (Rüppell 1837) giant catfish |
| 10 | *Osteogeneiosus militaris* (Linnaeus 1758) soldier catfish |
| 11 | *Sciades sona* (Hamilton 1822) Sona sea catfish |
| | **Bagridae** |
| 12 | *Bagrichthys macracanthus* (Bleeker 1854) black lancer catfish |
| 13 | *Bagrichthys obscurus* (Ng 1999) |
| 14 | *Hemibagrus spilopterus* (Ng & Rainboth 1999) blackspotted catfish |
| 15 | *Mystus atrifasciatus* (Fowler 1937) |
| 16 | *Mystus bocourti* (Bleeker 1864) |
| 17 | *Mystus multiradiatus* (Roberts 1992) |
| 18 | *Mystus mysticetus* (Roberts 1992) |
| 19 | *Mystus singaringan* (Bleeker 1846) |
| 20 | *Pseudomystus stenomus* (Valenciennes 1840) |

| # | Species |
|---|---|
| | **Callionymidae** |
| 21 | *Tonlesapia tsukwakii* (Motoura & Mukai 2006) |
| | **Carangidae** |
| 22 | *Carangoides bajad* (Forsskål 1775) orangespotted trevally |
| 23 | *Carangoides ferdau* (Forsskål 1775) blue trevally |
| 24 | *Carangoides hedlandensis* (Whitley 1934) bumpnose trevally |
| 25 | *Selar crumenophthalmus* (Bloch 1793) bigeye scad |
| 26 | *Selaroides leptolepis* (Cuvier 1833) yellowstripe scad |
| | **Channidae** |
| 27 | *Channa marulioides* (Bleeker 1851) |
| | **Cichlidae** |
| 28 | *Oreochromis mossambicus* (Peters 1852) Mozambique tilapia |
| 29 | *Oreochromis niloticus* (Linnaeus 1758) Nile tilapia |
| | **Clariidae** |
| 30 | *Clarias gariepinus* (Burchell 1822) North African catfish |
| 31 | *Clarias meladerma* ( Bleeker 1846) blackskin catfish |
| | **Clupeidae** |
| 32 | *Clupeichthys aesarnensis* (Wongratana 1983) Thai river sprat |
| 33 | *Clupeichthys goniognathus* (Bleeker 1855) Sumatran river sprat |
| 34 | *Nematalosa nasus* (Bloch 1795) Bloch's gizzard shad |
| 35 | *Tenualosa thibaudeaui* (Durand 1940) Laotian shad |
| | **Cynoglossidae** |
| 36 | *Cynoglossus cynoglossus* (Hamilton 1822) Bengal tongue sole |

## Appendix 3 Cont'd

| # | Species |
|---|---|
| | **Cyprinidae** |
| 37 | *Amblypharyngodon chulabhornae* (Vidthayanon & Keottelat 1990) |
| 38 | *Anematichthys repasson* (Bleeker 1853) Mekong barb |
| 39 | *Balantiocheilos ambusticauda* (Ng & Kottelat 2007) burnt tail fish |
| 40 | *Boraras urophthalmoides* (Kottelat 1991) least rasbora |
| 41 | *Crossocheilus reticulatus* (Fowler 1934) reticulate flying fox |
| 42 | *Cyclocheilichthys lagleri* (Sontirat 1989) |
| | **Cyprinidae** |
| 43 | *Garra fasciacauda* (Fowler 1937) |
| 44 | *Garra fisheri* (Fowler 1937) |
| 45 | *Hampala dispar* (Smith 1934) |
| 46 | *Hampala macrolepidota* (Kuhl & Van Hasselt 1823) Hempala barb |
| 47 | *Hypsibarbus lagleri* (Rainboth 1996) |
| 48 | *Hypsibarbus malcolmi* (Smith 1945) golden tinfoil barb |
| 49 | *Hypsibarbus pierrei* (Sauvage 1880) |
| 50 | *Hypsibarbus suvattii* (Rainboth 1996) |
| 51 | *Hypsibarbus wetmorei* (Smith 1931) |
| 52 | *Labeo chrysophekadion* (Bleeker 1849) black sharkminnow |
| 53 | *Laubuka caeruleostigmata* (Smith 1931) leaping barb |
| 54 | *Lobocheilos melanotaenia* (Fowler 1935) |
| 55 | *Lobocheilos rhabdoura* (Fowler 1934) |
| 56 | *Luciosoma setigerum* (Valenciennes 1842) |
| 57 | *Neolissochilus soroides* (Duncker 1904) |
| 58 | *Neolissochilus stracheyi* (Day 1871) |
| 59 | *Onychostoma gerlachi* (Peters 1881) |
| 60 | *Onychostoma ovale* (Pellegrin & Chevey 1936) |
| 61 | *Opsarius koratensis* (Smith 1931) |
| 62 | *Opsarius pulchellus* (Smith 1931) |
| 63 | *Parachela oxygastroides* (Bleeker 1852) glass fish |
| 64 | *Parachela siamensis* (Günther 1868) |
| 65 | *Paralaubuca barroni* (Fowler 1934) |
| 66 | *Paralaubuca harmandi* (Sauvage 1883) |
| 67 | *Paralaubuca typus* (Bleeker 1864) |
| 68 | *Poropuntius kontumensis* (Chevey 1934) |
| 69 | *Poropuntius laoensis* (Günther 1868) |
| 70 | *Probarbus jullieni* (Sauvage 1880) Isok barb |
| 71 | *Probarbus labeamajor* (Roberts 1992) thicklip barb |
| 72 | *Probarbus labeaminor* (Roberts 1992) thinlip barb |
| 73 | *Puntioplites bulu* (Bleeker 1851) |
| 74 | *Puntioplites proctozystron* (Bleeker 1865) |
| 75 | *Puntius brevis* (Bleeker 1849) swamp barb |
| 76 | *Rasbora daniconius* (Hamilton 1822) slender rasbora |
| 77 | *Rasbora myersi* (Brittan 1954) Myer's silver rasbora |
| 78 | *Rasbora trilineata* (Steindachner 1870) three-lined rasbora |
| 79 | *Systomus orphoides* (Valenciennes 1842) red cheek barb |
| 80 | *Trigonostigma espei* (Meinken 1967) lambchop rasbora |
| | **Dasyatidae** |
| 81 | *Hemitrygon laosensis* (Roberts & Karnasuta 1987) Mekong stingray |
| | **Eleotridae** |
| 82 | *Butis butis* (Hamilton 1822) duckbill sleeper |
| | **Gerreidae** |
| 83 | *Gerres erythrourus* (Bloch 1791) deep-bodied mojarra |
| | **Gobiidae** |
| 84 | *Aulopareia janetae* (Smith 1945) scalycheek goby |
| | **Haemulidae** |
| 85 | *Pomadasys maculatus* (Bloch 1793) saddle grunt |
| | **Heteropneustidae** |
| 86 | *Heteropneustes kemratensis* (Fowler 1937) stinging catfish |
| | **Latidae** |
| 87 | *Psammoperca waigensis* (Cuvier 1828) Waigeu seaperch |
| | **Leiognathidae** |
| 88 | *Eubleekeria splendens* (Cuvier 1829) splendid pony |
| 89 | *Leiognathus equulus* (Forsskål 1775) common ponyfish |
| | **Lethrinidae** |
| 90 | *Gymnocranius griseus* (Temminck & Schlegel 1843) grey large-eye bream |
| 91 | *Lethrinus nebulosus* (Forsskål 1775) spangled emperor |
| | **Lutjanidae** |
| 92 | *Lutjanus argentimaculatus* (Forsskål 1775) mangrove red snapper |
| 93 | *Lutjanus johnii* (Bloch 1792) John's snapper |
| 94 | *Lutjanus malabaricus* (Bloch & Schneider 1801) Malabar blood snapper |
| 95 | *Lutjanus russellii* (Bleeker 1849) Russell's snapper |
| | **Mastacembelidae** |
| 96 | *Macrognathus* sp. |
| | **Mugilidae** |
| 97 | *Crenimugil buchanani* (Bleeker 1853) bluetail mullet |
| 98 | *Crenimugil seheli* (Forsskål 1775) bluespot mullet |
| 99 | *Ellochelon vaigiensis* (Quoy & Gaimard 1825) squaretail mullet |
| | **Nemacheilidae** |
| 100 | *Schistura kengtungensis* (Fowler 1936) |
| 101 | *Schistura magnifluvis* (Kottelat 1990) |
| | **Ophichthidae** |
| 102 | *Ophichthus rutidoderma* (Bleeker 1852) olive snake eel |

## Appendix 3 Cont'd

| # | Species |
|---|---|
| | **Osphronemidae** |
| 103 | *Betta prima* (Kottelat 1994) |
| 104 | *Trichopodus microlepis* (Günther 1861) moonlight gourami |
| 105 | *Trichopsis pumila* (Arnold 1936) pigmy gourami |
| 106 | *Scleropages formosus* (Müller & Schlegel 1840) Asian bonytongue |
| | **Pangasiidae** |
| 107 | *Helicophagus waandersii* (Bleeker 1858) |
| 108 | *Pangasianodon hypophthalmus* (Sauvage 1878) striped catfish |
| 109 | *Pangasius djambal* (Bleeker 1846) |
| 110 | *Pangasius larnaudii* (Bocourt 1866) spot pangasius |
| | **Plotosidae** |
| 111 | *Plotosus canius* (Hamilton 1822) grey eel-catfish |
| 112 | *Plotosus lineatus* (Thunberg 1787) striped eel catfish |
| | **Scombridae** |
| 113 | *Rastrelliger brachysoma* (Bleeker 1851) short mackerel |
| | **Serranidae** |
| 114 | *Cephalopholis boenak* (Bloch 1790) chocolate hind |
| 115 | *Cephalopholis formosa* (Shaw 1812) bluelined hind |
| 116 | *Cephalopholis miniata* (Forsskål 1775) coral hind |
| 117 | *Cromileptes altrivelis* (Valenciennes 1828) humpback grouper |
| 118 | *Epinephelus amblycephalus* (Bleeker 1857) banded grouper |
| 119 | *Epinephelus areolatus* (Forsskål 1775) areolate grouper |
| 120 | *Epinephelus coioides* (Hamilton 1822) orange-spotted grouper |
| 121 | *Epinephelus quoyanus* (Valenciennes 1830) longfin grouper |
| 122 | *Epinephelus sexfaciatus* (Valenciennes 1828) sixbar grouper |
| | **Siganidae** |
| 123 | *Siganus argenteus* (Quoy & Gaimard 1825) streamlined spinefoot |
| 124 | *Siganus canaliculatus* (Park 1797) white-spotted spinefoot |
| 125 | *Siganus guttatus* (Bloch 1787) orange-spotted spinefoot |
| 126 | *Siganus javus* (Linnaeus 1766) streaked spinefoot |
| | **Siluridae** |
| 127 | *Kryptopterus cheveyi* (Durand 1940) |
| 128 | *Kryptopterus dissitus* (Ng 2001) Indochinese sheatfish |
| 129 | *Ompok bimaculatus* (Bloch 1794) butter catfish |
| 130 | *Ompok eugeneiatus* (Vaillant 1893) Malay glass catfish |
| 131 | *Pterocryptis torrentis* (Kobayakawa 1989) |
| 132 | *Silurichthys hasseltii* (Bleeker 1858) |
| 133 | *Silurichthys schneideri* (Volz 1904) |
| 134 | *Wallago leeri* (Bleeker 1851) striped wallago catfish |
| | **Synbranchidae** |
| 135 | *Macrotrema* sp. |
| 136 | *Ophisternon bengalense* (McClelland 1844) beneal eel |
| | **Tetraodontidae** |
| 137 | *Dichotomyctere nigroviridis* (Marion de Procé 1822) spotted green pufferfish |
| 138 | *Pao baileyi* (Sontirat 1985) hairy puffer |
| | **Toxotidae** |
| 139 | *Toxotes microlepis* (Günther 1860) smalescale archerfish |
| | **Zenarchopteridae** |
| 140 | *Zenarchopterus buffonis* (Valenciennes 1847) Buffon's river-garfish |
| 141 | *Zenarchopterus ectuntio* (Hamilton 1822) halfbeak |

## Appendix 4 Aquatic non-fish species designated as high importance to villages in the Sre Ambel River system, Cambodia

| # | Species |
|---|---|
| **Crustaceans** | |
| | **Attidae** |
| 1 | *Neocaridina serrata* |
| 2 | *Neocaridina* sp. |
| | **Gecarcinucidae** |
| 3 | *Somaniathelpusa* spp. black rice crab |
| | **Palaemonidae** |
| 4 | *Macrobrachium lotidachylus* |
| 5 | *Macrobrachium nipponese* |
| 6 | *Macrobrachium ohione* |
| 7 | *Macrobrachium rosenbergii* giant freshwater prawn |
| | **Potamidae** |
| 8 | *Johora tiomanensis* |
| **Molluscs** | |
| | **Ampullaridae** |
| 9 | *Pila gracilis* apple snail |
| 10 | *Pila scutata* Pila snail |
| | **Viviparidae** |
| 11 | *Mekongina pongensis* aeruginose snail |
| 12 | *Mekongina* sp. |

## Appendix 4 Cont'd

| # | Species |
|---|---|
| **Reptiles** | |
| | **Geoemydidae** |
| 13 | *Batagur* spp. royal turtle or mangrove turtle |
| 14 | *Cuora amboinensis* Asian box turle |
| 15 | *Heosemys annandalii* yellow-headed temple turtle |
| 16 | *Heosymes grandis* Asian giant terrapin |
| 17 | *Malayemys subtrijuga* rice-field terrapin |
| 18 | *Siebenrockiella crassicollis* black marsh turtle |
| | **Testudinidae** |
| 19 | *Indotestudo elongata* elongated tortoise |
| | **Trionychidae** |
| 20 | *Amyda cartilaginea* Asiatic soft-shell turtle |

 

# The status of coral reefs and seagrass meadows in the Kep Archipelago, Cambodia

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## មូលន័យសង្ខេប

បរិស្ថានសមុទ្រនៅក្នុងប្រទេសកម្ពុជាទទួលរងការគំរាមកំហែងដោយសកម្មភាពនេសាទខុសច្បាប់ ដែលបានបំផ្លិចបំផ្លាញទីជម្រក និងការដកហូតធនធានហួសកម្រិត។ ពីឆ្នាំ២០១៤ ដល់ ២០១៥ និងឆ្នាំ២០១៧ ពួកយើងបានធ្វើការអង្កេតទៅលើស្ថានភាពផ្កាថ្ម ចំនួន០៣កន្លែងគឺនៅ កោះសេះ កោះម៉ាក់ប្រាង និងកោះអង្រ្កង ស្ថិតនៅក្នុងប្រជុំកោះកែប ហើយក្នុងឆ្នាំ២០១៨ យើងបានប្រមូលទិន្នន័យមូលដ្ឋាននៃស្មៅសមុទ្រនៅតាមកោះសេះ កោះពូ និងកោះទន្សាយ។ តាមការស្រាវជ្រាវក្នុងឆ្នាំ២០១៤ ដល់ ២០១៥ បានបង្ហាញពីភាពអន់ថយនៃជីវិតសត្វត្រីដែលរស់នៅក្នុងតំបន់ផ្កាថ្ម។ ទោះជាយ៉ាងណា ដង់ស៊ីតេ និងភាពចម្រុះរបស់ត្រីមានការកើនឡើងគួរឱ្យកត់សម្គាល់ក្នុងរយៈពេល០៤ឆ្នាំកន្លងមកនេះ ហើយក៏មានការកើនឡើងផងដែរនូវតម្លៃផលនេសាទគោលដៅ ដែលមានដូចជា ក្រុមត្រី lutjanids serranids carangids និង haemulids។ ពពួកត្រីប្រភេទតិណាសី មិនសូវប្រទះឃើញទេ ហើយប្រភេទកាំប្រមាសមុទ្រ(តាអន់ *Diadema* spp.) នៅតែជាប្រភេទតិណាសីដែលសម្បូរជាងគេ។ ទោះជាបែបនេះក្តី ក្រុមត្រីsiganids មានការកើនឡើងគួរឱ្យកត់សម្គាល់នៅតំបន់ផ្កាថ្មនៃកោះសេះ។ ការលូតលាស់របស់សារាយសមុទ្រមានខ្នាតធំ(macroalga) មានកម្រិតទាបនៅឆ្នាំ២០១៧(គ្របដណ្តប់១%) ហើយផ្កាថ្មរឹង(hard corals) គឺជាស្រទាប់លេចធ្លោជាងគេក្នុងគ្រប់ករណីទាំងអស់(គ្របដណ្តប់៤២.៩%)។ តំបន់ស្មៅសមុទ្រ០៣កន្លែងត្រូវបានដៅក្នុងដែនទី។ ស្មៅសមុទ្រទាំងនោះគ្របដណ្តប់លើផ្ទៃដីប្រមាណ ៧.៥គម$^{2}$ ដែលក្នុងនោះមានស្មៅសមុទ្រចំនួន០៩ប្រភេទត្រូវបានកត់ត្រា។ ស្មៅសមុទ្រប្រភេទ*Thalassia hemprichii* ជាប្រភេទដែលមានច្រើនជាងគេនៅក្នុងតំបន់នីមួយៗ គឺមានរហូតដល់៧៦%នៃសំណាកទាំងអស់។ យុទ្ធសាស្ត្រអភិរក្សតាមការលើកកម្ពស់ការស្តារប្រព័ន្ធអេកូឡូស៊ីសមុទ្រនៅប្រជុំកោះកែបត្រូវបានអនុវត្តនៅក្នុងឆ្នាំ២០១៨ ដោយរាប់បញ្ចូលទាំងការបង្កើតដែនគ្រប់គ្រងជលផលសមុទ្រ និងការស្តារឡើងវិញយ៉ាងសកម្ម និងកិច្ចផ្តួចផ្តើមឲ្យមានការគ្រប់គ្រងសហគមន៍។ ការសិក្សាតាមដានជាបន្តគឺជាតម្រូវការចាំបាច់ដើម្បីវាយតម្លៃអំពីប្រសិទ្ធភាពនៃកិច្ចខំប្រឹងប្រែងកន្លងមក។ យើងសូមណែនាំឱ្យមានការសិក្សាពីផលប៉ះពាល់ និងការសិក្សាស្រាវជ្រាវពីប្រភេទដែលរស់នៅតាមតំបន់ស្មៅសមុទ្រ ព្រមទាំងសិក្សាតាមដានពីសកម្មភាពនេសាទខុសច្បាប់ ដើម្បីឈានទៅដល់ការយល់ដឹងកាន់តែប្រសើរឡើងអំពីស្ថានភាព និងកត្តាគំរាមកំហែងលើបរិស្ថានសមុទ្រនៅប្រជុំកោះកែប។

## Abstract

Cambodia's marine environment is threatened by illegal fishing activities that destroy habitat and overexploit resources. We investigated the status of three coral reefs fringing the Koh Seh, Koh Mak Prang and Koh Angkrong islands within the Kep Archipelago in 2014/15 and 2017 and collected baseline data on seagrass meadows adjacent to the Koh Seh, Koh Pou and Koh Tonsay islands in 2018. Surveys in 2014/15 revealed a paucity of fish life on reefs. However, total fish density and diversity increased significantly within four years and included increases of high-value fishery targets such as lutjanids, serranids, carangids and haemulids. Fish herbivores were poorly represented and the urchin *Diadema* sp. remained the dominant herbivore over time. Despite this, siganids increased significantly on the Koh Seh reef. Total

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macroalgal growth was relatively low in 2017 (1% cover) and hard corals were the dominant substrate in all cases (42.9% cover). Three seagrass meadows were mapped. These covered a total estimated area of 7.5 km$^2$ where nine species of seagrass were recorded. *Thalassia hemprichii* was dominant in each meadow, being present in 76% of samples. A conservation strategy to promote the recovery of marine ecosystems in the Kep Archipelago was implemented in 2018 and included the establishment of a marine fisheries management area and active restoration and community management initiatives. Monitoring is required to assess the effectiveness of this effort over time. We recommend this include impact assessments and species surveys in seagrass meadows and monitoring of illegal fishing activities to better understand the status of the marine environment of the Kep Archipelago and threats to this.

## Keywords

Fishing, Gulf of Thailand, marine angiosperms, reef ecosystems.

## Introduction

Fishery resources in the South China Sea (including the Gulf of Thailand) have been exploited unsustainably for decades, resulting in loss of habitat and biodiversity and altered trophic structures (Chou *et al*., 2002; UNEP, 2007b; Teh *et al*., 2017). Productivity has been particularly threatened by intensive inshore fishing and degradation of key ecosystems that support fisheries (UNEP, 2007b; Vo *et al*., 2013; Rogers *et al*., 2018). Destructive fishing methods have been identified as one of the most important drivers of degradation of marine ecosystems in the region, particularly for their contribution to the loss of coral reefs and seagrass meadows (Vo *et al*., 2013).

Coral reefs and seagrass meadows are vital to the livelihoods of many people that inhabit coastal provinces in Cambodia (UNEP, 2007a, 2008b; FAO, 2011). Small-scale fishers and commercial fisheries operate within the shallow inshore area, catching species associated with these habitats. High and low-value fish, shrimp, crab and squid are the main targets, with reef fishes being among the most valuable (UNEP, 2007a; UNEP, 2007b; Teh *et al*., 2014). Although marine fisheries only constitute approximately 20% of Cambodia's total annual fisheries production, with the majority coming from inland freshwater fisheries (Gillett, 2004; Paul & Keothyda, 2017), illegal fishing by national and foreign vessels is common and total marine fisheries catches have been estimated to be over twice the number of recorded landings (Teh *et al*., 2014). The Cambodian Fisheries Law (2006: Article 52) prohibits fishing or any form of exploitation that damages or disturbs the growth of seagrass or coral reefs. It also prohibits the use of destructive methods, including trawling of inshore fishing areas between the shore and the 20 m isobath (Article 49). However, enforcement of regulations has been generally poor and trawling and push net techniques remain among the most immediate threats to seagrass meadows. Over-fishing and destructive practices such as dynamite and cyanide fishing are also considered to present major threats to coral reefs (UNEP, 2007a, 2008b; Bobenrieth & Sun, 2012; Razak Latun *et al*., 2016; Paul & Keothyda, 2017).

Habitat destruction and other pressures have caused significant declines to Cambodia's inshore fisheries, which have been increasingly fished over time (Gillet, 2004; UNEP, 2007b; Leng, 2013). It is believed that the country's marine fisheries began declining in the 1980s when the number of trawling vessels expanded (Teh *et al*., 2014). A second expansion occurred in 1999–2000, which resulted in a high concentration of trawlers along Cambodia's coast (Gillett, 2008). As a consequence, the small-scale fishers that once dominated the inshore fishing areas are now in conflict with illegal fishers over space and resources (UNEP, 2007b; Sherman *et al*., 2007; Gillett, 2008).

The Cambodia-based NGO, Marine Conservation Cambodia (MCC) was invited by the Cambodian Fisheries Administration (FiA) to undertake research and monitoring on coral reef ecosystems and assist with the development and implementation of a conservation strategy in Kep Province in 2014. Kep is the smallest of Cambodia's four coastal provinces in terms of area and human population, although it has a relatively high population density. The mainland area is surrounded by Kampot Province, whereas the Kep Archipelago shares its eastern and southern borders with Vietnam's territorial sea. The archipelago includes 13 islands, most of which include fringing coral reefs, and has some of the most extensive and diverse seagrass meadows remaining in Cambodia (UNEP, 2008b; Vibol *et al*., 2010). Coral reefs and seagrass meadows share trophic linkages with mangroves and collectively form a significant part of the area's broader network of ecosystems (Davis *et al*., 2014). These habitats collectively provide food security and income for a large portion of the local population (UNEP, 2007a, 2008a,b; Bobenrieth & Sun, 2012; Sopanha *et al*., 2012). Crab, shrimp and finfish fisheries are among

 

the most important fisheries in Kep, with coral reefs supporting the most valuable species (UNEP, 2007b; Rizvi & Singer, 2011). UNEP (2007a) surveyed reefs fringing the Koh Pou island group in the Kep Archipelago in 2013 and found that high-value and common fisheries targets were lacking, whereas benthic assemblages appeared to be in better condition. The depleted fish life was largely attributed to the effects of seaweed farming rather than over-fishing, although signs of destructive fishing were observed along with discarded fishing gears. The current status of reefs in the Kep Archipelago is unknown and to our knowledge, research on seagrass has yet to be conducted.

This study documents the status of three fringing reefs in the Kep Archipelago between 2014/15 and 2017 and presents baseline data on benthic assemblages and seagrass meadows collected in the archipelago in 2017 and 2018. We assess changes in the density and diversity of reef fish over time, in addition to selected indicator organisms and major functional groups of herbivore. We conclude by relating our results to conservation efforts and illegal fishing pressures in the Kep Archipelago, and by outlining a conservation strategy that came to fruition in 2018, including the establishment of the Kep Marine Fisheries Management Area (MFMA).

## Methods

### Study area and locations

First proposed in 2016, the Kep MFMA was established in April 2018 and encompasses 113 km$^2$ (Fig. 1). Three fringing reefs within the MFMA were selected by MCC and FiA based on their perceived condition. These appeared to be among the least degraded in the archipelago and were dominated by hard coral and so were regarded as potentially important to protect and most likely to respond to conservation action.

The three reefs varied in size and fringe the Koh Seh (Koh Ach Seh), Koh Mak Prang and Koh Angkrong islands (Fig. 1; Table 1). Koh Seh and Koh Angkrong are situated approximately 1 km apart and both are located approximately 3 km from Koh Mak Prang.

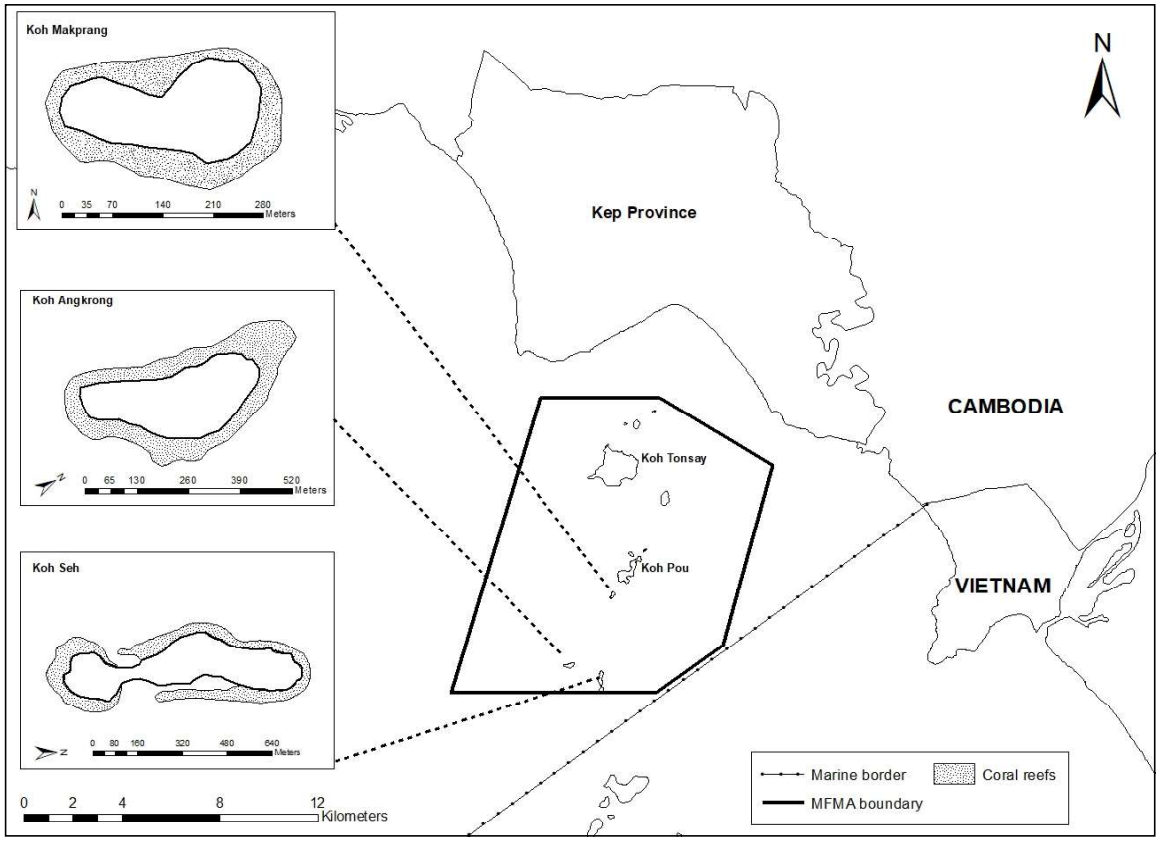


**Fig. 1** The Kep Archipelago including the Koh Seh, Koh Mak Prang, Koh Angkrong, Kou Pou and Koh Tonsay islands.

**Table 1** Survey effort in the Kep Archipelago in 2014/2015 and 2017.

| Reef | Area ($km^2$) | 2014/15 | | | | 2017 | | | |
|---|---|---|---|---|---|---|---|---|---|
| | | Sites | Replicates | Surveys | Period | Sites | Replicates | Surveys | Period |
| Koh Seh | 0.076 | 20 | 1 | 80 | Mar 14 | 5 | 3 | 60 | Apr–Dec |
| Koh Mak Prang | 0.023 | 7 | 1 | 28 | Jan 15 | 3 | 3 | 36 | Apr–Aug |
| Koh Angkrong | 0.059 | 9 | 1 | 36 | Jan–Feb 15 | 3 | 3 | 36 | Feb–Apr |

Three seagrass meadows were selected on the basis of their being the main meadows known to local fishers within the archipelago. These are located adjacent to the Koh Seh, Koh Pou and Koh Tonsay islands. Koh Seh is situated approximately 3.8 km from Koh Pou and 7.7 km from Koh Tonsay. Koh Pou and Koh Tonsay are situated approximately 2.8 km apart (Fig. 1).

## Coral reef surveys

Our procedures for collecting field data followed a modified version of the Reef Check international guidelines for coral reef monitoring, as detailed by Hodgson *et al*. (2006). Dive surveys were conducted by MCC staff and volunteers to collect data on substrates, reef impacts, fish and invertebrates. Volunteer involvement was mainly associated with the 2014 reef surveys and 2018 seagrass surveys. With the exception of pier surveys on the Koh Seh reef, 100 m belt transects were created parallel to reef crests. These were divided into four survey segments which were 5 m in width and 20 m in length and separated by 5 m intervals. As a consequence, 100 $m^2$ of reef was examined in each segment. Fish were recorded up to the water surface, which was ≤5 m above the transect line at all sites.

Survey effort differed between years for each of the monitored reefs (Table 1). Baseline surveys were undertaken in 2014 on the Koh Seh reef and in 2015 on the Koh Mak Prang and Koh Angkrong reefs. These included the entirety of each reef system so as to map their extent. By 2017, five survey sites had been established on the Koh Seh reef (including one pier site) and three sites on the Koh Mak Prang and Koh Angkrong reefs for monitoring purposes.

*Substrate*—Substrates were classified following Hodgson *et al*. (2006). Categories included live hard coral, recently killed coral, coral rubble, soft coral, nutrient indicator algae, sponges, zoanthids, rock, sand, silt/clay and other. These were recorded at 0.5 m intervals within each 20 m survey segment by lowering a plumb line at each point and registering the substrate directly beneath. Comparisons of substrates over time are not included in our study due to methodological differences between 2014/15 and 2017. Instead, substrate data collected in 2017 are presented as a baseline.

*Impact assessments*—The degree of coral damage and trash was recorded at each site. Categories for coral damage included boat/anchor, dynamite and other, whereas trash categories included fishing gear and other. The extent of these were recorded using the following scale: 0 = None, 1 = low (one piece/damage per 20 m survey segment), 2 = medium (two to four pieces/damage per 20 m survey segment) and 3 = high (more than four pieces/damage per 20 m survey segment).

*Fish and invertebrates* – Divers surveyed for indicator taxa recognised for their ecological and economic importance to the Kep Archipelago and coral reefs globally. These included the Reef Check indicator organisms, Green & Bellwood's (2009) key herbivorous fish families, and additional fish taxa selected by MCC (Appendix A). Similar taxa were monitored by van-Bochove *et al*. (2011) and Thorne *et al*. (2015) to assess the status of coral reefs in the Koh Rong Archipelago of Cambodia. Surveyors identified and counted fishes in each 20 m survey segment. A small number of trained MCC surveyors collected data from the Koh Seh reef in 2014, while one trained MCC surveyor, not present for 2014 surveys, collected data on the reefs in 2015 and 2017.

## Seagrass surveys

Seagrass meadows were investigated over approximately two weeks in October–November 2018. We determined the extent of seagrass habitat and collected data on the seagrass species present. Remote sensing was not employed because water clarity was generally poor. Instead, the three main areas of seagrass within the archipelago were mapped by ground truthing. Preliminary dives were made in each instance to determine the general boundaries of each meadow. We then produced a series of grid maps overlaying each seagrass area and distributed survey sites among the grids. Surveyors at

 

each site swam in predetermined directions (north-south or east-west) for 15 minutes and used 50x50 cm quadrats to record seagrass data every two minutes or when a noticeable change in the benthos was observed (e.g., the edge of a meadow or a change in species). Quadrat data were only recorded over seagrass habitat and the GPS location of each quadrat was recorded. Over the course of the survey, data were obtained from 270 quadrats within the Koh Seh seagrass meadow, 277 quadrats within the Koh Tonsay meadow and 367 quadrats within the Koh Pou meadow.

### Data analysis

Fish density and diversity were compared over time for each of the monitored reefs. Separate analyses were also undertaken for Reef Check indicator organisms (fish and invertebrates: Hodgson *et al*., 2006) and selected herbivorous fish families (Green & Bellwood, 2009). Data was analysed using PAST 3.2 statistical software (Hammer *et al*. 2001). Box and whisker plots and tables were created in Microsoft Excel version 16.16.8, whereas maps were created in ArcGIS version 10.5.1. Diversity analyses were performed across aggregated taxonomic levels (family – species) following Obura (2014). Alpha ($\alpha$) diversities were characterised using the Shannon Weiner Index ($H$) and beta ($\beta$) diversities using Whittaker's (1960) method. Because Shapiro-Wilk tests revealed that datasets (excluding substrates) were not normally distributed, we applied two-tailed (Wilcoxon) Mann-Whitney $U$ tests to compare the density (individuals/100 $m^2$ and individuals/400 $m^2$) and diversity ($H$/100 $m^2$) of taxa between years. One-sample sign tests were undertaken in Excel when a taxon was only observed in one monitoring year. We also used a one-way ANOVA (analysis of variance) with a *post hoc* Tuckey's pairwise test to compare live hard coral cover between the reef sites in 2017. The critical threshold for significance was set at $p<0.05$ in all tests.

## Results

### Substrate

The composition of substrates varied between each of the monitored reefs (Table 2). Live hard coral varied significantly between reefs but was also the dominant substrate in all cases (ANOVA: $F_{2,117}=7.15$, $p=0.001$). Our Tuckey's pairwise test revealed significant differences in cover between the Koh Angkrong and Koh Mak Prang reefs ($p=<0.001$). Hard coral cover on the Koh Seh reef did not differ significantly from the Koh Angkrong reef ($p=0.078$) or the Koh Mak Prang reef ($p=0.159$). Sponges, zoanthids and rock were the next most prevalent groups, respectively. Nutrient indicator algal cover did not exceed 3% on any of the reefs. The Koh Mak Prang reef exhibited the highest mean cover of coral rubble and sponges as well as the lowest mean cover of hard corals, whereas the Koh Seh reef exhibited a relatively high mean zoanthid cover compared to other substrates.

**Table 2** Mean substrate cover of coral reefs studied in the Kep Arichipelago in 2017.

| Substrate (%) | Koh Seh ($n$=60) | Koh Mak Prang ($n$=36) | Koh Angkrong ($n$=36) | Total ($n$=132) |
|---|---|---|---|---|
| Live hard coral | 42.4 (±3.1) | 33.7 (±8.2) | 52.3 (±12.2) | 42.9 (±2.1) |
| Recently killed coral | 0.2 (±0.1) | 0.2 (±0.2) | 0 | 0.1 (±0.1) |
| Coral rubble | 3.2 (±0.5) | 10.1 (±0.6) | 4.9 (±3.8) | 6.3 (±0.7) |
| Soft coral | 0 | 7.1 (±4.5) | 1.6 (±0.6) | 2.6 (±0.5) |
| Nutrient indicator algae | 1.5 (±0.4) | 0.1 (±0.1) | 2.6 (±1.9) | 1 (±0.3) |
| Sponge | 9.2 (±0.8) | 22.6 (±6.2) | 13.8 (±6.2) | 14.7 (±1) |
| Zoanthid | 24.2 (±1.9) | 2.2 (±0.8) | 5.6 (±4.1) | 11.3 (±1.3) |
| Rock | 11.7 (±0.9) | 8.5 (±1.1) | 12.4 (±2.2) | 11.1 (±0.7) |
| Sand | 7.17 (±1) | 8.6 (±1.8) | 5.1 (±1.4) | 7.4 (±0.6) |
| Silt/clay | 0.1 (±0.1) | 1.1 (±0.5) | 0.8 (±0.6) | 0.6 (±0.2) |
| Other | 0.3 (±0.2) | 5.8 (±1.8) | 0.9 (±0.3) | 2 (±0.4) |

### Impact assessment

Levels of coral damage and trash were low across all reefs (Table 3). No coral damage caused by dynamite was observed. Damage caused by boat/anchor decreased on the Koh Seh and Koh Angkrong reefs over time, and the first instances of coral damage on the Koh Mak Prang reef were observed in 2017. Both trash types (fishing gear and other) were observed on each of the reefs, with yearly totals remaining similar over time.

### Indicators of over-exploitation

Four of the eighteen indicators of over-exploitation (excluding *Diadema* sp. and *Acanthaster planci*) monitored were recorded on reefs during the 2014/15 surveys (Table 4). This increased to seven in 2017 with the appearance of sweetlips (Haemulidae), jacks (Carangidae), and the giant clam *Charonia tritonis*. Butterflyfish (Chaetodontidae), grouper (Serranidae), snapper (Lutjanidae), sweetlips and jacks displayed significant increases in density over time. The greatest increases were exhibited by snapper (1,050%) and butterflyfish (157%). High densities of the long-spinned black sea urchin *Diadema* sp. were recorded each monitoring year (>165 individuals/400 $m^2$). Changes in density over time trended downwards but were not significant, although their populations were less variable between reefs in 2017. Only the pencil urchin *Heterocentrotus mammillatus* exhibited a significant decline over time.

### Herbivorous fish

Some major herbivorous fish families and their associated functional groups were entirely absent from the reefs (Table 5). Siganidae was the only family observed on reefs in 2014/15 and was represented by three species. Fish belonging to Siganidae and Ephippidae were observed in 2017 and were represented by six siganid species (including the same species previously recorded) and one ephippid species. Siganids belong to the grazer functional group, whereas ephippids (*Platax* spp.) are browsers. Browsers were represented by only two observations of the batfish *Platax tiera*, whereas other functional groups were not found at all. The total density of ephippids did not change significantly over time, whereas the total density of siganids did (1,700%).

The total density of herbivorous fish (which largely reflects the density of siganids) changed significantly on two of the reefs monitored (Fig. 2). These increased significantly over time on the Koh Seh reef from a median of 0 to 8.5 individuals/100 $m^2$ (2014 mean rank=25.9, 2017 mean rank=44.6, $U$=390, $p$=<0.001), whereas they declined significantly on the Koh Mak Prang reef from a median of 5.5 to 0 individuals/100 $m^2$ (2015 mean rank=17.3, 2017 mean rank=15.3, $U$=310, $p$=0.007). Herbivore density on the Koh Angkrong reef remained at a median of 0 individuals/100 $m^2$ (2015 mean rank=17.3, 2017 mean rank=19.2, $U$=581.5, $p$=0.374). The combined total herbivorous fish density increased significantly over time from a median of 0 to 2 individuals/100 $m^2$ (2014/15 mean rank=59.4, 2017 mean rank=79.1, $U$=5966, $p$=<0.001; Fig 2).

### Fish density and diversity

The density of fish increased significantly over time on each of the reefs. Specifically, median values increased from 14 to 76.5 individuals/100 $m^2$ on the Koh Seh reef (2014 mean rank=27.5, 2017 mean rank=43.2, $U$=589, $p$=<0.001), from 26 to 72 individuals/100 $m^2$ on the Koh Mak Prang reef (2015 mean rank=9.4, 2017 mean rank=23.1, $U$=195.5, $p$=<0.001), and from 10 to 39 individuals/100 $m^2$ on the Koh Angkrong reef (2015 mean rank=10.5, 2017 mean rank=26, $U$=88.5, $p$=<0.001; Fig. 3).

**Table 3** Mean values for coral damage and trash at reefs monitored in the Kep Arichipelago in 2014/15 and 2017.

| Impact Type | 2014/15 | | | 2017 | | | Total | |
|---|---|---|---|---|---|---|---|---|
| | Koh Seh | Koh Mak Prang | Koh Angkrong | Koh Seh | Koh Mak Prang | Koh Angkrong | 2015 | 2017 |
| Coral damage: boat/anchor | 0.1 | 0 | 0.6 | 0 | 0 | 0 | 0.2 | 0 |
| Coral damage: dynamite | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| Coral damage: other | 0.1 | 0 | 0.2 | 0 | 0.7 | 0.3 | 0.1 | 0.4 |
| Trash: fishing gear | 0.4 | 0.3 | 0.4 | 0.1 | 0.3 | 0.8 | 0.4 | 0.4 |
| Trash: other | 0.1 | 0.3 | 0.6 | 0.1 | 0.5 | 0.2 | 0.3 | 0.3 |

Key: 0=none, 1= low (1 piece), 2=medium (2–4 pieces) and 3=high (5+ pieces).

 

**Table 4** Relative occurrence of indicators of over-exploitation on reefs in the Kep Arcipelago in 2014/15 ($n$=36) and 2017 ($n$=33).

| Species / Group | 2014/15 | | 2017 | | Positive Sign * | Test values ($U$, $p$) |
|---|---|---|---|---|---|---|
| | Median Abundance (per 400 m$^2$) | Interquartile Range (Mean Rank) | Median Abundance (per 400 m$^2$) | Interquartile Range (Mean Rank) | | |
| **Fish** | | | | | | |
| Barrimundi cod (*Cromileptes altivelis*) [1,2,3] | | Absent | | Absent | | |
| Bumphead parrotfish (*Bolbometopon muricatum*) [1] | | Absent | | Absent | | |
| Butterflyfish (Chaetodontidae) [1,4] | 7 | 3–11 (13) | 18 | 10–25.5 (22) | | 233, <0.001 |
| Grouper (Serranidae) [1,4] | 0 | 0–0 (11.7) | 2 | 1–3.5 (23.3) | | 144, <0.001 |
| Grunts/sweetlips (Haemulidae) [1] | | Absent | 0 | 0–1 | 9 | -, <0.002 |
| Humphead wrasse (*Cheilinus undulates*) [1,2] | | Absent | | Absent | | |
| Jacks (Carangidae) [1] | | Absent | 1 | 0–5 | 20 | -, <0.001 |
| Moray eel (Muraenidae) [1] | | Absent | | Absent | | |
| Other parrotfish (Scaridae) [1] | | Absent | | Absent | | |
| Snapper (Lutjanidae) [1] | 2 | 1–14 (11.1) | 23 | 13–59 (23.9) | | 98.5, <0.001 |
| **Invertebrates** | | | | | | |
| Banded coral shrimp (*Stenopus hispidus*) [4] | | Absent | | Absent | | |
| Collector urchin (*Tripneustes* sp.) [1] | | Absent | | Absent | | |
| Crown-of-thorns starfish (*Acanthaster planci*) [5] | | Absent | | Absent | | |
| Long-spinned black sea urchin (*Diadema* sp.) [6] | 237.5 | 43.3–342.5 (19.5) | 167 | 103.8–232.8 (14) | | 457, 0.294 |
| Edible sea cucumbers (*Holothuria edulis*, *Stichopus chloronotus*, *Thelenota ananas*) [7] | | Absent | | Absent | | |
| Giant clam (*Charonia tritonis*) [1] | | Absent | 0 | 0–1 | 1 | -, 0.5 |
| Lobster (Decapoda) [1,4] | | Absent | | Absent | | |
| Pencil urchin (*Heterocentrotus mammillatus*) [8] | 0 | 0–6.5 (20.9) | 0 | 0 (12.6) | | 369, 0.006 |
| Triton (*Charonia tritonis*) [8] | | Absent | | Absent | | |

Key: *= One sample sign test. Indicators of 1=Over-fishing, 2=Live fish trade, 3=Spear-fishing, 4=Aquarium trade, 5=Crown-of-thorns outbreaks, 6=In high numbers, over-fishing of urchin predators, 7=Beche-de-mer fishing, 8=Curio trade.

These values correspond to increases of 446%, 177% and 290%, respectively. The total combined density of fish increased significantly over time from a median of 16 to 60 individuals/100 m$^2$ (2014/15 mean rank=46.9, 2017 mean rank=91.6, $U$=2517.5, $p$=<0.001).

Alpha ($\alpha$) diversity index values also increased significantly on each of the monitored reefs (Fig. 4). The median values increased over time from 0.88 to 1.57 $H$/100 m$^2$ on the Koh Seh reef (2014 mean rank=28.8, 2017 mean rank=41.7, $U$=794.5, $p$=<0.001), from 1.67 to 2.03 $H$/100 m$^2$ on the Koh Mak rang reef (2015 mean rank=10, 2017 mean rank=22.5, $U$=235.5, $p$=<0.001), and from 0.58 to 1.63 $H$/100 m$^2$ on the Koh Angkrong reef (2015 mean rank=9.3, 2017 mean rank=27.2, $U$=6, $p$=<0.001). Total

**Table 5** Relative occurrence of herbivorous fish families and associated functional groups on reefs in the Kep Arcipelago in 2014/15 ($n$=36) and 2017 ($n$=33).

| Herbivorous Fish Families | 2014/15 | | 2017 | | Positive Sign * | Test Values ($U$, $p$) | Functional Group Present |
|---|---|---|---|---|---|---|---|
| | Median Abundance (per 400 m$^2$) | Interquartile Range (Mean Rank) | Median Abundance (per 400 m$^2$) | Interquartile Range (Mean Rank) | | | |
| Acanthuridae (surgeonfish, unicornfish) [1,2] | Absent | | Absent | | | | |
| Ephippidae (batfish) [1] | Absent | | 0 | 0–1 | 2 | -, 0.25 | Browsers |
| Kyphosidae (rudderfish) [1] | Absent | | Absent | | | | |
| Pomacanthidae (angelfish) [2] | Absent | | Absent | | | | |
| Scaridae (parrotfish) [1,3,4] | Absent | | Absent | | | | |
| Siganidae (rabbitfish) [1,2] | 1 | 0–15.8 (13.2) | 18 | 4–65 (21.8) | | 244, <0.001 | Grazers |

Key: *= One sample sign test. Functional group: 1=Browsers, 2=Grazers/detritivores, 3=Large excavators/bioeroders, 4=Scrapers/small excavators.

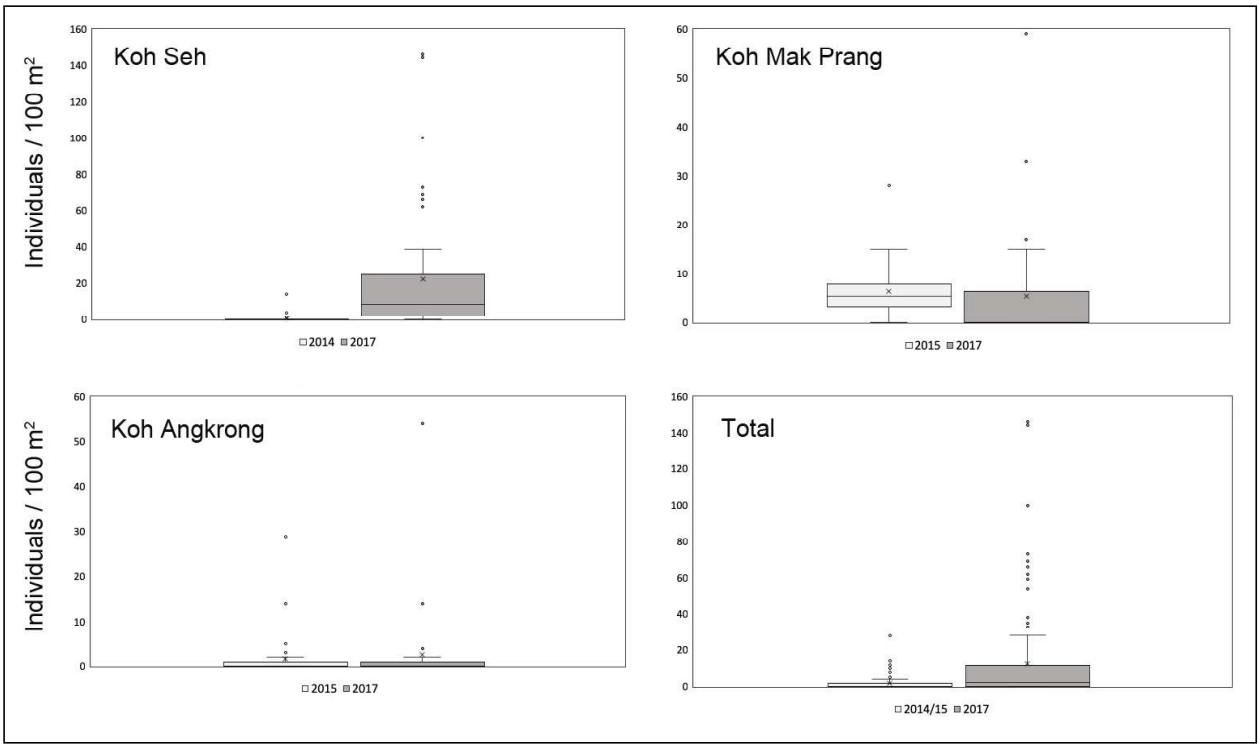


**Fig. 2** Variation in herbivorous fish density between years on the Koh Seh, Koh Mak Prang and Koh Angkrong islands. Centre lines within boxes represent medians, whereas boxes indicate the 25$^{th}$ and 75$^{th}$ percentile values and 'x' represents means.

$\alpha$-diversity increased significantly over time from 0.95 to 1.76 $H$/100 m$^2$ (2014/15 mean rank=47.9, 2017 mean rank=90.6, $U$=2788.5, $p$=<0.001).

Beta (β) diversity values indicated substantial differences in the composition of species between years, with the greatest change occurring on the Koh Angkrong reef

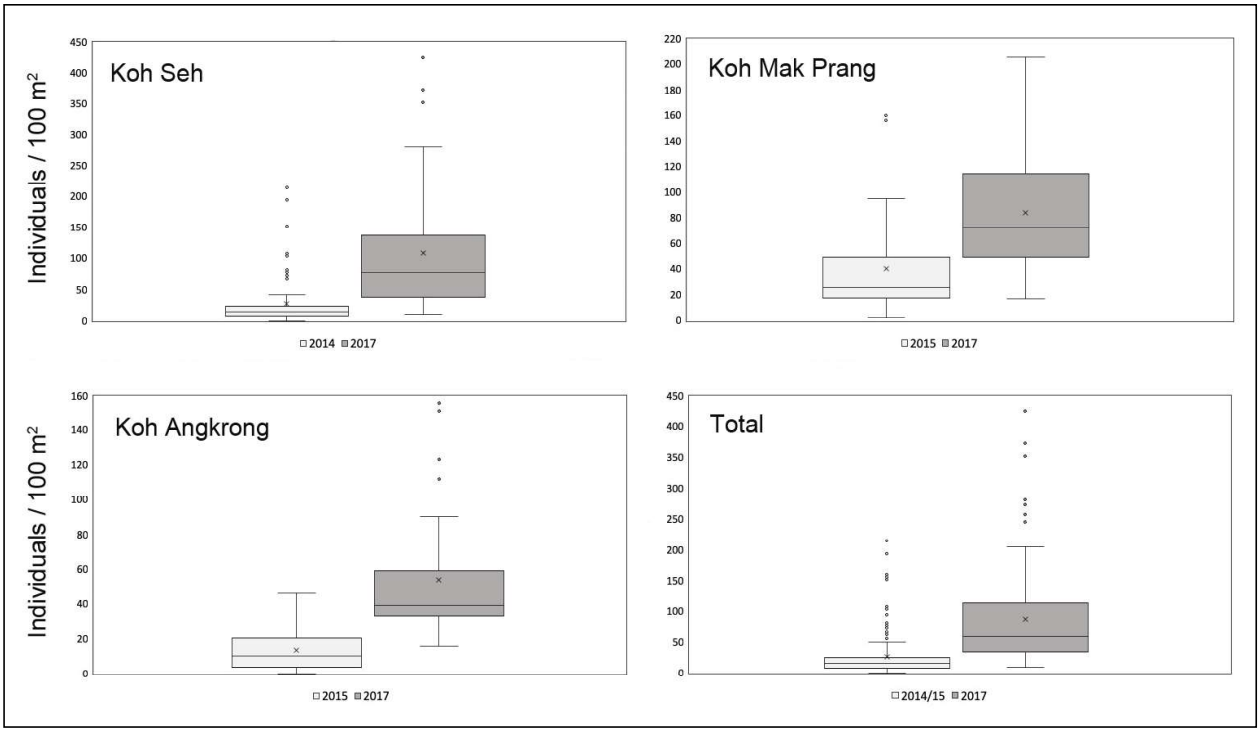


**Fig. 3** Variation in fish density between years on the Koh Seh, Koh Mak Prang and Koh Angkrong islands. Centre lines within boxes represent medians, whereas boxes indicate the 25th and 75th percentile values and 'x' represents means.

**Table 6** Beta (β) diversity index values between study sites in the Kep Archipelago in 2014/2015 and 2017.

| Reef | 2014/15 | | | 2017 | | | β-Diversity between years |
|---|---|---|---|---|---|---|---|
| | Koh Seh | Koh Mak Prang | Koh Angkrong | Koh Seh | Koh Mak Prang | Koh Angkrong | |
| Koh Seh | / | 0.21 | 0.36 | / | 0.29 | 0.39 | 0.58 |
| Koh Mak Prang | 0.21 | / | 0.42 | 0.29 | / | 0.35 | 0.51 |
| Koh Angkrong | 0.36 | 0.42 | / | 0.39 | 0.35 | / | 0.69 |

(Table 6). Species compositions differed less between reefs in comparison. The greatest differences between reefs were observed between Koh Angkrong and Koh Mak Prang in 2015 and between Koh Angkrong and Koh Seh in 2017 (Table 6).

## Seagrass

The three main seagrass meadows in the Kep Archipelago were estimated to cover a combined area of 7.5 km² (Fig. 5). Nine species of seagrass were identified in total, with the most common overall being *Thalassia hemprichii*, which was present in 76% of quadrats (Table 7).

The Kou Pou seagrass meadow was the largest of the three meadows, covering an area of 4.56 km² and exhibiting a mean seagrass cover of 22.1%. This was dominated by *T. hemprichii*, which was present in 87.8% of quadrats. *Halophila ovalis* was the next most common species, present in 18% of quadrats, whereas *Enhalus acoroides* occurred in 11.5%. Other seagrass species observed in the meadow included *Halodule uninervis* (7.6% of quadrats), *Syringodium isoetifolium* (2.8%), *Cymodocea serrulata* (2%) and *H. decipiens* (0.4%).

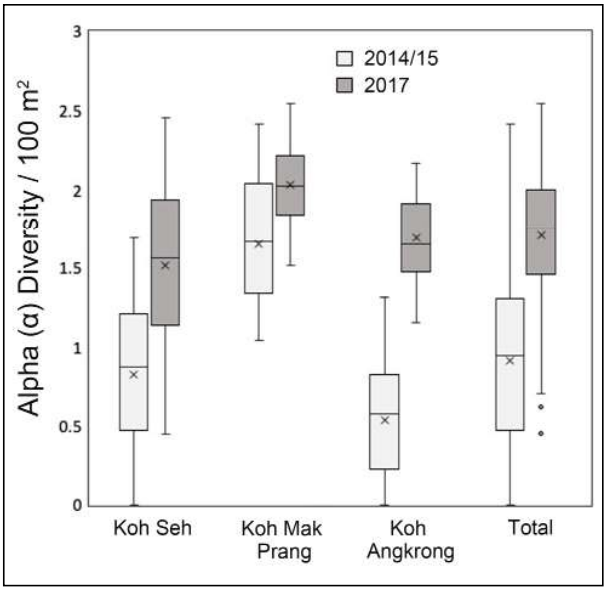


**Fig. 4** Variation in alpha ($\alpha$) diversity between years on the Koh Seh, Koh Mak Prang and Koh Angkrong islands. Centre lines within boxes represent medians, whereas boxes indicate the 25th and 75th percentile values and 'x' represents means.

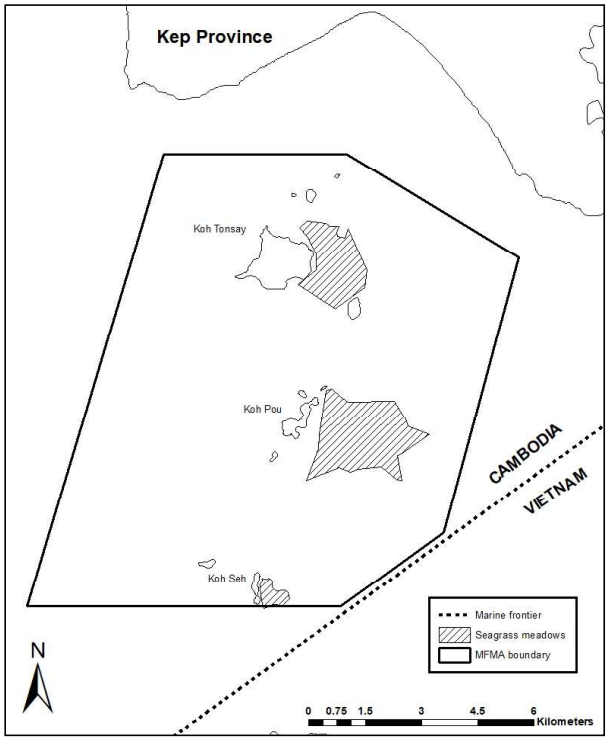


**Fig. 5** Seagrass meadows surveyed in the Kep Archipelago in 2018.

The Koh Tonsay meadow covered 2.61 km² with a mean seagrass cover of 24.6%. This mostly comprised *E. acoroides* and *T. hemprichii*, which occurred in 62.7% and 62.3% of quadrats respectively. The next most prevalent species were *H. ovalis* and *C. serrulata*, which occurred in 13.6% and 12.3% of quadrats respectively. Other species observed included *H. uninervis* (8% of quadrats), *C. rotundata* and *H. pinifolia* (both 2.5%).

The Koh Seh meadow was the smallest of the three meadows, covering an area of 0.38 km² with a mean seagrass cover of 21.2%. This was dominated by *T. hemprichii*, which was present in 76% of quadrats. The next most common species was *H. ovalis* which was present in 36% of quadrats. Other species observed included *H. uninervis* (5.6% of quadrats), C. *serrulata* (2.8%), *E. acoroides*, *H. decipiens* and *H. pinifolia* (all 0.9%).

**Table 6** Relative presence of seagrass species in the Kep Archipelago in 2018.

| Species | Percentage of Samples |
|---|---|
| *Thalassia hemprichii* | 76 |
| *Enhalus acoroides* | 29 |
| *Halophila ovalis* | 20 |
| *Halophila universalis* | 7 |
| *Cymodocea serrulata* | 6 |
| *Cymodocea rotundata* | 1 |
| *Halodule pinifolia* | 1 |
| *Syringodium isoetifolium* | 1 |
| *Halophila decipiens* | 0.3 |

## Discussion

The absence of indicator taxa combined with the high number of *Diadema* sp. suggest that reefs in the Kep Archipelago have been heavily over-exploited (Hodgson *et al.*, 2006). Moreover, the absence of certain indicator fish and invertebrates suggest over-harvesting across trophic levels. Our surveys in 2014/2015 revealed a paucity of fish life, including high-value fishery targets and important functional groups of herbivores. Similar results were found on reefs in the Kou Pou island group of the Kep Archipelago in 2003 (UNEP, 2007a). At this time, Reef Check indicator organisms were absent from all reefs, including parrotfishes which were undetected during our study, along with a number of other major groups of herbivorous fish. Herbivorous fish are often the most

 

susceptible to fishing pressure on coral reefs and over-fishing of key groups can have profound adverse effects on an ecosystem including loss of functionality and lowered resilience (Hughes *et al*., 2007; Nyström *et al*., 2008; Edwards *et al*., 2014; Pratchett *et al*., 2014; Heenan *et al*., 2016).

Rabbitfishes in the grazer functional group were the most important herbivorous fish in our study and increased significantly over time. The other families of herbivorous fish that we targeted were largely absent and showed no signs of recovery between 2014 and 2017, which means that browser, scraper and excavator functional groups remained either poorly represented or absent from the reefs studied. Representation of each herbivore functional group is important for substrate maintenance and controlling algal growth (Green & Bellwood, 2009). In the absence of certain groups of fish herbivores, the control of algal growth might be attributed to urchin grazing, particularly by *Diadema* sp. If rabbitfish in the archipelago continue to increase in abundance and competition for food resources becomes greater, population sizes of *Diadema* sp. could trend further downward. However, our data indicates that the recovery of rabbitfish was limited to the Koh Seh reef only.

With the exception of jacks and sweetlips, the indicator taxa (Reef Check indicators) and selected herbivores that were lacking in 2014/15 either remained absent or did not show any sign of significant recovery. However, certain taxa that were present in 2014/15 displayed significant increases in density over time. In particular, the increases in high-value snapper, grouper, jacks and sweetlips are promising as these fish are important in domestic and export markets (UNEP, 2007b). Snapper were the most common of these in 2017 when large schools of blackspot snapper *Lutjanus ehrenbergii* (>300 individuals/400 $m^2$) were observed on the Koh Seh reef. Another ecouraging finding was the increase in butterflyfish on reefs. Butterflyfishes play important ecological roles, possessing a wide range of feeding behaviours that include plankton feeding, cleaning activity, invertivory and corallivory (Cole *et al*., 2008; Green & Bellwood, 2009; Konow & Ferry-Graham, 2013). The eight-banded butterflyfish *Chaetodon octofasciatus*, which was present on reefs in Kep, is an obligate hard coral feeder most often associated with the coral genus *Acropora* (Mazlan *et al*., 2006). This could potentially make the species an important bioindicator of coral health and over-fishing (Madduppa *et al*., 2014).

The condition of benthic assemblages at our study sites in 2017 did not entirely reflect the state of reef fish. Hard coral cover ranged from moderate to high by Cambodian standards and appeared to be dominated by massive growth forms (Chou *et al*., 2002; van-Bochove *et al*., 2011; Thorne *et al*., 2015). Our total mean cover differed by only 1.9% from the group mean (41%) recorded at Koh Pou island approximately 14 years before (UNEP, 2007a). While this might suggest that coral cover on reefs has not changed substantially over this period, hard coral cover differed significantly between our studied reefs and we noted that some reefs at Koh Pou were among the most degraded in the archipelago. Similar to findings in 2003 (UNEP, 2007a), we also found coral damage was low. However, we found no evidence of damage from dynamite fishing which was previously identified as a major threat (UNEP, 2007a), although instances where hard corals had been broken and used to weight fishing cages were observed on each of the reefs studied (Fig. 6). Bleached and diseased corals were also observed regularly and sediment appeared to be a major issue affecting water quality.

Sponges and zoanthids were the most prevalent substrates after hard coral on the Koh Mak Prang and Koh Seh reefs respectively and some patches of degraded reef appeared to be dominated by these two groups. In comparison, macroalgae cover was low (total mean=1%) and seemed to have been controlled reasonably successfully by *Diadema* sp. Because a macroalgae cover of >10% was previously recorded on the reefs of Kou Pou (UNEP, 2007a), our data could reflect the apparent reduction in seaweed farming in Cambodia after 2006 (with no production having been reported since this time: FAO, 2011). The population density of *Diadema* sp. also appears to have changed, having shifted from an average of 4.3 individuals/100 $m^2$ in 2003 (estimated from 167 individuals/ 400$m^2$: UNEP, 2007a) to 41.6 individuals/100 $m^2$ in 2017, which is equivalent to an increase of 867%.

We identified nine seagrass species in the Kep Archipelago in 2018, all of which were found by Supkong & Bourne (2014) in seagrass meadows in the neighbouring Kampot Province in 2013. Our community structure appears to differ with *T. hemprichii* being the dominant species in the Kep Archipelago, whereas *H. uninervis* and *E. acoroides* were found to be dominant in Kampot, albeit in different studies (Vibol *et al*., 2010; Supkong & Bourne, 2014). We observed trawl lines through much of the seagrass meadows in Kep and large areas appeared to be in a state of recovery. They also supported populations of the collector urchin *Tripneustes* sp. (which was not found on reefs: Table 4), which appeared to be relatively common.

A joint patrol system was introduced to alleviate fishing pressure in the Kep Archipelago in 2014. The patrols were undertaken by MCC, marine police and FiA within the boundary of the MFMA, albeit before its estab-

lishment. During this time, Cambodian and Vietnamese benthic trawlers (including pair trawlers) appeared to be the most abundant vessels engaged in illegal fishing and most of these appeared to target shrimp using electric nets. Air-tube fishing vessels were also often seen operating around coral reefs. Seagrass habitats were the most challenging to protect as these extend over relatively large areas and were often illegally fished by trawlers at night. However, over time we found that patrols discouraged illegal fishing activities and our study demonstrates that total reef fish density and diversity increased significantly within four years of the patrols commencing. We believe these increases are attributable to the protection provided by the patrols, but acknowledge that this conclusion is speculative due to factors such as pseudoreplication, seasonal variation and surveyor changes.

First, pseudoreplication is a valid concern for the surveys we undertook in 2014/15, because these only included one replicate per site (four surveys). However, there was a greater number of monitoring sites on reefs at that time and because of this each reef received a similar number of surveys in 2014/15 and 2017 (Table 1). Further, the surveys in 2014/15 were subject to greater temporal variation as they were conducted over approximately four weeks. We assume that the survey effort in 2014/15 was sufficient to capture the basic conditions on each reef for these reasons.

Second, seasonal variation, particularly in reef fish recruitment, tends to be greater during summer months although it is rarely consistent between years (Sale & Dybdahl, 1975; Talbot *et al*., 1978; Williams, 1983). Our species surveys were largely conducted during the dry season (winter months), although some of the surveys around Koh Seh and Koh Mak Prang in 2017 were conducted at other times. While the data from these sites could therefore include seasonal variation, we believe this is unlikely to have affected our overall findings. This is supported by the fact that the data from these sites are consistent with data from the Koh Angkrong reef where surveys were undertaken in the same season throughout the study.

Third, the use of volunteers with varying abilities and changes in surveyors can affect the ability of a monitoring programme to detect ecological changes (Savage *et al*., 2017). This can be particularly true with respect to identification of fish and seagrass species, which can be challenging. In our study however, our surveyors only changed between 2014 and 2015 (as the same fish surveyor was involved from 2015 onwards) and the findings in both years were relatively consistent. In addition, the seagrass species identified by MCC staff and trained volunteers were consistent with the findings of Vibol *et al*. (2010) and Supkong & Bourne (2014) from the neighbouring Kampot Province.

**Fig. 6** Example of a fish cage illegally weighted with live coral, Koh Mak Prang, 2017 (© Amick Haissoune).

A conservation strategy was launched in early 2018 to promote the recovery of marine ecosystems in the Kep Archipelago. This aims to protect, promote and enhance marine life and the livelihoods of local fishers and their communities. The strategy included the establishment of the Kep MFMA, which encompasses coral reefs, seagrass beds and mangroves and includes no-take zones. Anti-trawling reefs (ATR) have been deployed within the boundaries of the MFMA to attract marine life and deter benthic trawlers. These have been used to conserve seagrass beds in the Mediterranean and can be important for conserving coral reefs, particularly where habitat complexity has been lost (Giakoumi *et al*., 2015; Rogers *et al*., 2015). We anticipate that the ATRs deployed in the Kep MFMA will help to disperse fish biomass, making exploitation more difficult (Smith *et al*., 2015). Small-scale subsistence fishers and recreational line fishers operating outside of no-take zones in the MFMA are not expected to substantially compromise fish assemblages at low intensities (Martin *et al*., 2017). In addition, bivalves are being deposited alongside the ATR's to facilitate the formation of bivalve beds, which also occur naturally and provide important water filtration services (Grabowski & Peterson, 2007; Walles *et al*., 2016). It is envisaged that local fishers will be able to harvest bivalves from some of the sites over time. It is also anticipated that community stakeholders will progressively adopt the various management activities of the MFMA with continued support.

Law enforcement patrols are integral to protecting and enabling the recovery of degraded ecosystems in the Kep Archipelago. The establishment of Kep MFMA and conservation activities there should contribute to mitigating a multitude of threats, protect ecosystem processes and promote the recovery of coral reefs and seagrass meadows. MCC will continue to monitor these ecosystems to assess the effectiveness of ongoing conservation efforts. Our study highlights the importance of baseline studies and ecosystem monitoring to ensure that the limited resources available for conservation are allocated appropriately. Looking forward, we recommend continuation of impact assessments and fish and invertebrate surveys in the Koh Seh, Koh Pou and Koh Tonsay seagrass meadows. We also recommend documentation of patrol effort and monitoring of illegal fishing activities to assess the effectiveness of law enforcement in reducing related pressures in the Kep Archipelago.

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## Appendix 1 Fish species monitored in the Kep Archipelago in 2014/15 and 2017

| Survey Taxa | | Observed |
|---|---|---|
| **Common Name** | **Family / Species** | |
| Angelfish | Pomacanthidae | |
| Bamboo shark | *Chiloscyllium* spp. | |
| Barramundi cod | *Cromileptes altivelis* | |
| Barracuda | Sphyraenidae | Yes |
| Great | *Sphyraena barracuda* | |
| Obtuse | *Sphyraena obtusata* | |
| Yellowtail | *Sphyraena flavicauda* | |
| Boxfish | Ostrasiidae | Yes (1–2 species) |
| Bream/whiptail bream | Nemipteridae | Yes |
| Bridled monocle | *Scolopsis affinis* | |
| Monogram monocle | *Scolopsis monogramma* | |
| Paradise whiptail | *Pentapodus paradiseus* | |
| White-cheek monocle | *Scolopsis vosmeri* | |
| White-streak monocle | *Scolopsis ciliata* | |
| Other | | 2–3 species |
| Butterflyfish | Chaetodontidae | Yes |
| Eight-banded | *Chaetodon octofasciatus* | |
| Long-beaked coralfish | *Chelmon rostartus* | |
| Longfin bannerfish | *Heniochus acuminatus* | |
| Ocellated | *Parachaetodon ocellatus* | |
| Cardinalfish | Apogonidae | Yes (1–4 species) |
| Carpet eel blenny | *Congrogadus subducens* | Yes |
| Catfish | *Plotosus lineatus* | Yes |
| Double-banded soapfish | *Diplioprion bifasciatum* | Yes |
| Emperor | Lethrinidae | Yes |
| Emperor | *Lethrinus* spp | (2–3 species) |
| Filefish | Monacanthidae | Yes (5–8 species) |
| Fusilier | Caesionidae | Yes (3–5 species) |
| Grouper | Serranidae | Yes |
| Blue-lined | *Cephalopholis formosa* | |
| Chocolate | *Cephalopholis boenak* | |
| Honeycomb | *Epinephelus merra* | |
| Orange-spotted | *Epinephelus coioides* | |
| Peacock | *Cephalopholis argus* | |
| Squaretail | *Plectropomus areolatus* | |
| Other | | 6 species |
| Grunts/sweetlips | Haemulidae | Yes |
| Gold-spotted sweetlips | *Plectorhinchus flavomaculatus* | |
| Gurnard | Triglidae | |
| Jacks/scads | Carangidae | Yes |
| Jacks | | 3–5 species |
| Scad | | 2–3 species |

## Appendix 1 Cont'd

| Survey Taxa | | Observed |
|---|---|---|
| **Common Name** | **Family / Species** | |
| Moray eel | Muraenidae | |
| Mullet | Mugilidae | Yes (1–3 species) |
| Needlefish | Belonidae | Yes (2–3 species) |
| Parrotfish | Scaridae | |
| Pipefish | Syngnathinae | Yes (5–6 species) |
| Porcupinefish | Diodontidae | Yes (1 species) |
| Pufferfish | Tetraodontidae | Yes (1–2 species) |
| Rabbtfish | Siganidae | Yes |
| Dusky | *Siganus fuscescens* | |
| Golden | *Siganus guttatus* | |
| Java | *Siganus javus* | |
| Virgate | *Siganus virgatus* | |
| White-spotted | *Signanus canaliculatus* | |
| Rudderfish | Kyphosidae | |
| Scatfish | Scatophagidae | Yes |
| Spotted | *Scatophagus argus* | |
| Scorpionfish | Scorpaenidae | |
| Seahorse | *Hippocampus* spp. | Yes (4 species) |
| Sergeantfish | *Abudefduf* spp. | Yes (3–5 species) |
| Shark sucker | Echeneidae | Yes (1–2 species) |
| Snapper | Lutjanidae | Yes |
| Black-spot | *Lutjanus ehrenbergii* | |
| Brown-stripe | *Lutjanus vitta* | |
| Checkered | *Lutjanus decussatus* | |
| One-spot | *Lutjanus monostigma* | |
| Red | *Lutjanus campechanus* | |
| Spanish flag | *Lutjanus carponotatus* | |
| Other | | 1–4 species |
| Soldierfish/squirrelfish | Holocentridae | Yes (1–2 species) |
| Spadefish | Ephippidae | Yes |
| Batfish | *Platax teira* | |
| Surgeonfish/tangs/unicornfish | Acanthuridae | |
| Sweeper | *Pempheris* spp. | Yes |
| Toadfish | *Batrachoididae* spp. | |
| Triggerfish | Balistidae | |
| Wrasse | Labridae | Yes |
| Cleaner | *Labroides* spp. | |
| Weedy surge | *Halichoeres margaritaceus* | |
| Other | | 1–3 species |

 

# Herpetofauna of the Phnom Kulen National Park, northern Cambodia—An annotated checklist

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## មូលន័យសង្ខេប

យើងរាយការណ៍នូវលទ្ធផលនៃការសិក្សាថលជលិក និងល្មូនជាលើកដំបូងពីឧទ្យានជាតិភ្នំគូលេន ខេត្តសៀមរាប ភាគខាងជើងនៃប្រទេសកម្ពុជា។ ក្នុងរយៈពេលនៃការសិក្សានៅឆ្នាំ២០០៨, ២០០៩ និង២០១១ គេបានកំណត់អត្តសញ្ញាណថលជលិកចំនួន ២៥ប្រភេទ និងល្មូនចំនួន ៦១ប្រភេទ សរុបទាំងអស់ចំនួន ៨៦ប្រភេទ និងប្រមូលបានទិន្នន័យស្តីពីអេកូឡូស៊ីរបស់សត្វទាំងនោះ។ ក្នុងចំណោមប្រភេទសត្វដែលបានកំណត់អត្តសញ្ញាណ មានហ៊ីងឆ្នូតខ្នងមួយប្រភេទ *Kaloula mediolineata* Smith, 1817 ជាប្រភេទដែលទើបបានធ្វើកំណត់ត្រាជាលើកដំបូងសំរាប់ប្រទេសកម្ពុជា។ ការវិភាគរកចំណីអាហារនៅក្នុងពោះនៃសត្វទាំងនោះមួយចំនួនបានឱ្យគេយល់ដឹងជាលើកដំបូងស្តីពីអេកូឡូស៊ីនៃការស៊ីចំណីរបស់ពួកវា។ នេះគឺជាការសិក្សានៅក្នុងឧទ្យានជាតិនៃប្រទេសកម្ពុជាដ៏យូរមួយ ក្រៅពីការសិក្សានៅតំបន់ជួរភ្នំក្រវាញ។ សិក្សានេះបង្ហាញនូវចំនួនប្រភេទសត្វដ៏ច្រើនលើសគេ បើប្រៀបធៀបទៅនឹងទិន្នន័យដែលមានពីឧទ្យានជាតិផ្សេងៗទៀតនៅក្នុងប្រទេសកម្ពុជា។

## Abstract

We report the findings of the first herpetofaunal surveys conducted in Phnom Kulen National Park, Siem Reap Province, northern Cambodia. During three intensive survey periods in 2008, 2009 and 2011, 86 species (25 amphibians and 61 reptiles) were recorded and data on their natural history were collected. One of the species, *Kaloula mediolineata* Smith, 1917, represents a new country record for Cambodia. Our analyses of stomach contents provide the first insight into the feeding ecology of several species. Our study is the first long term survey of amphibians and reptiles in a Cambodian protected area outside of the Cardamom Mountains. It shows the second highest number of species recorded nationally when compared with available data for other protected areas in Cambodia.

## Keywords

Amphibians, distribution, feeding ecology, Indochina, natural history, reptiles.

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## Introduction

Being part of tropical Indochina, Cambodia is known to host an extremely species rich herpetofauna (Bain & Hurley, 2011). In addition to surveys dating back to the colonial and postcolonial period of the 20th century (Smith, 1935; Bourret, 1941, 1942; Smith, 1943; Saint Girons, 1972), recent research has furthered our knowledge on the taxonomy and distribution of amphibians and reptiles in Cambodia within the last 20 years. However, survey efforts are still unequally distributed over the country, mainly focusing on the Cardamom Mountains range in the southwest (Daltry & Chheang, 2000; Daltry & Wüster, 2002; Long *et al*., 2002; Ohler *et al*., 2002; Swan & Daltry, 2002; Daltry & Traeholt, 2003; Stuart & Platt, 2004; Stuart & Emmett, 2006; Grismer *et al*., 2007a,b, 2008a,b, 2010; Wood *et al*., 2010; Neang *et al*., 2010, 2011a,b; Murdoch *et al*., 2019) and the foothills of the southern Annamite range in the northeast (Long *et al*., 2000; Stuart *et al*., 2006, 2010; Rowley *et al*., 2010; Neang *et al*., 2011a; Geissler *et al*., 2012). Knowledge on the herpetofauna of northern central Cambodia remains scarce and is based on only few field studies or singular sightings (Bezuijen *et al*., 2009; Hartmann *et al*., 2009, 2010, 2011, 2013b, 2014; Ihlow *et al*., 2012). However northern Cambodia represents an interesting biogeographic transition zone between the Khorat Plateau in eastern Thailand, the Mekong River along the border to Laos and the foothills of the Annamite Mountain Range in the east (Bain & Hurley, 2011; Geissler *et al*., 2015).

## Methods

### Study area

Phnom Kulen National Park (PKNP) is situated in the north of Siem Reap Province in north-central Cambodia, approximately 50 km north of Siem Reap town and the UNESCO World Heritage Site of Angkor. Covering 37,373 ha, the PKNP is a rather small protected area (Fig. 1). The national park was established in 1993 by a Royal Degree and is under the management jurisdiction of the Cambodian Ministry of Environment, although areas of archaeological value are managed by the Apsara Authority (Gaughan *et al*., 2009; Furey *et al*., 2012). PKNP is an exclusive geographical, predominantly sandstone feature in the largely flat central plains of northern Cambodia. Its highest peak is the Phnom (=Mount) Kulen with an elevation of 496 m above sea level (a.s.l.). The park is divided into two separate plateaus (Phnom Kbal Spean in the northwest and Phnom Kulen in the southeast) and is the source of the Siem Reap River.

Vegetation in PKNP comprises two main forest types (Fig. 2), the most abundant type being semi-evergreen forest on the hillside plateaus, whereas the small lowland areas were originally dominated by dry deciduous

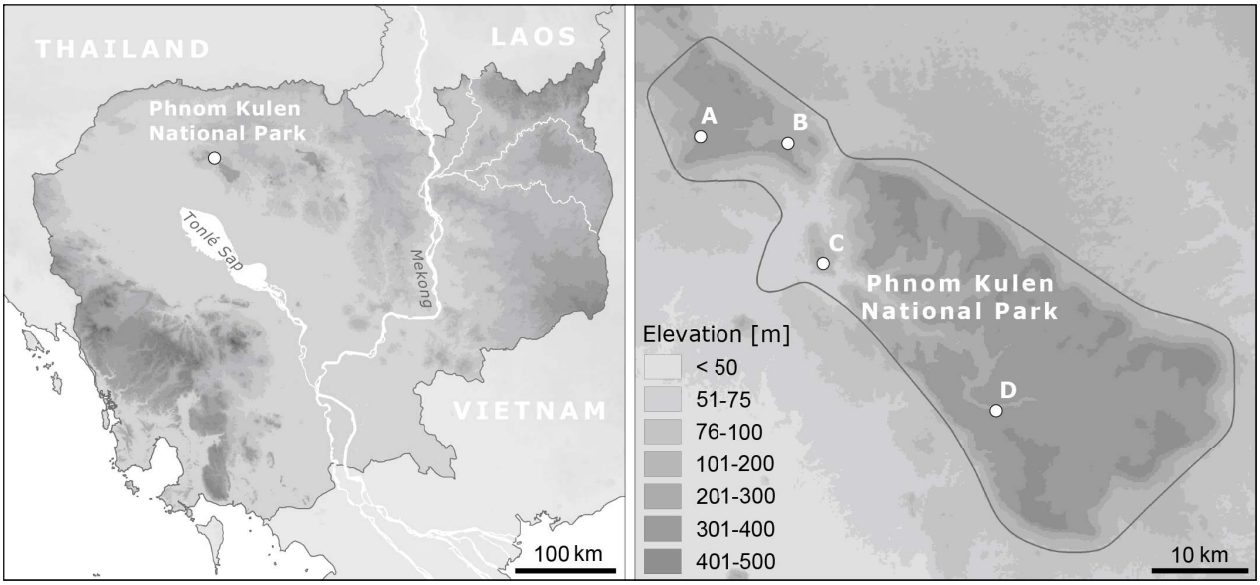


**Fig. 1** (left) Location of Phnom Kulen National Park in Siem Reap Province, Cambodia. (right) Two distinct plateau areas and four survey sites (A—Banteay Srei District, Phnom Chor; B—Banteay Srei District, Phnom Kbal Spean; C—Banteay Srei District, Phnom Hop; D—Svay Leu District, Phnom Kulen Plateau) in Phnom Kulen National Park.

 

**Fig. 2** Two major forest types in Phnom Kulen National Park: semi-evergreen forest on hillside plateaus (left) and dry deciduous dipterocarp forest (right) (© P. Geissler).

dipterocarp forest, of which only small and degraded areas remain (Neou *et al*., 2008).

### Field surveys

Field surveys were conducted by T. Hartmann in September 2008, June 2009 and (together with P. Geissler) June 2011 (comprising 82 days in total). Survey sites were chosen to cover both of the main forest types on the eastern and western parts of the Phnom Kulen plateau. Localities are shown in Fig. 1. Surveys were conducted during all hours of the day and night. Specimens were caught by hand or by using snares in the case of lizards. Leaf litter fauna were encountered visually while gently turning leaf litter and rotten logs. Drift fences and pitfall-traps were installed in each study site.

A total of 517 voucher specimens were collected over the three periods, including a maximum of four specimens of one species per month and site. Additional specimens encountered were photographed and released. All specimens collected were photographed prior to euthanasia using ethyl acetate. These were subsequently fixed and preserved in 70% ethanol. Measurements were taken with digital vernier callipers. Stomach contents were removed by dissecting the preserved specimens and examined using a stereo microscope. Upon dissection, individuals were sexed by examination of gonads. Prey items were sorted, counted, identified to the lowest practical taxonomic level (order or family level), and measured using a calibrated ocular micrometre (length and width 0.01 mm) fitted to the stereo microscope. The volume of prey items was calculated using the formulae for a cylinder ($V = \pi \times r^2 \times h$) and the volume percentage (%V) of each prey item category was subsequently calculated. Photographic vouchers were labelled as ZFMK-PA and these and all physical specimens were deposited at the Zoologisches Forschungsmuseum Alexander Koenig (ZFMK), Bonn, Germany.

## Results

A total of 86 species (25 amphibians and 61 reptiles) are currently known to occur within PKNP. Voucher information as well as the species' current status on the *IUCN Red List for Threatened Species* (IUCN, 2018) are shown in Appendix 1. Fifty-seven of the species recorded are characteristic of anthropogenically modified environments and are widely distributed in Indochina and beyond. The remaining 29 species are dealt with in detail in the following accounts.

### Amphibia

**Bufonidae**

***Ingerophrynus macrotis* (Boulenger, 1877) (Fig. 3)**

IUCN status: Least Concern.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 89259–265, 90157–166.

Remarks: Voucher specimens from PKNP agree with the diagnosis of Taylor (1962): head crests absent; parotoid glands low, little larger than eyelid; tympanum large, equal to or little less than eye diameter; skin tubercles on head being the smallest; tarsal fold absent, but a row of larger tubercles on tarsus present; distinct inner and a smaller outer metatarsal tubercle present; palmar

**Fig. 3** Anurans recorded in Phnom Kulen National Park. Left, top to bottom: *Ingerophrynus macrotis* (ZFMK 90166), *Glyphoglossus molossus* (ZFMK 89311), *Kaloula mediolineata* (ZFMK 92546) and *Micryletta* cf. *inornata* (ZFMK 90234). Right, top to bottom: *Glyphoglossus guttulata* (ZFMK 90175), *Kalophrynus interlineatus* (ZFMK 90181), *Microhyla berdmorei* (ZFMK 90204) and *Limnonectes gyldenstolpei* (ZFMK 89290) (© T. Hartmann & P. Geissler).

 

tubercle large and rounded; the first finger longer than the second; subarticular tubercles on hand.

In September 2008, six individuals (ZFMK 89259–265) were encountered foraging in degraded secondary forest on rainy evenings (19:00–23:00 hrs). In early June 2009, after the first heavy rain of the year, eight mating adult toads (males in yellowish breeding colouration) and two juveniles (ZFMK 90157–166) were found in a temporary breeding pond in disturbed secondary forest in daytime (11:00–17:00 hrs). The stomachs contents of 14 specimens (four adult males, six adult females, four juveniles of unknown gender) contained the following items (in % volume): Blattodea (23.1), Coleoptera (31.7) and Hymenoptera (Formicidae) (42.5), while the remaining 2.5% comprised undefined plant matter, soil and chitinous fragments.

**Microhylidae**

***Glyphoglossus guttulatus* (Blyth, 1856) (Fig. 3)**

IUCN status: Least Concern.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 89309–310, 90168–172 and 90174–175. Siem Reap Province, Banteay Srei District, Phnom Hop: ZFMK 90173.

*Remarks*: Voucher specimens from PKNP accord with Stuart & Emmett's (2006) description of specimens from the Cardamom Mountains: snout obtusely rounded, longer than eye diameter; fourth finger shorter than the second; webbing on the fourth toe nearly reaching proximal subarticular tubercle, with a continuing fringe to tip; dorsum light brown with distinct cream-edged dark brown irregular markings. They also resemble Taylor's (1962) colour description: transverse black stripes on back of thighs and a distinct diagonal dark brown mark following the supratympanic fold.

In September 2008, two froglets (ZFMK 89309–310) were found close to a potential breeding pond in degraded forest. In early June 2009, seven adult individuals (ZFMK 90168–172 and 90174–175) were encountered at a breeding pond in disturbed secondary forest after the first heavy rain of the year. ZFMK 90173 was found in mid-June at 18:30 hrs in a little rivulet in disturbed secondary forest.

***Glyphoglossus molossus* Günther, 1869 (Fig. 3)**

IUCN status: Near Threatened.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 89311–314, 90176.

*Remarks*: Voucher specimens from PKNP accord with the description of Vassilieva *et al.* (2016) for specimens from southern Vietnam: sharply truncate snout; smooth round flat lip on lower jaw; body robust and inflatable; hind limbs short; toes webbed, fingers unwebbed, with lateral skin fringes; prominent metatarsal tubercles present; large spade shaped metatarsal tubercles on feet; colouration dark grey with an irregular yellow speckling.

In September 2008, three adult individuals (ZFMK 89311–313) were encountered between 19:00 and 23:00 hrs during heavy rain in disturbed lowland forest. One froglet (ZFMK 89314) was found at the end of September 2008. In June 2009, a sole individual (ZFMK 90176) was found hibernating 10 cm deep in sandy soil during construction works in our field camp.

***Kalophrynus interlineatus* (Blyth, 1855) (Fig. 3)**

IUCN status: Least Concern.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 89307–308, 90177–181. Siem Reap Province, Svay Leu District, Phnom Kulen: ZFMK 92545.

*Remarks*: Our specimens match the diagnosis provided by Parker (1934), Matsui *et al.* (1996) and Vassilieva *et al.* (2014): toes less than one-third webbed, with the third toe webbing not extending beyond the distal subarticular tubercle and the free portion of the fifth toe longer than the distance from snout to nostril; several pairs of wart-like glands on breast; dorsum pattern-less or with an indistinct camouflage pattern.

In September 2008, two individuals (ZFMK 89307–308) were found in degraded secondary forest in a heap of dead wood during daytime (10:30 hrs). In June 2009, five individuals (ZFMK 90177–181, were encountered at a small breeding pond in degraded lowland forest. At the end of June 2011, a single individual (ZFMK 92545) was collected within semi-evergreen forest.

***Kaloula mediolineata* Smith, 1917 (Fig. 3)**

IUCN status: Near Threatened.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 90187–199, 92546–547.

*Remarks*: Our voucher specimens agree with the descriptions provided by Bourret (1942), Taylor (1962) and Chan-ard *et al.* (2011) in the following characteristic features: dorsum dark brown, two broad light bands from upper eyelid to groin; median light stripe from middle of back to a point above vent; two large metatarsal tubercles, outer smaller; toes pointed, half webbed. Selected measurements are given in Table 1.

**Table 1** Selected measurements of voucher specimens of *Kaloula mediolineata* Smith, 1917 from Phnom Kulen National Park.

| Voucher No. | ZFMK 90196 | ZFMK 92547 | ZFMK 92546 | ZFMK 90198 | ZFMK 90187 | ZFMK 90192 | ZFMK 90195 | ZFMK 90197 | ZFMK 90199 | ZFMK 90193 |
|---|---|---|---|---|---|---|---|---|---|---|
| Sex | female | male | female | male | male | female | female | female | female | female |
| SVL | 70.85 | 53.1 | 56.9 | 51.3 | 49.0 | 48.4 | 53.3 | 45.9 | 55.0 | 43.9 |
| HL | 16.4 | 13.9 | 14.4 | 12.9 | 12.3 | 11.8 | 13.6 | 11.8 | 13.9 | 11.5 |
| HW | 18.1 | 15.1 | 16.7 | 14.0 | 13.6 | 13.5 | 14.9 | 13.7 | 16.8 | 13.4 |
| SL | 7.5 | 5.4 | 6.4 | 6.1 | 5.5 | 5.5 | 6.0 | 5.4 | 5.4 | 4.3 |
| ED | 5.6 | 5.1 | 5.8 | 4.9 | 3.7 | 4.5 | 5.3 | 4.4 | 4.8 | 3.9 |
| IOD | 6.2 | 4.3 | 5.1 | 4.6 | 4.2 | 4.0 | 4.6 | 4.4 | 5.1 | 4.0 |
| IND | 4.4 | 3.5 | 3.9 | 2.7 | 3.0 | 2.6 | 3.2 | 3.0 | 2.8 | 2.8 |
| TBL | 20.4 | 18.6 | 19.3 | 16.8 | 16.1 | 16.3 | 16.4 | 16.1 | 17.5 | 14.3 |
| Fin3DW | 0.8 | 0.6 | 0.8 | 0.5 | 0.6 | 0.7 | 0.6 | 0.5 | 0.5 | 0.5 |

Measurements follow Chan *et al.* (2013): snout–vent length (SVL), from tip of snout to vent; head length (HL), from posterior margin of mandible to tip of snout; head width (HW), measured at the level of the jaw articulation; snout length (SL), from anterior corner of eye to tip of snout; eye diameter (ED), length between anterior and posterior corners of eye; interorbital diameter (IOD), istance between medial margins of palpebrae at its closest point; internarial distance (IND), measured from medial, inner margins of nostrils; tibia length (TBL), measured from from knee inflection to tarsal inflection; third finger disc width (Fin3DW), widest horizontal diameter of third finger disc.

Our report from the PKNP is the first record of this species in Cambodia. Until now the species was only documented to occur in eastern Thailand (Taylor, 1962; Heyer, 1973; Nutphund, 2001; Chan-ard, 2003; Chan-ard *et al.*, 2011), southern Laos (Stuart, 1999), and southern Vietnam (Orlov *et al.*, 2002; Phung *et al.*, 2013). Due to this disjunct distribution pattern, a more widely occurrence, including Cambodia, was predicted (van Dijk & Chan-ard, 2004; Stuart *et al.*, 2008; Frost, 2019).

All individuals (ZFMK 90187–199, 92546–547) were encountered at a small breeding pond in degraded lowland forest at the very beginning of the rainy season in early June 2009 and 2011. In total, far more than 100 individuals of *K. mediolineata* were observed in early June 2009. The stomach contents of 14 specimens contained the following prey items (in % volume): Arachnida (1.5), Blattodea (14.0), Coleoptera (8.0) and Hymenoptera (Formicidae) (76.2).

***Microhyla berdmorei* (Blyth, 1856) (Fig. 3)**

IUCN status: Least Concern.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Chor: ZFMK 90202–203. Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 90200–201, 90204.

*Remarks*: The specimens from PKNP match the combination of traits described by Bain & Nguyen (2004) and Vassilieva *et al.* (2016) for specimens from Indochina: first finger shorter than one-half of the second; tibiotarsal joint beyond snout tip, when legs are adpressed; toes elongated, fully webbed; toe discs well developed; belly and thighs lemon yellow.

In June 2009, five individuals (ZFMK 90200–90204) were encountered actively foraging on leaf-litter in semi-evergreen forest (15:30–19:30 hrs).

***Micryletta* cf. *inornata* (Boulenger, 1890) (Fig. 3)**

IUCN status: Near Threatened.

*Material examined*: Siem Reap Province, Banteay Srei District, Phnom Kbal Spean: ZFMK 89337–340, 90234–246.

*Remarks*: The specimens from PKNP accord with Bain & Nguyen's (2004) characterization: snout blunt; dorsal skin smooth; first finger longer than one-half of the second; no discs and median grooves at finger and toe tips; toes not completely webbed, only one metatarsal tubercle present; arms and limbs bearing an orange marbled pattern.

Further molecular studies are needed to clarify the taxonomy of Cambodian populations currently assigned to this species. Populations in southern Vietnam and Thailand were recently assigned to the morphologically similar species *Micryletta erythropoda* (Tarkhnishvili, 1994) by Vassilieva *et al.* (2016) and Poyarkov *et al.* (2018) based on morphological and molecular traits. Though the specimens from PKNP resemble *M. erythropoda* in colouration, they lack an outer metatarsal tubercle, one

 

of the diagnostic traits mentioned by Tarkhnishvili (1994) for the type specimens from southern Vietnam. Hence, additional sampling is necessary to show whether Cambodian populations east or also west of the Mekong River should be assigned to this species.

In September 2008 and June 2009, all individuals (ZFMK 89337–340, ZFMK 90234–246) were found (16:30–23:30 hrs) relatively close to a small permanent pond in disturbed lowland forest.

**Dicroglossidae**

***Limnonectes gyldenstolpei* (Anderson, 1916) (Fig. 3)**

IUCN status: Least Concern.

*Material examined*: Svay Leu District, Phnom Kulen Plateau: ZFMK 89286–293. Banteay Srei District, Phnom Kbal Spean: ZFMK 89294–295, 90252–260. Banteay Srei District, Phnom Hop: ZFMK 90261–265.

*Remarks*: The voucher specimens from the PKNP correspond with the descriptions of Bourret (1942), Taylor (1962), Neang & Holden (2008) and Aowphol *et al*. (2015): males larger than females; male heads enlarged, bearing a dermal flap reaching beyond the interorbital region and swollen occipital regions; males bearing a pair of fangs on the lower jaw; tympanum and supratympanic fold distinct; dorsum and flanks bearing prominent tubercles.

All individuals were encountered actively foraging in semi-evergreen forest, always in very close proximity of rivers and rivulets (19:00–23:30 hrs, September 2008 and June 2009). The stomach contents of 24 specimens (8 males, 13 females, 2 juveniles) revealed the following items (in % volume): Arachnida (3.9), Blattodea (4.7), Coleoptera (9.4), Hymenoptera (Formicidae) (8.6), Insecta (4.5), Isopoda (2.7), Orthoptera (50.7) and Polydesmida (3.2), while the remaining 9% comprised undefined plant matter, soil and chitinous fragments. One individual was found to have swallowed a juvenile skink (*Scinella* sp.).

**Ranidae**

***Hylarana lateralis* (Boulenger, 1877) (Fig. 4)**

IUCN status: Least Concern.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 92555.

*Remarks*: Our female specimen accords with the diagnosis provided by Bourret (1942), Taylor (1962) and Vassilieva *et al.* (2016): dorsolateral fold thick and distinct, laterally contrasted by a thin dark line; tympanum large, slightly less than eye; upper jaw thickened, bearing a white stripe, forming a triangular mark behind tympanum; males possessing well-developed humeral glands and small posterior vocal slits; dorsum bearing an irregular series of diagonal lines.

In June 2011, the female specimen was encountered at 20:00 hrs in a disturbed secondary lowland forest.

***Sylvirana mortenseni* (Boulenger, 1903) (Fig. 4)**

IUCN status: Near Threatened.

*Material examined*: Banteay Srei District, Phnom Hop: ZFMK 89341. Banteay Srei District, Phnom Kbal Spean: ZFMK 89342–347, 90287–294, 92553–554.

*Remarks*: Our series of specimens agrees with the expanded diagnosis published by Sheridan & Stuart (2018): all digit tips expanded, bearing a circummarginal groove; dorsal skin finely granular; ventral skin smooth; males and females equal in size; males bearing round black humeral glands and a thin nuptial pad on the first finger; pineal gland visible; vocal sac opening located near corner of mouth; no distinct gular pouch; flank with dark stripe below dorsolateral fold extending to groin; no strong demarcation between dark upper parts of flank and its light lower parts.

Sheridan & Stuart (2018) were the first to discover this species in Siem Reap Province. Formerly the species was only known to occur in the Cardamom Mountains in southwestern Cambodia, where it was recorded from 220 to 1,000 m a.s.l. (Ohler *et al*., 2002; Stuart & Emmet, 2006).

All individuals were encountered in semi-evergreen forest very close to rivers and rivulets from 17:00–21:00 hrs in September 2008 and June 2009 and 2011. The ZFMK 92553 male was observed calling, while sitting in a shallow pool between rocks and roots close to Kbal Spean River at 18:00 hrs on 5 June 2011. The stomach contents of 16 specimens (13 males, 3 females) contained the following items (in % volume): Arachnida (0.8), Blattodea (0.2), Coleoptera (72.9), Hymenoptera (Formicidae) (0.3), Gastropoda (12.7), and Insecta (6.3), while the remaining 6.5% comprised undefined plant matter, soil and chitinous fragments.

**Rhacophoridae**

***Theloderma* cf. *stellatum* Taylor, 1962 (Fig. 4)**

IUCN status: Near Threatened.

*Material examined*: Banteay Srei District, Phnom Chor: ZFMK 92565–566.

*Remarks*: Our one adult and one froglet agree with Taylor's (1962) original description: skin warty; dorsal surface brownish grey, covered with silvery and whitish asperities; shoulder area bearing a dark trifoliate spot; a large black spot on groin; fingers about one-third webbed, the third finger disc nearly equal to the diam-

**Fig. 4** Anurans and chelonians from Phnom Kulen National Park. Left, top to bottom: *Hylarana lateralis* (ZFMK 92555), *Sylvirana mortenseni* (ZFMK 89346), *Cyclemys* cf. *oldhamii* (ZFMK-PA TH02) and *Malayemys subtrijuga* (ZFMK-PA TH03). Right, top to bottom: *Sylvirana mortenseni* (ZFMK 89347), *Theloderma* cf. *stellatus* (ZFMK 92565, 92566), *Cyclemys* cf. *oldhamii*, juvenile in lateral view (ZFMK-PA PG01) and head of *Indotestudo elongata* (ZFMK-PA TH04) (© T. Hartmann & P. Geissler).

 

eter of tympanum; whitish, velvety nuptial pads on the dorsal and medial surface of the first finger; interorbital distance almost equal to the width of upper eyelid; ventral surface bearing light reticulations. As stated by Poyarkov *et al.* (2015), the colour pattern is highly variable within populations and even within one individual, depending on the daytime of observation. As depicted in Fig. 4D, the colouration may also depend on the age of the specimen. Nevertheless, Poyarkov *et al.* (2015) identified the colour of the toe and finger pads as constant colouration traits. In this character, the two specimens from PKNP resemble *Theloderma vietnamense* Poyarkov *et al*. (2015) in bearing rusty red pads, instead of the pinkish ones of *Theloderma stellatum* specimens from Thailand (Poyarkov *et al*. 2015). The latter authors also summarize current knowledge on the distribution on the two sister species across Indochina, although the populations from PKNP and the recent record from Kulen Promtep Wildlife Sanctuary in northern Cambodia (Hartmann *et al*., 2013b) were not evaluated. Further studies should show whether the populations in central and northern Cambodia belong to *T. stellatum sensu stricto* or to *T. vietnamense* which is known from eastern Cambodia and southern Vietnam.

Both individuals were found on 3 June 2011 in a water-filled tree hollow at night after moderate rain.

Reptilia

**Geoemydidae**

***Cyclemys* cf. *oldhamii* Gray, 1863 (Fig. 4)**

IUCN status: Endangered (Rhodin *et al.*, 2018).

*Material examined*: Banteay Srei District, Phnom Chor: ZFMK-PA TH 02. Banteay Srei District, Phnom Kbal Spean: ZFMK 92567, ZFMK-PA PG 01.

*Remarks*: The morphology and colouration pattern of *Cyclemys* specimens from PKNP were characterized by Vamberger *et al.* (2017): head crown bearing a speckled pattern; neck dark with salmon striping; throat salmon showing a mottled dark pattern; carapace dark brownish; plastron spotted in juveniles, plastron with dense radiating dark streaks in subadults and adult specimens; in old specimens the plastron becomes uniformly dark coloured. This pattern fits the conditions of the eastern colouration morph of *C. oldhamii* described by Fritz *et al*. (2008).

The population in PKNP was first recorded by Durkin *et al.* (2010) as *Cyclemys* aff. *atripons*. Due to the morphological traits described above, Kim (2011) and Durkin (2012) assigned the population to *C. oldhamii*. The PKNP population seems to be geographically isolated and located between the ranges of *C. atripons* and *C. oldhamii*. The genetic work of Vamberger *et al.* (2017) revealed the presence of mitrochondrial haplotypes of *C. atripons*. The latter authors argued the PKNP population either represents a natural hybrid swarm or a distinct and as yet undescribed species. Alternatively, an anthropogenic translocation of confiscated specimens may have occurred within PKNP.

Our single collected individual (ZFMK 92567) and the photo-vouchered subadult (ZFMK-PA PG 01) were encountered in the evening in shallow, rather fast flowing areas within the Kbal Spean River in June 2011. The adult photo-vouchered individual (ZFMK-PA TH 02) was encountered at midday in a shallow and slow flowing area of Kbal Spean River in June 2011.

***Malayemys subtrijuga* (Schlegel & Mueller, 1845) (Fig. 4)**

IUCN status: Near Threatened (Rhodin *et al*., 2018).

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK-PA TH 03.

*Remarks*: Characters visible in the voucher photo match the diagnostic traits mentioned by Taylor (1970) and Ihlow *et al.* (2016a): lower marginal scutes 8–12 bearing only very narrow blackish bars along the posterior margin; infraorbital stripe extending across loreal seam, joining the supraorbital stripe; infraorbital stripes distinctly angled below the anterior edge of eye; two yellowish orbital rings present.

Our photo-vouchered subadult individual was encountered foraging in a pond in heavily disturbed lowland forest habitat close to the foothills of Phnom Kbal Spean on 22 June 2009.

**Testudinidae**

***Indotestudo elongata* (Blyth, 1854) (Fig. 4)**

IUCN status: Critically Endangered (Rhodin *et al*., 2018).

*Material examined*: Svay Leu District, Phnom Kulen Plateau: ZFMK-PA TH 04.

*Remarks*: In September 2008, a photo voucher was taken of the shrunken head of a single tortoise that was mounted on a stick. This was encountered at the entrance of a home located within the national park. The residents reported that the tortoise had been collected behind the house in a heavily disturbed forest area for human consumption. The shrunken head fits Taylor's (1970) diagnosis: very well-defined pair of prefrontal shields; horny edge of upper jaw slightly denticulated. The length of the horny sheath of the upper jaw exceeds the head hight of the specimen. This condition differs clearly

from the head morphology of the other two Indochinese tortoise species: *Manouria impressa* and *M. emys*. For comparison, see photographs in Emmett (2009), Ihlow *et al*. (2016b) and Stanford *et al*. (2015).

**Agamidae**

***Leiolepis rubritaeniata* Mertens, 1961 (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 90305–07, ZFMK 92599–605.

*Remarks*: The colouration of our males agrees with the description of Peters (1971) and Hartmann *et al*. (2012): dorsum bearing a polygonal net-like pattern formed by the margins of faded ocelli; post-axillary region barred in red and black; posterior part of flanks plain reddish-orange.

All specimens were encountered and caught in snares at the entrance of their burrows at the end of the dry season in early June 2009 and 2011. Hartmann *et al*. (2012) provided further information on the ecology of the population in PKNP.

***Physignathus cocincinus* Cuvier, 1829**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 90305–307, ZFMK 92599–605.

*Remarks*: One subadult and one juvenile specimen were recorded. These fully accord with Taylor's (1963) expanded description: two diverging series of enlarged scales on lower jaw, larger than infralabials; tail laterally compressed, heavily keeled below; toes with extended fringes; the adult also agrees with Taylor's (1963) description in having a well-developed continuous nuchal and dorsal crest, while the caudal crest is well separated by a hiatus.

The juvenile specimen was found resting on a small tree close to a relatively big river at 19:00 hrs in early June 2011. The subadult specimen was found resting on a branch (approximately three meters above ground) close to a waterfall at 20:00 hrs on 3 June 2011.

**Gekkonidae**

***Cyrtodactylus* cf. *intermedius* (Smith, 1917) (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 88356–359, 90309–311, 92572–75.

*Remarks*: Specimens encountered within PKNP were assigned to the *C. intermedius* complex by the following trait combination (see Smith, 1917; Ngo *et al*., 2010; Murdoch *et al*., 2019): infralabials 8–11; lateral fold present, bearing slightly enlarged scales; midventrals 38–43; precloacal pores in males 9–10; dorsum greyish brown bearing four to five dark brown, yellow-edged cross-bars, the first forming a nuchal loop. However, a molecular phylogeny published by Grismer *et al*. (2015) showed that *C. intermedius* actually forms a species complex comprising at least five undescribed species in Cambodia. Murdoch *et al*. (2019) described six new species in the *C. intermedius* complex from the Cardamom Mountains of western Cambodia, restricting the known distribution of *C. intermedius sensu stricto* to eastern Thailand. Our specimens bear characters listed as diagnostic for *C. intermedius* by Murdoch *et al.* (2019): 24 enlarged femoral scales, proximal femoral scales one-half the size of the distal ones; three rows of enlarged post-precloacal scales; two or three postcloacal tubercles; no dark blotches on top of head; no pocketing between toes and fingers. But specimens from the PKNP also differ in some diagnostic traits (opposing diagnostic characters from Murdoch *et al*. 2019 are given in brackets): posterior border of nuchal loop chevron shaped (vs. rounded); supralabials 9–11 (vs. 8); ventral scales 34–42 (vs. 42–44). Further molecular and morphological studies are needed to clarify the taxonomic status of the population in the PKNP.

All specimens were found after sunset (17:30–23:00 hrs) in rock crevices or foraging on sandstone rocks in semi-evergreen forest.

***Dixonius siamensis* (Boulenger, 1894) (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Chor: ZFMK 90317. Banteay Srei District, Phnom Kbal Spean: ZFMK 88365, 90312–315, 92568. Banteay Srei District, Phnom Hop: ZFMK 90316.

*Remarks*: Five adult voucher specimens (SVL 45.2–51.9 mm) from PKNP show an array of diagnostic traits compiled by Taylor (1963) and Das (2010): terminal parts of digits bearing widened lamellae; 5 dorsolateral rows of enlarged, keeled scales on each side, ventrally blend into larger imbricate scales; ventral scales bearing minute posterior serrations; up to 6 precloacal pores in a curving angular series; supranasals separated by two granular scales; absence of a distinct canthal stripe. The genetic work of Ziegler *et al.* (2016) showed that the taxonomic status of Indochinese populations assigned to the genus *Dixonius* require further integrated study.

All specimens but one were caught after sunset (17:30–23:00 hrs in June 2009 and 2011) actively foraging on the forest floor in semi-evergreen forest. In September

 

**Fig. 5** Lizards from Phnom Kulen National Park. Left, top to bottom: *Leiolepis rubritaeniata* (ZFMK 92602), *Scincella rupicola* (ZFMK 92587), *Tropidophorus cocincinensis* (ZFMK 92592) and *Dixonius siamensis* (ZFMK 92568). Right, top to bottom: *Lipinia vittigera microcercum* (ZFMK 92577), *Sphenomorphus lineopunctulatus* (ZFMK 92615), *Cyrtodactylus* cf. *intermedius* (ZFMK 88357) and *Hemiphyllodactylus* sp. (ZFMK 92571) (© T. Hartmann & P. Geissler).

2008, a single juvenile specimen was found in daytime (10:00 hrs) hidden in a pile of dead wood in a heavily disturbed area of semi-evergreen forest.

***Hemiphyllodactylus* sp. (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 92571.

*Remarks*: Our single female voucher specimen may be assigned to a currently undescribed taxon which Zug (2010) referred to as *Hemiphyllodactlus* "*yunnanensis*". Zug (2010) morphologically distinguishes the southern mainland Southeast Asian populations (named *H.* "*yunnanensis*") from southern Chinese and northern Vietnamese populations close to the type locality of *H. yunnanensis*. We assign our single female specimen to this taxon based on the following combination of morphological characters: snout-vent length 38.4 mm, tail length 33.8 mm, trunk length 20.6 mm, eye diameter 2.1 mm, head length 9.8 mm, head width 6.9 mm, nare-eye length 3.2 mm, snout-eye length 4.3 mm, internarial distance 1.2 mm, ear opening diameter 0.5 mm, 14–15 dorsal scale rows, 11 ventral scale rows, two feeble developed cloacal spurs, two scales between supranasals, four scales surrounding the nasal scale, 11/10 supralabials, 10/10 infralabials, 10/12 enlarged chin scales, distinct ear openings not bordered by enlarged scales, 3–3–3–3 lamella formula on forelimbs (lamella pairs only), 3–4–4–4 on hindlimbs, no precloacal pores, but six enlarged precloacal scales, no femoral pores or enlarged scales. The combination of bearing four circumnasal scales, only three lamellae on first finger and first toe and 10/12 enlarged chin shields also clearly differs from the conditions of newly described species from adjacent Thailand: *H. chiangmaiensis*, *H. khlonglanensis* and *H. flaviventris* (Grismer *et al*., 2014; Sukprasert *et al*., 2018), Laos: *H. indosobrinus*, *H. kizirani* and *H. serpispecus* (Nguyen *et al*., 2014; Eliades *et al*., 2019) and Vietnam: *H. banaensis* and *H. zugi* (Nguyen *et al*., 2013; Ngo *et al*., 2014). Further molecular and morphological studies are needed to clarify the taxonomic status of the population in PKNP.

Our single female specimen was found in June 2011 at 19:30 hrs on a leaf in semi-evergreen forest relatively near to a river.

**Scincidae**

***Lipinia vittigera microcercum* (Boettger, 1901) (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Svay Leu District, Phnom Kulen Plateau: ZFMK 90339, 92577–582.

*Remarks*: Our seven voucher specimens from PKNP agree with the description of this Indochinese subspecies by Vassilieva *et al.* (2016): 28–32 scales around midbody; head elongated; lower eyelid bearing a transparent window; frontonasal scales in broad median contact; narrow light vertebral stripe from snout tip to tail base; two paravertebral dark stripes from snout tip to tail base, two light dorsolateral stripes being less distinct; tail orange or bright red.

All seven individuals were found between 09:00 and 14:00 hrs in June 2009 and 2011 running down and around tree trunks in heavily disturbed semi-evergreen forest.

***Scincella rupicola* (Smith, 1916) (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Chor: ZFMK 90355. Banteay Srei District, Phnom Kbal Spean: ZFMK 88372–374, 90346–354, 92586–588. Svay Leu District, Phnom Kulen Plateau: ZFMK 88375–377, 90356–359.

*Remarks*: The traits of our voucher specimens from the PKNP accord with the diagnostic traits reported by Smith (1916), Taylor (1963) and Neang *et al.* (2018): hind limb reaching the elbow when adpressed; lower eyelid bearing an undivided transparent disc; supranasals absent; prefrontals in broad contact; two preoculars; two presuboculars; nuchals feebly enlarged; seven supralabials, fifth and sixth largest, situated below the eye; ear opening large, nearly as large as eye; 17 to 18 lamellae beneath fourth toe; two pairs of enlarged preanals; colouration in females: dorsum light brown, outer scale rows a little lighter; a series of large irregular black spots along a vertebral line, smaller spots paired on neck; dark brown band from eye to tail base, interrupted by large light patches; tail pinkish-olive; colouration in males: dorsum without dark spots; dorsolateral stipes faint. However, the specimens from PKNP differ slightly in the following characters: midbody scale rows 34–37 (vs. 33–36 reported by Neang *et al.,* 2018); ventrals in transverse rows 71–74 (vs. 63–69 reported by Neang *et al.*, 2018); paravertebral scale rows 63–68 (vs. 68–73 reported by Neang *et al.*, 2018).

We follow Shea & Greer (2002), Teynié & David (2010) and Neang *et al.* (2018) in recognising this species as valid. The species was recently recorded from Laos (Teynié & David, 2010) and Vietnam (Nguyen *et al*., 2010a). Formerly it was only known from central and eastern Thailand (Taylor, 1963). However, the species was not listed in recent checklists for Thailand (Chanard *et al*., 2015). PKNP is the fourth known locality of

 

the taxon in Cambodia, it being previously only known from the Kampong Thom, Stung Treng and Preah Vihear Provinces (Hayes *et al*., 2015; Neang *et al.*, 2018).

All specimens were found actively foraging in leaf litter in disturbed semi-evergreen rainforest (09:00–17:00 hrs in June 2009 and 2011). Except for one juvenile (ZFMK 88372) found in September 2008, all specimens were encountered in June 2009 and 2011. Males bear a reddish breeding colouration in early June (Fig. 5).

***Sphenomorphus lineopunctulatus* Taylor, 1962 (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Svay Leu District, Phnom Kulen Plateau: ZFMK 88379, 88382, 92614–619.

*Remarks*: Currently only one species assigned to the genus *Sphenomorphus* Fitzinger, 1843 is known to occur within PKNP. Hartmann *et al.* (2010) provided a detailed morphological description of our voucher specimens (see Table 1 in Hartmann *et al*., 2010) and identified them as *S. lineopunctulatus*. Until now, this remained the only known population of the species in Cambodia and one of only three documented occurrences in the world.

All specimens were found on a rocky, sandy and scarcely vegetated plateau during the day (09:00–16:30 hrs). Four juvenile specimens (ZFMK 92616–92619) were encountered at the end of the rainy season in June 2011.

***Tropidophorus cocincinensis* Duméril & Bibron, 1839 (Fig. 5)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Chor: ZFMK 90364. Banteay Srei District, Phnom Kbal Spean: ZFMK 88378, 90360–363, 92589–598.

*Remarks*: The species was first recorded in PKNP and Cambodia by Hartmann *et al*. (2009) who provided a detailed morphological description of the specimens from PKNP. Because its core distribution area is situated in central Vietnam (Quang Binh to Kon Tum Provinces: Nguyen *et al*., 2010b), southern Laos (Champasak and Xe Kong Provinces: Chuaynkern *et al*., 2005) and north-eastern Cambodia (Virachey National Park: Stuart *et al*., 2010), the population inhabiting PKNP forms the westernmost point known of the species' putative range. It is only known from one other locality in Cambodia and records from eastern Thailand may have been based on a misidentification of *Tropidophorus microlepis* Günther, 1861 specimens (Hartmann *et al*., 2009; Chan-ard *et al*., 2015).

The following ecological data were recorded during the transition of the dry and monsoon season in early June 2011: individuals were mainly active in early morning and one hour before sunset; 44% of recorded specimens ($n$=36) were found on rocks near a stream; 31% were found on leaf litter or logs; 22% were active within flowing water; mean body temperature was 28.9°C (±1.1 SD; $n$=26) at a mean air temperature of 27.1°C (±0.9 SD; $n$=26). The stomach contents of 28 specimens contained the following items (in % volume): Ephemeroptera (0.2), Plecoptera (0.3), Anisoptera (larvae) (3.3), Zygoptera (larvae) (0.2), Blattodea (0.2), Isoptera (0.3), Coleoptera (3.9), Diplopoda (0.8), Decapoda (85.3), Aranae (1.2), Oligochaeta (0.4) and Gastropoda (4.1). Besides using the water body as a retreat when approached by predators, our data show that the population in the PKNP also seems to highly depend on aquatic prey items (Odonata larvae and Decapoda). This is the first indication of aquatic foraging behaviour within the genus *Tropidophorus* (Nguyen *et al*., 2010b).

**Colubridae**

***Boiga siamensis* (Nutaphand, 1971) (Fig. 6)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 88337, 92624.

*Remarks*: Our two voucher specimens from PKNP correspond with the diagnostic traits published by Vassilieva *et al*. (2016) and Das (2010): body compressed laterally; midbody scale rows 23; ventrals 247–270; subcaudals paired, 116–129; anal entire; vertebral scales enlarged; head very distinct from neck; pupils vertical; light brown on back with dark brown, chevron shaped blotches; dark stripe from eye to jaw angle.

Both specimens were found resting in trees in daytime in disturbed semi-evergreen forest.

***Dendrelaphis subocularis* (Boulenger, 1888) (Fig. 6)**

IUCN status: Least Concern.

*Material examined*: Banteay Srei District, Phnom Hop: ZFMK 88324.

*Remarks*: The voucher specimen from PKNP fits the description of Vietnamese specimens provided by Vassilieva *et al.* (2016): midbody scale rows 15; ventrals 173; subcaudals paired, 103; anal divided; dorsal scales smooth; head elongated; loreal present; 8 supralabials, only fifth in contact with orbit; dorsum brown, with bronze tint; paravertebral yellow dots form an vertebral stripe on anterior parts of dorsum; cream ventrolateral stripe from labial scales to tail base.

Our single specimen was found actively hunting a subadult *Fejervarya limnocharis* on a sunny morning

**Fig. 6** Snakes from Phnom Kulen National Park. Left, top to bottom: *Boiga siamensis* (ZFMK 92624), *Lycodon davisonii* (ZFMK 92628), adult *Lycodon subcinctus* (ZFMK 92631) and adult *Oligodon fasciolatus* (ZFMK 92633). Right, top to bottom: *Dendrelaphis subocularis* (ZFMK 88324), juvenile *Lycodon subcinctus* (ZFMK 90372), juvenile *Oligodon fasciolatus* (ZFMK 92634) and *Amphiesma stolatum* (ZFMK-PA RW01) (© T. Hartmann, P. Geissler & R. Weckauf).

 

(09:00 hrs) on 1 September in 2008 in disturbed lowland habitat.

***Lycodon davisonii* (Blanford, 1878) (Fig. 6)**

IUCN status: Least Concern.

*Material examined*: Svay Leu District, Phnom Kulen Plateau: ZFMK 92628.

*Remarks*: Voucher specimens from PKNP match the descriptions of other Indochinese populations published by Saint-Girons (1972), Geissler *et al.* (2011) and Vassilieva *et al.* (2016): midbody scale rows 13; ventrals 226; subcaudals paired, 97; anal entire; dorsal scales smooth; head flattened; loreal present; preocular absent; nasals separated by two internasals; whitish cross-bars alternate with broad semicircles in dark brown; on posterior parts of body and tail the pattern appears dissolved into a reticulate pattern.

The species was formerly assigned to the genus *Dryocalamus*, which was put into the synonomy of *Lycodon* by Figueroa *et al.* (2016). Our single specimen was found resting on the twigs of a bush in disturbed semi-evergreen forest at 20:30 hrs on 7 June 2011.

***Lycodon subcinctus* Boie, 1827 (Fig. 6)**

IUCN status: Least Concern.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK 90371–372, 92631.

*Remarks*: The three voucher specimens from the PKNP match the descriptions of other Indochinese populations published by Saint-Girons (1972), Geissler *et al.* (2011) and Vassilieva *et al.* (2016): midbody scale rows 17; ventrals 192–230; subcaudals paired, 60–91; anal divided; scales feebly keeled; snout broad; nasals separated by two internasals; dorsal colouration dark grey to black, with broad distinct white cross-bars on anterior part of body; cross-bars on anterior part of body and tail almost invisible.

All individuals were found actively foraging after dawn (17:30–21:00 hrs) in leaf litter in disturbed semi-evergreen forest.

***Oligodon fasciolatus* (Günther, 1864) (Fig. 6)**

IUCN status: Least Concern.

*Material examined*: Banteay Srei District, Phnom Hop: ZFMK 88380. Banteay Srei District, Phnom Kbal Spean: ZFMK 92633–634.

*Remarks*: Our three specimens agree with the descriptions of other Indochinese populations published by Saint-Girons (1972), Grismer *et al.* (2008b) and Vassilieva *et al.* (2016): midbody scale rows 21–23; ventrals 147–210; tail short, tapering; subcaudals paired, 33–61; one preocular; one presubocular; two postoculars; supralabials 7–8; dorsum grey to yellowish brown; 11–22 brownish, dark edged rhomboid blotches on back, each separated by three reticulated cross-bars.

All three specimens were encountered being active during the daytime (11:00–16:30 hrs) in leaf litter within disturbed semi-evergreen forest.

***Amphiesma stolatum* (Linnaeus, 1758) (Fig. 6)**

IUCN status: Not Evaluated.

*Material examined*: Banteay Srei District, Phnom Kbal Spean: ZFMK-PA RW 01.

*Remarks*: A photo voucher taken by Regine Weckauf shows the characteristic colouration pattern of this species as described by Saint-Girons (1972) and Vassilieva *et al*. (2016): dorsum grey; dark cross-bars on back and flanks, more distinct on anterior part of body; two cream to brownish dorsolateral stripes, interrupted by brownish blotches on the anterior part of body and edged by a thin dark line on the posterior part of body and tail; neck rusty orange.

The photo-vouchered specimen was encountered in heavily disturbed open dipterocarp forest at 15:30 hrs on 24 August.

## Discussion

Though one of the smaller national parks (covering 37,373 ha: Hayes *et al*., 2013) in Cambodia, PKNP is important for conserving the herpetofauna of lowland habitats in mainland Southeast Asia. Three species confirmed in our study (*Sphenomorphus lineopunctulatus*, *Hemiphyllodactylus* sp. and *Kaloula mediolineata*) are currently unknown from any other locality in Cambodia and only two additional localities in Laos and Thailand are known for *S. lineopunctulatus,* neither of which are in a protected area. Semi-evergreen and evergreen lowland forests and their species-rich herpetofauna are under severe threat, having faced extensive clearance in recent years (Souter *et al*., 2016).

To infom effective conservation efforts in future, better understanding of species assemblages in protected areas in Cambodia is needed. Of the 41 protected areas in the country, PKNP and Phnom Samkos Wildlife Sanctuary are the only sites where long-term surveys of herpetofauna have been undertaken over several

years. Grismer *et al.* (2008a,b) documented the highest diversity of amphibians (29) and reptiles (65) known for Cambodia in Phnom Samkos Wildlife Sanctuary. This is followed by PKNP with 25 amphibians and 61 reptiles. All other protected areas of Cambodia have so far only received short term assessments resulting in much lower species numbers e.g., 22 amphibians and 33 reptiles in Kulen Promtep National Park (Hartmann *et al*., 2013b), 20 amphibians and 22 reptiles in Keo Seima Wildlife Sanctuary (Stuart *et al*., 2010), 21 amphibians and 17 reptiles in Phnom Nam Lyr Wildlife Sanctuary (Stuart *et al*., 2010) and 12 amphibians and 16 reptiles in Virachey National Park (Stuart *et al*., 2010). These figures probably reflect different levels of survey effort rather than an actual gradient in herpeto-diversity. More extensive long-term surveys are therefore urgently needed. This need is underlined by the fact that in the case of the PKNP, 42.5 % of the species have yet to be classified on the *IUCN Red List of Threatened Species*, in most cases due to a lack of information on their distribution and status.

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## Appendix 1 Amphibian and reptile species recorded in Phnom Kulen National Park, with voucher specimen numbers and capture localities

Locality abbreviations correspond with Fig. 1 and refer to A) Banteay Srei District, Phnom Chor (13°41′13′′N, 103°58′45′′E), B) Banteay Srei District, Phnom Kbal Spean (13°41′21′′N, 104°00′55′′E), C) Banteay Srei District, Phnom Hop (13°37′87′′N, 104°01′91′′E) and D) Svay Leu District, Phnom Kulen Plateau (13°32′49′′N 104°06′76′′E).

Photographic vouchers are indicated by ZFMK-PA with following initials referring to the photographer: AM=Alistair Mould, JBC=Jean-Baptiste Chevance, LA=Lukas Ackermann, PG=Peter Geissler, RW=Regine Weckauf, TH=Timo Hartmann and PW=Philipp Wagner.

Distribution in Indochina: Species characteristic of anthropogenically modified environments and widespread in Indochina (*sensu* Stuart & Emmett, 2006; Bezuijen *et al*., 2009; Bain & Hurley, 2011; Hartmann *et al*., 2013b) are marked with an asterisk (*). Species records based on literature alone (Hayes *et al*., 2013; Herr & Lee, 2016) are marked with a "L". Distribution abbreviations for the remainder follow Bain & Hurley (2011): NWU=Northwest Uplands, NEU=Northeast Uplands, NAN=Northern Annamites, NEL=Northeast Lowlands, UML=Upper Mekong Lowlands, CAN=Central Annamites, SAN=Southern Annamites, CSL=Central-south Vietnam Lowlands, SLU=Southern Lao Uplands, SLL=Southern Lao Lowlands, MEK=Mekong Delta, CMB=interior Cambodian Lowlands, CDU=Cardamom Uplands, CDL=Cardamom Lowlands; NC=Northern Coast, CC=Central Coast, SC=Southern Coast, NIS=Northern Islands and SIS=Southern Islands.

IUCN Status: CR=Critically Endangered, EN=Endangered, LC=Least Concern, NE=Not evaluated, NT=Near Threatened, VU=Vulnerable (IUCN, 2018).

| Taxon | Locality: Voucher Number /Record | Distribution in Indochina | IUCN Status |
|---|---|---|---|
| **Bufonidae** | | | |
| *Duttaphrynus melanostictus* (Schneider, 1799) | A: 90167, B: ZFMK 89255–258, 90154–156 | * | LC |
| *Ingerophrynus macrotis* (Boulenger, 1877) | B: ZFMK 89259–265, 90157–166 | UML, CAN, CSL, SLL, CMB, CDU, CDL | LC |

 

## Appendix 1 Cont'd

| Taxon | Locality: Voucher Number /Record | Distribution in Indochina | IUCN Status |
|---|---|---|---|
| **Microhylidae** | | | |
| *Glyphoglossus guttulatus* (Blyth, 1856) | B: ZFMK 89309–310, 90168–172, 90174–175, C: ZFMK 90173 | NWU, NEL, CAN, CSL, SLL, CMB, CDL | LC |
| *Glyphoglossus molossus* Günther, 1869 | B: ZFMK 89311–314, 90176 | CSL, SLL, MEK, CMB | NT |
| *Kalophrynus interlineatus* (Blyth, 1855) | B: ZFMK 89307–308, 90177–181, D: ZFMK 92545 | NWU, NEU, NAN, NEL, UML, SAN, CSL, SLL, MEK, CMB, CDU, CDL | LC |
| *Kaloula mediolineata* Smith, 1917 | B: ZFMK 90187–199, 92546–547 | CSL SLL SIS | NT |
| *Kaloula pulchra* Gray, 1831 | A: ZFMK 89325–326, B: ZFMK 89317–322, 89324, 90182–186, D: ZFMK 89323 | * | LC |
| *Microhyla berdmorei* (Blyth, 1856) | A: ZFMK 90202–203, B: ZFMK 90200–201, 90204 | * | LC |
| *Microhyla butleri* Boulenger, 1900 | B: ZFMK 89315–316, 90205–210, 92548 | * | LC |
| *Microhyla mukhlesuri* Hasan, Islam, Kuramoto, Kurabayashi & Sumida, 2016 | A: ZFMK 90220, B: ZFMK 89327–331, 90211–219 | * | LC |
| *Microhyla heymonsi* Vogt, 1911 | B: ZFMK 89332, 90221–229, 92549 | * | LC |
| *Microhyla pulchra* (Hallowell, 1861) | A: ZFMK 89333, B: ZFMK 89334–336, 90230–233, D: ZFMK 92550 | * | LC |
| *Micryletta* cf. *inornata* (Boulenger, 1890) | B: ZFMK 89337–340, 90234–246 | NAN, NEL, UML, CSL, SLL, MEK, CMB, CDU, CDL | LC |
| **Dicroglossidae** | | | |
| *Fejervarya limnocharis* (Gravenhorst, 1829) | A: ZFMK 89274, B: ZFMK 89266–268, 276–278, 90247–249, C: ZFMK 89269–272, D: ZFMK 89275 | * | LC |
| *Hoplobatrachus rugulosus* (Wiegmann, 1834) | A: ZFMK 89281, B: ZFMK 89279–280, 90250–251 D: ZFMK 89282–284 | * | LC |
| *Limnonectes gyldenstolpei* (Anderson, 1916) | B: ZFMK 89294–295, 90252–260, C: ZFMK 90261–265, D: ZFMK 89286–293 | NWU, UML, SLL, CDU, CDL | LC |
| *Occidozyga lima* (Gravenhorst, 1829) | B: ZFMK 89297–303, 90266–90270, C: ZFMK 89296, 92556 | * | LC |
| *Occidozyga martensii* (Peters, 1867) | B: ZFMK 89304, 90271-281, D: ZFMK 89305–306, , 92557 | * | LC |
| **Ranidae** | | | |
| *Hylarana erythraea* (Schlegel, 1837) | B: ZFMK 90282–286, 92551–52 | * | LC |
| *Pelophylax lateralis* (Boulenger, 1877) | B: ZFMK 92555 | CAN, SAN, CSL, SLL | LC |
| *Sylvirana mortenseni* (Boulenger, 1903) | B: ZFMK 89342–347, 90287–294, 92553–554, C: ZFMK 89341 | CDU, CDL | NT |
| **Rhacophoridae** | | | |
| *Feihyla vittata* (Boulenger, 1877) | B: ZFMK 89349–353, 92560–562 | * | LC |
| *Chiromantis nongkhorensis* (Boulenger, 1877) | B: 92558–559, C: ZFMK 89348 | * | LC |
| *Theloderma* cf. *stellatum* (Taylor, 1962) | A: ZFMK 92565–566 | CAN, SAN, CSL, CDL, SIS | NT |
| *Polypedates megacephalus* (Hallowell, 1861) | A: ZFMK 89354–360, 89366, B: 90295–297, 92563–564, C: ZFMK 89361–362, D: ZFMK 89363–365 | * | LC |

## Appendix 1 Cont'd

| Taxon | Locality: Voucher Number /Record | Distribution in Indochina | IUCN Status |
|---|---|---|---|
| **Bataguridae** | | | |
| *Cyclemys* cf. *oldhamii* | A: ZFMK-PA TH 02, B: ZFMK 92567, ZFMK-PA PG 01 | NWU, NAN, NEL, UML, CAN, SLL, CMB, CDU, NC | EN |
| *Malayemys subtrijuga* (Schweigger, 1812) | B: ZFMK-PA TH 03 | UML, SLL, MEK, CMB | NT |
| **Testudinidae** | | | |
| *Indotestudo elongata* (Blyth, 1854) | D: ZFMK-PA TH 04 | NEU, NEL, CSL, SLL, MEK, CMB, CDU, CDL | CR |
| **Agamidae** | | | |
| *Calotes* aff. *mystaceus* Duméril & Bibron, 1837 | B: ZFMK 88340–341, 90298– 299, 92606–607 | * | NE |
| *Calotes versicolour* (Daudin, 1802) | A: ZFMK 88350, B: ZFMK 88342, 88349, 90300–303, C: ZFMK 88343, D: ZFMK 88344–348 | * | NE |
| *Draco maculatus* (Gray, 1845) | D: ZFMK 88351-352, 90304, 92608–611 | * | LC |
| *Leiolepis rubritaeniata* Mertens, 1961 | B: ZFMK 90305–307, 92599–605 | UML, SLL, CSL, CMB | NE |
| *Physignathus cocincinus* Cuvier, 1829 | B: ZFMK 92612–613 | NWU, NEU, NAN, NEL, CAN, SAN, CSL, SLU, SLL, MEK, CMB, CDL, SC, SIS | NE |
| **Gekkonidae** | | | |
| *Cyrtodactylus* cf. *intermedius* (Smith, 1917) | B: ZFMK 88356–359, 90309–311, 92572–575 | CSL, CMB | NE |
| *Dixonius siamensis* (Boulenger, 1894) | A: ZFMK 90317, B: ZFMK 88365, 90312–315, 92568, C: ZFMK 90316 | NEL, CMB, SAN, SLL, MEK, CDU, CDL | NE |
| *Gehyra mutilata* (Wiegmann, 1834) | B: ZFMK 90320 | * | NE |
| *Gekko gecko* (Linnaeus, 1758) | C: ZFMK 90308, D: ZFMK 88363–864 | * | NE |
| *Hemidactylus frenatus* Schlegel, 1836 | B: ZFMK 90318–319, 92569 | * | NE |
| *Hemidactylus platyurus* (Schneider, 1792) | B: ZFMK 88360, 88362, 90321–322, D: ZFMK 88361, 92570 | * | NE |
| *Hemiphyllodactylus* sp. | B: ZFMK 92571 | | NE |
| *Ptychozoon lionotum* Annandale, 1905 | L, Herr & Lee (2016) | CSL, CDU, SIS | LC |
| **Scincidae** | | | |
| *Eutropis longicaudata* (Hallowell, 1857) | B: 90325–326, D: ZFMK 88366, 92576 | * | NE |
| *Eutropis macularia* (Blyth, 1853) | B: ZFMK 90327–333 | * | NE |
| *Eutropis multifasciata* (Kuhl, 1820) | A: ZFMK 88367, ZFMK 90342, B: ZFMK 88371, 90340–341, C: ZFMK 88368–369, D: ZFMK 88370, 90343–345 | * | NE |
| *Lipinia vittigera microcercum* (Boulenger, 1894) | D: ZFMK 90339, 92577–582 | NAN, CAN, SAN, CSL, SLL, CMB, CDU, CDL, SC, SIS | NE |
| *Lygosoma bowringii* (Günther, 1864) | A: ZFMK 90335, B: ZFMK 90334, 90336, 92583–584, D: ZFMK 90337–338 | * | NE |
| *Lygosoma siamensis* Siler, Heitz, Davis, Freitas, Aowphol, Termprayoon and Grismer, 2018 | B: ZFMK 92585 | * | NE |

 

## Appendix 1 Cont'd

| Taxon | Locality: Voucher Number /Record | Distribution in Indochina | IUCN Status |
|---|---|---|---|
| *Scincella rupicola* (Smith, 1916) | A: ZFMK 90355, B: ZFMK 88372–374, 90346–90354, 92586–588, D: ZFMK 88375–377, 90356-359 | SAN | NE |
| *Sphenomorphus lineopunctulatus* Taylor, 1962 | D: ZFMK 88379, 88382, 92614–619 | SLL, CMB | NE |
| *Tropidophorus cocincinensis* Duméril and Bibron, 1839 | A: ZFMK 90364, B: ZFMK 88378, 90360–363, 92589–598 | NAN, CAN, CSL, CMB, MEK | NE |
| **Lacertidae** | | | |
| *Takydromus sexlineatus* Daudin, 1802 | C: ZFMK 90323–324 | * | LC |
| **Varanidae** | | | |
| *Varanus nebulosus* (Gray, 1831) | A: ZFMK–PA PW 01, L, Hayes *et al.* (2013) | * | NE |
| *Varanus salvator* (Laurenti, 1768) | B: ZFMK-PA AM 01 | * | LC |
| **Typhlopidae** | | | |
| *Indotyphlops braminus* (Daudin, 1803) | B: ZFMK 88338–339, 90365–366, 92620 | * | NE |
| **Xenopeltidae** | | | |
| *Xenopeltis unicolour* Boie, 1827 | B: ZFMK 92621 | * | LC |
| **Pythonidae** | | | |
| *Python bivittatus* Kuhl, 1820 | L, Hayes *et al.* (2013) | * | VU |
| *Malayopython reticulatus* (Schneider, 1801) | L, Hayes *et al.* (2013) | * | LC |
| **Pareatidae** | | | |
| *Pareas carinatus* (Boie, 1828) | A: ZFMK 90376, B: ZFMK 90375, 90377, D: ZFMK 92635 | * | LC |
| *Pareas margaritophorus* (Jan, 1866) | B: ZFMK 90378, 92636–637 | * | LC |
| **Colubridae** | | | |
| *Ahaetulla prasina* (Boie, 1827) | B: ZFMK 90392 | * | LC |
| *Boiga cyanea* (Duméril, Duméril & Bibron, 1854) | B: ZFMK 88335, ZFMK 92622–623, D: ZFMK 88336, | * | NE |
| *Boiga multomaculata* (Boie, 1827) | B: ZFMK 92625–627 | * | NE |
| *Boiga siamensis* (Nutaphand, 1971) | B: ZFMK 88337, 92624 | SAN, CSL, SLL, CMB, CDU, CDL | NE |
| *Chrysopelea ornata* (Shaw, 1802) | A: ZFMK 88322, B: ZFMK 90367–368, D: ZFMK 88323 | * | NE |
| *Coelognathus radiatus* (Boie, 1827) | A: ZFMK-PA PW 02, B: Sight record by TH | * | LC |
| *Dendrelaphis pictus* (Gmelin, 1789) | B: ZFMK 90393 | * | LC |
| *Dendrelaphis subocularis* (Boulenger, 1888) | C: ZFMK 88324 | SAN, SLL, MEK, CMB, CDU, CC, SC | LC |
| *Gonyosoma oxycephalum* (Boie, 1827) | D: ZFMK 92629 | * | LC |
| *Lycodon capucinus* (Boie, 1827) | B: ZFMK 90370, 92630 | * | LC |
| *Lycodon davisonii* (Blanford, 1878) | D: ZFMK 92628 | NAN, UML, CAN, CSL, SLL, MEK, CMB, CDU, CDL, SC, SIS | LC |
| *Lycodon laoensis* (Günther, 1864) | B: ZFMK-PA LA 01-03 | * | LC |

## Appendix 1 Cont'd

| Taxon | Locality: Voucher Number /Record | Distribution in Indochina | IUCN Status |
|---|---|---|---|
| *Lycodon subcinctus* Boie, 1827 | B: ZFMK 90371–372, 92631 | CAN, SAN, CSL, SLL, MEK, CMB | LC |
| *Oligodon fasciolatus* (Günther, 1864) | B: ZFMK 92633–634, C: ZFMK 88380 | SAN, CSL, SLL; MEK, CMB, CDU, CDL, CC, SC | LC |
| *Oligodon taeniatus* (Günther, 1861) | B: ZFMK 90373–374, 92632 | * | |
| *Ptyas korros* (Schlegel, 1837) | B: ZFMK 88319 | * | NE |
| **Natricidae** | | | |
| *Amphiesma stolatum* (Linnaeus, 1758) | B: ZFMK-PA RW 01 | UML; CAN, CSL, SLL; MEK, CMB, CDU, CC | NE |
| *Rhabdophis subminiatus* (Schlegel, 1837) | B: ZFMK 88330, 92640, D: ZFMK 88331 | * | LC |
| *Xenochrophis flavipunctatus* (Hallowell, 1860) | B: ZFMK 90390–391, 92641, D: ZFMK 88321 | * | LC |
| **Homalopsidae** | | | |
| *Hypsiscopus plumbeus* (Boie, 1827) | B: ZFMK 90369 | * | NE |
| **Lamprophiidae** | | | |
| *Psammodynastes pulverulentus* (Boie, 1827) | A: ZFMK 88332, 88334, B: ZFMK 90379–382, 92639, D: ZFMK 88333, 92638 | * | NE |
| **Elapidae** | | | |
| *Bungarus candidus* (Linnaeus, 1758) | B: ZFMK 88320 | * | LC |
| *Calliophis maculiceps* (Günther, 1858) | B: ZFMK 90383, 92642 | * | LC |
| *Naja kaouthia* Lesson, 1831 | B: ZFMK-PA LA 04 | * | LC |
| *Ophiophagus hannah* (Cantor, 1836) | B: ZFMK-PA PW 03 | * | VU |
| **Viperidae** | | | |
| *Trimeresurus* cf. *macrops* Kramer, 1977 | A: ZFMK 88326, B: ZFMK 88325, 88328–329, 90384–389, 92643-648, D: ZFMK 88327 | * | NE |
| *Calloselasma rhodostoma* (Kuhl, 1824) | D: ZFMK-PA JBC 01 | * | LC |

 

# Recent Master's Theses

*This section presents the abstracts of research theses produced by Royal University of Phnom Penh graduates recently awarded the degree of Masters of Science in Biodiversity Conservation. The abstracts have been edited for English and brevity.*

## Conservation status of threatened Mekong megafishes: a study using local ecological knowledge in northern Cambodia

PIN Kakada


### មូលន័យសង្ខេប

សម្ពាធនានាទៅលើជីវៈចម្រុះទឹកសាបនៅអាស៊ីអាគ្នេយ៍គឺកំពុងមានការកើនឡើង ខណៈដែលតម្រូវការនៃការអភិរក្សប្រភេទសត្វមាឌធំដែលរងការគំរាមកំហែងនៅក្នុងទន្លេមេគង្គនៅមិនទាន់មានភាពច្បាស់លាស់នៅឡើយ។ ទិន្នផលនេសាទនៃត្រីមាឌធំនៅក្នុងទន្លេកម្ពុជាមានអត្រាថយចុះខ្លាំងបើធៀបទៅនឹងត្រីមាឌតូច ហើយប្រភេទមួយចំនួនដូចជា៖ ត្រីប៉ាសាណាក់ (*Aaptosyax grypus*) ប្រហែលជាអាចផុតពូជរួចទៅហើយ។ ប៉ូពុយឡាស្សុងនៃប្រភេទត្រីផ្សេងៗទៀតដូចជា ត្រីរាជ(*Pangasianodon gigas*) ត្រីពោព្រុយ (*Pangasius sanitwongsei*) ក៏ប្រហែលជាកំពុងមានការថយចុះផងដែរ។ ខ្ញុំបានសម្ភាសអ្នកនេសាទត្រីដើម្បីទទួលបានចំណេះដឹងអេកូឡូស៊ីក្នុងតំបន់ និងកំណត់និន្នាការប៉ូពុយឡាស្សុងនៃត្រីមាឌធំ៧ប្រភេទនៅភាគខាងជើងនៃប្រទេសកម្ពុជាសម្រាប់រយៈពេល២០ឆ្នាំចុងក្រោយនេះ។ លទ្ធផលរបស់ខ្ញុំបានបង្ហាញថា ស្ថានភាពប៉ូពុយឡាស្សុងនៃប្រភេទត្រីទាំងអស់មានការថយចុះក្នុងអត្រាខុសៗគ្នាបើគិតចាប់តាំងពីឆ្នាំ១៩៩៨ រហូតដល់បច្ចុប្បន្ន។ វាក៏បង្ហាញផងដែរថា ត្រីរាជនៃទន្លេមេគង្គគឺជាប្រភេទត្រីដែលកម្រជាងគេបំផុត ហើយវាបានបង្ហាញពីបម្រែបម្រួលខ្ពស់ជាងគេបើផ្អែកទៅលើទិន្នន័យ។ ចំនួនប៉ូពុយឡាស្សុង និងទំហំខ្លួនរបស់ត្រីពោព្រុយក៏មានការថយចុះខ្លាំងផងដែរ។ ត្រីទាំងបីប្រភេទដែលសម្បូរជាងគេបំផុតគឺ ត្រីត្រសក់ក្រហម(*Probarbus jullieni*) ត្រីស្វក់(*Wallago micropogon*) និងត្រីគល់រាំង(*Catocarpio siamensis*) ដែលគេចាប់បានចុងក្រោយគឺ ប្រហែលប្រាំខែមុន។ ទោះជាយ៉ាងណាក៏ដោយ ទំហំខ្លួនរបស់វាមានការថយចុះគួរឱ្យកត់សម្គាល់ ខណៈពេលដែលប៉ូពុយឡាស្សុងរបស់វានៅមានទំហំធំ បើប្រៀបធៀបទៅនឹងប្រភេទត្រីផ្សេងទៀតដែលបានសិក្សារួចមកហើយ ដូចនេះ ពួកវាគួរតែត្រូវបានចាត់បញ្ចូលជាប្រភេទពុំសូវសម្បូរ៕

### Abstract

Pressures on freshwater biodiversity in Southeast Asia are accelerating and the conservation needs of threatened megafauna in the Mekong River remain unclear. Catches of large-bodied fish in the Cambodian section of the river have declined at a much greater rate than small-bodied fish and species such as Mekong giant salmon carp *Aaptosyax grypus* may already be extinct. Populations of other species such as Mekong giant catfish *Pangasianodon gigas* and giant pangasius *Pangasius sanitwongsei* are also likely to be declining. I interviewed fishers to obtain local ecological knowledge and determine population trends for seven megafish species in northern Cambodia over the last 20 years. Overall, my results indicate that the perceived population status of all species has declined at varying rates from 1998 to present. They also suggest that the Mekong giant catfish is the rarest species and this taxon had the greatest variation in estimate data. Populations and body size of the giant pangasius also decreased greatly. The three most common species were the seven-striped barb *Probarbus jullieni*, *Wallago micropogon* and giant barb *Catocarpio siamensis*, with mean dates for last capture of five months before present. However, their body size decreased considerably over time and while their populations are still relatively abundant compared to other study species, these should be considered as at least uncommon.


 

# The species diversity and distribution of gliding lizards in the genus *Draco* in Cambodia

SAMORN Vireak


## មូលន័យសង្ខេប

នៅប្រទេសកម្ពុជា ការចាប់អារម្មណ៍ចំពោះសត្វថ្នាក់លូននៅមានកម្រិតនៅឡើយ បើប្រៀបធៀបទៅនឹងប្រទេសផ្សេងៗនៅក្នុងតំបន់អាស៊ីអាគ្នេយ៍ ទោះជាមានចំណាប់អារម្មណ៍ទោះលើការស្រាវជ្រាវក្នុងពេលថ្មីៗនេះ បាននាំទៅដល់របកគំហើញប្រភេទដែលជាកំណត់ត្រាថ្មីសម្រាប់កម្ពុជា និងជាប្រភេទថ្មីសម្រាប់វិទ្យាសាស្ត្រ។ គោលបំណងនៃការសិក្សារបស់ខ្ញុំគឺ ដើម្បីរំលឹកឡើងវិញនូវនានាភាពនៃប្រភេទ និងរបាយរបស់បង្គួយហោះនៅក្នុងពូក*Draco* នៅក្នុងប្រទេសកម្ពុជា និងដើម្បីចងក្រងទិន្នន័យប្រភេទសម្រាប់ប្រភេទនីមួយៗ ដែលបានកំណត់អត្តសញ្ញាណ ដោយរួមមានទិន្នន័យរូបសាស្ត្រលម្អិត កំណត់ត្រាពីប្រវត្តិធម្មជាតិរបស់ប្រភេទ និងស្ថានភាពអភិរក្សរបស់វា។ ដើម្បីសម្រេចគោលបំណងទាំងនេះ ខ្ញុំបានពិនិត្យឯកសារដែលបានបោះពុម្ព និងត្រួតពិនិត្យសំណាកដែលមាននៅក្នុងសារៈមន្ទីរសត្តវិទ្យានៃសាកលវិទ្យាល័យភូមិន្ទភ្នំពេញ។ ការវាស់វែងតាមលំដាប់លំដោយនៃរូបសាស្ត្រ ការរាប់ស្រកា និងលក្ខណៈបែបគុណភាព ដូចជាពណ៌ពេលវានៅរស់ និងពេលងាប់ដែលរក្សាទុកក្នុងអាល់កុល ត្រូវបានធ្វើកំណត់ត្រាសម្រាប់សំណាកនីមួយៗ ហើយប្រៀបធៀបជាមួយនឹងការពិពណ៌នារបស់ប្រភេទដែលបានបោះពុម្ពរួច។ បន្ថែមលើសំណាកដែលមានស្រាប់ ការសិក្សានេះបានត្រួតពិនិត្យលើសំណាកដែលប្រមូលបានក្នុងឆ្នាំ២០១៧ និង២០១៨ នៅទីតាំងបីផ្សេងគ្នាក្នុងប្រទេសកម្ពុជា រួមមាន ឧទ្យានជាតិព្រះមុន្នីវង្សបូកគោ ឧទ្យានជាតិវឺនសៃ–សៀមប៉ាង និងដែនជម្រកសត្វព្រៃកែវសីមា។ នៅក្នុងការសិក្សានេះ ខ្ញុំបានពិនិត្យ សំណាកចំនួន១២៤ ត្រូវជា៤ប្រភេទគឺ៖ *Draco indochinensis* *D. taeniopterus* *D. maculatus* និង*Draco* sp.។ ៣ប្រភេទដំបូងគេអាចបែងចែកវាបានយ៉ាងច្បាស់តាមរយៈរូបសាស្ត្រ ចំណែក*D. maculatus* និង*Draco* sp. មានលក្ខណៈស្រដៀងគ្នាយ៉ាងខ្លាំង ប៉ុន្តែយើងអាចបែងចែកវាបានតាមរយៈពណ៌ស្បែកបូរក ដែលមានទាំងលើសត្វញី និងសត្វឈ្មោល ព្រមទាំងខុសគ្នាដោយទិន្នន័យរង្វាស់រូបសាស្ត្រផងដែរ។ ពូកវាក៏រស់នៅលើទីតាំងភូមិសាស្ត្រដាច់ពីគ្នាផងដែរ ដោយ*D. maculatus* មាននៅខាងលិចទន្លេមេគង្គ និង *Draco* sp. មាននៅខាងកើតទន្លេមេគង្គ។ ការធ្វើកំណត់អត្តសញ្ញាណជាក់លាក់នៃ *Draco* sp. នឹងតម្រូវឲ្យមានការប្រៀបធៀបជាមួយនឹងសំណាកផ្សេងបន្ថែមទៀត ដើម្បីបញ្ជាក់ឲ្យកាន់តែច្បាស់ ហើយខ្ញុំសូមស្នើឡើងថា ប្រវត្តិកំណត់ត្រានៃ*Draco indochinensis* ពីតំបន់ភ្នំបូកគោ អាចជាការភាន់ច្រឡំ ព្រោះទិន្នន័យនៃការសិក្សានេះបង្ហាញថា ប្រភេទ*Draco indochinensis* នេះទំនងជាមានវត្តមានតែនៅខាងកើតទន្លេមេគង្គប៉ុណ្ណោះ។

## Abstract

The reptile fauna of Cambodia has received limited attention compared to other countries in Southeast Asia, although recent interest has led to the discovery of many new country records and species to science. The aim of my study was to review the species diversity and distribution of gliding lizards in the genus *Draco* in Cambodia and compile species accounts for each taxon confirmed, including details of morphology and notes on their natural history and conservation status. To achieve this, I reviewed the published literature and examined specimen material held in the zoological collection of the Royal University of Phnom Penh. In addition to historical material, my study examined included specimens I collected in 2017 and 2018 in three sites in Cambodia: Bokor Preah Monivong National Park, Veun Sai-Siem Pang National Park and Keo Seima Wildlife Sanctuary. A series of morphometric measurements and scale counts and qualitative features such as colour in life and preservative were recorded for each specimen and compared with published species descriptions. Over the course of my study, I examined a total of 124 specimens and referred these to four species: *Draco indochinensis*, *D. taeniopterus*, *D. maculatus* and *D.* sp. The first three taxa are clearly separable morphologically, whereas *D. maculatus* and *D.* sp. are very similar but can be separated by the colour of the dewlap in both males and females and statistical differences in morphometric data. They are also separated geographically, with *D. maculatus* occurring west of the Mekong River and *D.* sp. occurring east of the river. Confirmation of the specific identity of *D.* sp. will require comparisons with additional specimen material and I suggest that a historical record of *D. indochinensis* from Bokor may have been in error because my data indicates the species likely only occurs east of the Mekong River.


 

# Quantifying fishing effort and mapping fishing distribution in the Koh Sdach Archipelago to inform development of a new marine protected area

SONG Det

## មូលន័យសង្ខេប

ការសិក្សាស្រាវជ្រាវថ្មីៗកន្លងទៅនេះបានបង្ហាញថា ប្រជុំកោះស្តេចគឺជាតំបន់ដែលសម្បូរទៅដោយធនធានសមុទ្រ ដែលរួមមានពពួកផ្កាថ្ម និងប្រភេទសត្វរងគ្រោះដូចជាសេះសមុទ្រ ហើយពួកវាទំនងជារងការគំរាមកំហែងដោយសារការនេសាទហួសកម្រិត និងការប្រើប្រាស់ឧបករណ៍នេសាទមិនបានត្រឹមត្រូវ។ ការសិក្សារបស់ខ្ញុំបានផ្តោតជារួមទៅលើការកំណត់នូវបរិមាណផលនេសាទនៅក្នុងដែនសហគមន៍នេសាទក្នុងតំបន់ប្រជុំកោះស្តេច ដោយមានគោលបំណង៖ ១. វាយតម្លៃបរិមាណផលនេសាទ ចាប់បានដោយឧបករណ៍នេសាទបែបលក្ខណៈគ្រួសារចំនួន៣ប្រភេទផ្សេងគ្នា និង ២. ធ្វើផែនទីទីតាំងដែលមានសកម្មភាពនេសាទខ្ពស់ជាងគេ និងទីតាំងដែលទូកនេសាទឈប់ចត។ គោលបំណងរួមនៃការសិក្សានេះគឺ ដើម្បីបង្កើត និងផ្តល់ព័ត៌មានសម្រាប់ផែនការអភិវឌ្ឍន៍តំបន់ការពារដែនសមុទ្រថ្មីនៅប្រជុំកោះស្តេច។ ខ្ញុំបានប្រមូលទិន្នន័យដោយការប្រើទូកដើម្បីកំណត់ទិន្នផលនេសាទ និងកំណត់ទីតាំងចម្បង។ និងផ្លូវទូកនេសាទ។ ទិន្នន័យស្រាវជ្រាវរបស់ខ្ញុំបានបង្ហាញថា មងក្តាមមានលទ្ធភាពនេសាទប្រហែល៥៥%នៃទិន្នផលនេសាទ ហើយមងត្រីមានលទ្ធភាពនេសាទបានប្រហែល២៦%នៃទិន្នផលនេសាទ និងលបត្រីមានលទ្ធភាពនេសាទបានប្រហែល ១៩%នៃទិន្នផលនេសាទ។ ខ្ញុំបានគណនាផលនេសាទក្នុងមួយលើកដោយប្រើប្រាស់សូចនាករ៣បែប(ពេលវេលា ចម្ងាយធ្វើដំណើរ និងទីតាំង ដាក់ឧបករណ៍នេសាទ) ហើយវាបង្ហាញថា គ្មានទំនាក់ទំនងគ្នាទេ(no correlation)រវាងទិន្នផលនេសាទជាមួយនឹងសូចនាករទាំង៣។ ប្រជានេសាទហាក់ដូចជាមិនបានផ្តោតទៅលើទីតាំងនេសាទជាក់លាក់ណាមួយទេ គឺពួកគាត់ធ្វើការនេសាទនៅទីតាំងផ្សេងៗ គ្នានៅក្នុងពេលនីមួយៗ។ ទោះជាយ៉ាងណា ទិន្នន័យផ្លូវនិងចំណុចដែលទទួលបានពីការសិក្សានេះអាចឱ្យខ្ញុំធ្វើផែនទីរបាយសកម្មភាពនេសាទនៅតំបន់ប្រជុំកោះ និងបានបង្ហាញថាកោះមួយចំនួនហាក់មានសកម្មភាពនេសាទច្រើនជាងគេគួរយ៉ាង កោះឆាន់ កោះទទឹង និង កោះអណ្តើក។ ខ្ញុំសូមផ្តល់យោបល់ឱ្យមានការសិក្សាស្រាវជ្រាវបន្ថែមទៀត ពីព្រោះលទ្ធផលទាំងនោះនឹងអាចផ្តល់ជាព័ត៌មានចាំបាច់សម្រាប់ការអភិរក្ស និងការគ្រប់គ្រងជលផលសមុទ្រនៅក្នុងតំបន់ប្រជុំកោះនាពេលអនាគត។

## Abstract

Recent research has shown that the Koh Sdach Archipelago has a high level of marine resources, including coral reefs and endangered species such as seahorses, and that these may be threatened by over-fishing and use of inappropriate fishing gears. My study focused on quantifying fishing effort within the boundary of a community fishery within the archipelago and aimed to 1) assess catch effort with three different family-scale fishing gears, and 2) map the hotspots for fishing effort and locations where fishing catch is landed. The overall purpose of my study was to generate information to inform the potential development of a new marine protected area within the archipelago. To this end, I undertook boat surveys to determine fishing yields and identify the major locations and routes of fishing effort. My data suggest crab gillnets accounted for ≈55% of fishing yields, whereas fish gillnets accounted for ≈26% of yields and fish traps accounted for ≈19%. I calculated catch per unit effort using three indicators (time, distance travelled and trap area) and found no correlation between fishing yields and any of these indicators. Fishers did not appear to focus on particular locations, visiting different areas on each occasion. However, the trail and point data generated from my field surveys allowed me to map the distribution of fishing activities within the archipelago and showed that several islands are visited on most fishing excursions, namely Koh Chhan, Koh Toting and Koh Anderk. I conclude by recommending additional studies because these will provide crucial information for future conservation and management of coastal fisheries in the region.

 

# Conversion of wetlands to agriculture over the last decade in Beoung Prek Lapouv Protected Landscape, Takeo Province, Cambodia

SOPHATT Reaksmey

## មូលន័យសង្ខេប

តំបន់ដីសើមមានសារៈសំខាន់ខ្លាំងណាស់សម្រាប់ជីវៈចម្រុះ និងមនុស្សជាតិ។ តំបន់ការពារទេសភាពបឹងព្រែកល្ពៅដែលស្ថិតនៅភាគខាងត្បូងប្រទេសកម្ពុជាមានសារៈសំខាន់សម្រាប់ប្រភេទសត្វស្លាបដែលកំពុងរងគ្រោះ និងជិតរងគ្រោះជាសកល ជាច្រើនដូចជាៈ សត្វក្រៀលក្បាលក្រហម(*Antigone antigone*) រនៀលពណ៌(*Mycteria luecocephala*) និងឪរឹប(*Houbaropsis bengalensis*)។ ការសិក្សារបស់ខ្ញុំបានពិនិត្យទៅលើកត្តាដែលនាំឱ្យមានការប្រែប្រួលការប្រើប្រាស់ដីនៅក្នុងតំបន់ការពារទេសភាពបឹងព្រែកល្ពៅដើម្បីៈ ១)កំណត់បរិមាណប្រែប្រួលនៃការប្រើប្រាស់ដី គិតចាប់ពីពេលដែលគេបានដាក់ដំបន់នេះជាតំបន់អភិរក្សក្នុងឆ្នាំ២០០៧ និង ២)កំណត់ពីកត្តាទាំងឡាយដែលនាំឱ្យមានការបម្លែងដីអភិរក្សឱ្យទៅជាផ្ទៃដីកសិកម្ម។ ដើម្បីឆ្លើយតបទៅនឹងគោលបំណងទាំងនេះ ខ្ញុំបានប្រើប្រាស់រូបភាពផ្កាយរណបពីឆ្នាំ២០០៧ ដល់ ឆ្នាំ២០១៧ មកធ្វើចំណាត់ថ្នាក់គម្របដី និងកំណត់បរិមាណប្រែប្រួលប្រចាំឆ្នាំរបស់វា។ ខ្ញុំក៏បានធ្វើការសម្ភាសន៍ជាមួយនឹងប្រជាជនមកពី១១២គ្រួសារ ដើម្បីស្វែងយល់ពីមូលហេតុនៃការបម្លែងតំបន់ដីសើមនោះ។ ការប្រមូលទិន្នន័យនៅទីវាលរបស់ខ្ញុំ បានចាប់ផ្តើមពីខែមីនា ដល់ខែកក្កដា ឆ្នាំ២០១៧។ ជាទូទៅ លទ្ធផលរបស់ខ្ញុំបានបង្ហាញថា ដីសើមនៅក្នុងតំបន់ការពារទេសភាពបឹងព្រែកល្ពៅចំនួនប្រហែល១៧% ត្រូវបានគេបម្លែងទៅជាផ្ទៃដីកសិកម្ម ក្នុងរយៈពេលមួយទសវត្សចុងក្រោយនេះ ដោយមូលហេតុចម្បងគឺការទន្ទ្រានដីអភិរក្ស។ ការសិក្សានេះក៏បានបង្ហាញផងដែរថា ប្រជាជនដែលរស់នៅក្នុងតំបន់នោះ មិនទាន់មានការយល់ដឹងអំពីសារៈសំខាន់នៃការអភិរក្សនៅតំបន់ទេសភាព ហើយទំនាក់ទំនងរវាងអាជ្ញាធរមូលដ្ឋាននិងភាគីពាក់ព័ន្ធក៏នៅមានកម្រិត។ យុទ្ធសាស្ត្រគ្រប់គ្រងដោយមានការចូលរួមពីសហគមន៍មូលដ្ឋាន និងការពង្រឹងការអនុវត្តច្បាប់ គឺជាតម្រូវការចាំបាច់ដើម្បីកាត់បន្ថយនូវការបាត់បង់តំបន់ដីសើមនៅបឹងព្រែកល្ពៅ។ គំនិតផ្តួចផ្តើមអភិវឌ្ឍឲ្យមានជីវភាពរស់នៅប្រកបដោយចីរភាពក៏ជាកត្តាចាំបាច់ដើម្បីធានានូវការអភិរក្ស ព្រោះការថែរក្សាធនធានដីសើមអាចធ្វើឱ្យជីវភាពរស់នៅរបស់ប្រជាជនដែលរស់នៅក្នុង និងជុំវិញតំបន់ការពារមានជីវភាពប្រសើរឡើង៕

## Abstract

Wetlands support important biodiversity and provide significant services to people. The Boeung Prek Lapouv Protected Landscape in southern Cambodia is important for a distinct set of globally threatened and near-threatened species including sarus crane *Antigone antigone*, painted stork *Mycteria luecocephala* and Bengal florican *Houbaropsis bengalensis*. My study looked at factors influencing land use change in the protected landscape and aimed to 1) quantify land use change since the establishment of the landscape as a conservation area in 2007, and 2) identify factors underlying its conversion to agriculture. To achieve this, I obtained satellite images from 2007 to 2017 to classify land cover and quantify yearly changes in this. I also interviewed 112 respondents in a household survey to understand how wetland conversion has occurred. My field research was carried out from March to July 2017. Overall, my results suggest that ≈17% of wetlands in the Boeung Prek Lapouv Protected Landscape have been converted to agricultural fields over the last decade and that the main reason for this has been land-grabbing. They also suggest that local residents lack awareness of the conservation importance of the protected landscape and that communication between local authorities and stakeholders has been limited. Community-based management and strengthened enforcement strategies are needed to reduce loss of wetlands in Boeung Prek Lapouv. Initiatives to develop sustainable livelihoods are also needed to ensure their conservation because preservation of wetland resources could make a significant difference to the livelihoods of households in and around the protected landscape.

 

# Genetic diversity of the striped snakehead fish *Channa striata* in the floodplains of Cambodia

UY Sophorn

## មូលន័យសង្ខេប

ផលិតកម្មវារីវប្បកម្មត្រីរ៉ស់ (*Channa striata*) ទើបតែបានចាប់ផ្តើមថ្មីៗនៅក្នុងប្រទេសកម្ពុជា បន្ទាប់ពីការដាក់កម្រិតអស់រយៈពេល ១២ឆ្នាំ។ ព័ត៌មានសេនេទិចបានពីកន្លែងផ្សេងៗគ្នា តាមទំនាបលិចទឹកនៃប្រទេសកម្ពុជាគឺជាតម្រូវការចាំបាច់ ជាព័ត៌មានសម្រាប់កម្មវិធីចិញ្ចឹមត្រីប្រភេទនេះ និងជាពិសេសគឺដើម្បីធានានូវប៉ូពុយឡាស្យុងដែលមានសុខភាពល្អ និងការអភិវឌ្ឍន៍វារីវប្បកម្មប្រកបដោយនិរន្តរភាព។ ក្នុងការសិក្សារបស់ខ្ញុំ ត្រីរ៉ស់ធម្មជាតិត្រូវបានប្រមូលពីទីតាំងចំនួន៨ ក្នុងទំបន់ទំនាបលិចទឹកនៃប្រទេសកម្ពុជា ដែលមានប្រាំតំបន់ស្ថិតក្នុងបឹងទន្លេសាប (ក្នុងខេត្តបាត់ដំបង សៀមរាប កំពង់ធំ ពោធិ៍សាត់ និងកំពង់ចាម) និង៣តំបន់ស្ថិតនៅតាមដងទន្លេមេគង្គ (ក្នុងខេត្តកំពង់ចាម កណ្តាល និងព្រៃវែង)។ ទិន្នន័យសេនេទិចនៃប៉ូពុយឡាស្យុងចំនួន៣ក្នុងកសិដ្ឋានបង្កាត់ពូជត្រីនៃប្រទេសវៀតណាមក៏ត្រូវបានប្រមូលសម្រាប់ធ្វើការប្រៀបធៀប។ ទិន្នន័យតំណលំដាប់ហ្សែនត្រូវបានបង្កើនបរិមាណពីDNAក្នុងមីតូកុងទ្រីចំនួនពីរបែប(cytochrome b និង D-loop) ហើយបានបង្ហាញពីភាពចម្រុះកម្រិតខ្ពស់នៃហ្សែនក្នុងប៉ូពុយឡាស្យុងត្រីរ៉ស់ធម្មជាតិស្ទើរទាំងអស់ក្នុងប្រទេសកម្ពុជា ឯភាពចម្រុះកម្រិតទាបបំផុតនៃហ្សែនត្រូវបានរកឃើញនៅក្នុងកសិដ្ឋានបង្កាត់ពូជត្រីនៃ ប្រទេសវៀតណាម។ ការវិភាគតាមស្ថិតិ បានបង្ហាញពីភាពដាច់ដោយឡែកពីគ្នាកម្រិតខ្ពស់នៃហ្សែនក្នុងប៉ូពុយឡាស្យុងធម្មជាតិទាំងអស់នៃបឹងទន្លេសាប ឯភាពដាច់ដោយឡែកពីគ្នាកម្រិតមធ្យមនៃហ្សែនត្រូវបានប្រទះឃើញក្នុងប៉ូពុយឡាស្យុងចំនួនពីរតាមបណ្តោយទន្លេមេគង្គ(កំពង់ចាម និងកណ្តាល)។ ប៉ូពុយឡាស្យុងធម្មជាតិក្នុងខេត្តព្រៃវែងមានភាពចម្រុះនៃហ្សែនទាប ស្រដៀងគ្នាទៅនឹងប៉ូពុយឡាស្យុងចំនួនបីពីកសិដ្ឋានបង្កាត់ពូជត្រីក្នុងប្រទេសវៀតណាម។ ជាលទ្ធផល ប៉ូពុយឡាស្យុងត្រីរ៉ស់ក្នុងទន្លេសាបមានធនធានហ្សែនល្អសម្រាប់ការអភិវឌ្ឍន៍វារីវប្បកម្មប្រកបដោយនិរន្តរភាព ដែលរួមមានកម្មវិធីបន្សាំ និងបង្កាត់ និងការគ្រប់គ្រងពូជមេបាដើម្បីកាត់បន្ថយការបាត់បង់ហ្សែន ជាន់ឈាម និងការរសាត់នៃហ្សែន(genetic drift) តាមរយៈការចិញ្ចឹមបន្សាំ។ ផ្ទុយទៅវិញ ប៉ូពុយឡាស្យុងក្នុងកសិដ្ឋានបង្កាត់ពូជត្រីនៃប្រទេសវៀតណាម មិនមែនជាធនធានពូជមេបាល្អសម្រាប់កម្មវិធីចិញ្ចឹមបន្សាំទេ ដោយវាអាចបណ្តាលឲ្យមានផលលំបាកគឺការជាន់ឈាម។

## Abstract

Aquaculture production of the striped snakehead fish *Channa striata* has recently begun in Cambodia after 12 years restriction. Genetic information from sites across the floodplains of Cambodia are required to inform domestication programmes for the species and specifically to ensure healthy populations and sustainable aquaculture development. In my study, wild striped snakehead fish were collected from eight sites in the floodplains of Cambodia, including five sites in the Tonle Sap Lake (in the Battambang, Siem Reap, Kampong Thom, Pursat and Kampong Chhnang provinces) and three sites along the Mekong River (in the Kampong Cham, Kandal and Prey Veng provinces). Genetic data of three cultured populations in Vietnamese hatcheries were also obtained for comparison. Sequence data were amplified from two mitochondrial DNA markers (cytochrome b and D-loop region) and indicated the highest levels of genetic diversity occurred in most of the wild populations in Cambodia, whereas the lowest occurred in cultured populations in Vietnamese hatcheries. More specifically, statistical analysis revealed highly significant genetic variation in all the wild populations in the Tonle Sap Lake, whereas moderate genetic variation was found in two of the populations sampled along the Mekong River (Kampong Cham and Kandal). The wild population in Prey Veng Province had low genetic diversity, similar to three cultured populations in Vietnamese hatcheries. As a consequence, wild striped snakehead fish populations in the Tonle Sap Lake have good genetic resources for sustainable aquaculture development, including domestication and breeding programmes and brood-stock management to minimize genetic loss, inbreeding and random genetic drift associated with domestication. Conversely, cultured populations in Vietnamese hatcheries are not a good source of brood-stock for domestication programmes as these could lead to inbreeding depression.

 

# Recent literature from Cambodia

*This section summarizes recent scientific publications concerning Cambodian biodiversity and natural resources. The complete abstracts of most articles are freely available online (and can be found using Google Scholar or other internet search engines), but not necessarily the whole article. Lead authors may be willing to provide free reprints or electronic copies on request and their email addresses, where known, are included in the summaries below.*

*Documents that use the Digital Object Identifier (DOI) System can be opened via the website http://dx.doi.org (enter the full DOI code in the text box provided, and then click Go to find the document).*

*If you or your organisation have recently published a technical paper, report or conference abstract that you wish to be included in the next issue, please send an electronic copy, summary or web-link to: Editor.CJNH@gmail.com or Editor.CJNH@rupp.edu.kh*

## New species & taxonomic reviews

Adamson, E.A.S., Britz, R. & Lieng S. (2019) *Channa auroflammea*, a new species of snakehead fish of the *marulius* group from the Mekong River in Laos and Cambodia (Teleostei: Channidae). *Zootaxa*, **4571**, 398–408.

The authors describe a new species of snakehead fish to science from the Mekong River system: *Channa auroflammea* sp. nov. Previously reported as *C. marulius*, *C.* cf. *marulius* or *C.* aff. *marulius*, the new species is readily distinguished from *C. marulius* and other members of the *marulius* group by its differing colour pattern. It also forms a regular component of the wild fisheries catch in the Tonle San and Tonle Srepok rivers.

Assing, V. (2018) A revision of Palaearctic and Oriental *Pseudolathra*. V. Two new species from Cambodia and Thailand, and additional records (Coleoptera: Staphylinidae: Paederinae). *Linzer biologische Beiträge*, **50**, 1005–1014.

This study presents records of beetles within the *Pseudolathra* genus from Thailand and Cambodia, including the first records of four species in Cambodia and a description of one new species to science: *P. aviformis* nov. sp. Author: vassing.hann@t-online.de

Averyanov, L.V., Averyanova, A.L., Nguyen K.S., Orlov, N.L., Maisak, T.V. & Nguyen H.T. (2018) New and rare orchid species (Orchidaceae) in the flora of Cambodia and Laos. *Novitates Systematicae Plantarum Vascularium*, **59**, 24–41.

The authors present data on orchids based on herbarium material collected in Cambodia and Laos in 2012–2017. These include the first records of three orchid species in Cambodia: *Eria ochracea*, *Luisia macrotis* and *Trichoglottis seidenfadenii*. Author: av_leonid@mail.ru

Bae, Y-S. & Bayaraikhan, U. (2019) New and newly recorded species of the genus *Halone* Walker, 1854 (Lepidoptera, Erebidae, Arctiinae, Lithosiini) from Cambodia, Laos and Vietnam. *Zootaxa*, **4586**, 395–400.

Paper not seen.

Bursey, C.R., Goldberg, S.R. & Grismer L.L. (2019) New Species of *Meteterakis* (Nematoda: Heterakidae) in *Physignathus cocincinus* (Squamata: Agamidae) from Cambodia. *Comparative Parasitology*, **86**, 1–4.

The authors describe a new species of nematode (*Meteterakis pursatensis* n. sp.) to science which was found in the large intestine of a Chinese water dragon (*Physignathus cocincinus*) in Pursat Province. Author: lgrismer@lasierra.edu

Constant, J. & Bartlett, C.R. (2019) New records and species in five planthopper families from Keo Seima Wildlife Sanctuary, Cambodia with checklist of Cambodian planthoppers (Hemiptera: Fulgoromorpha). *Belgian Journal of Entomology*, **83**, 1–27.

This paper presents recent records of planthoppers from Keo Seima Wildlife Sanctuary. These include the description of one species new to science (*Vishnuloka bunonga* sp. nov.) and the first country records of three species: *Vizcaya longispinosa*, *Macrobrachys tonkinensis* and *Hemisphaerius hippocrepis*. A checklist of Fulgoromorpha planthoppers is also provided for Cambodia which includes 42 species. Author: jerome.constant@naturalsciences.be

Gorfol, T., Furey, N.M., Bates, P. & Csorba, G. (2018) The identity of '*Falsistrellus' affinis* from Myanmar and Cambodia and new records of *Hypsugo dolichodon* from these countries. *Acta Chiropterologica*, **20**, 301–309.

This study reviews specimens reported as '*Falsistrellus affinis*' from Cambodia and Myanmar using molecular, morphological and morpho-metric methods. The authors conclude that these actually represent the long-toothed pipistrelle *Hypsugo dolichodon*, which was recently described as a new bat species to science from Laos and Vietnam. Author: gorfol.tamas@nhmus.hu

Hamalainen, M., Kosterin, O.E. & Kompier, T. (2019) *Euphaea cyanopogon* sp. nov. from the Cardamom ecoregion in Cambodia and Vietnam (Odonata: Euphaeidae). *Zootaxa*, **2555**, 28–44.

The authors describe a new species of damselfly (*Euphaea cyanopogon* sp. nov.) from the Kampong Saom Peninsula in Cambodia and Phu Quoc Island in Vietnam. They

 

discuss the differences and affinities of the new species with *E. pahyapi* and some of its other congeners. Author: matti.hamalainen@helsinki.fi

Kosterin, O.E. (2019) Occasional photographic records of butterflies (Lepidoptera, Papilionoidea) in Cambodia. 1. The coastal Cardamom foothills (SW Cambodia), 2010–2018. A*cta Biologica Sibirica*, **5**, 84–105.

The author presents records of butterflies at 63 localities in four provinces in southwestern Cambodia. These include 151 confirmed species and 15 provisionally identified species. Thirty-nine of the former and eight of the latter represent first records for the country. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2019) New synonyms and a new subspecies of *Macrogomphus* Selys, 1858 (Odonata: Gomphidae) from continental south-east Asia. *Zootaxa*, **4615**, 57–90.

The author revises the taxonomy of species within the *Macrogomphus* genus in mainland Southeast Asia and describes a new subspecies to science (*M. phalantus jayavarman* subsp. nov.) from the northern bank of the Tonle Sap Lake in Siem Reap Province. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2019) Update of 2017–2018 to Odonata of Kampong Saom Peninsula, Cambodia. *Journal of the International Dragonfly Fund*, **129**, 1–24.

This report presents new data on Odonata recorded in the Preah Sihanouk Province, with survey areas including the Kbal Chhay Waterfall, Ream Peninsula and Koh Rong Island. The total number of Odonata recorded in the Kampong Saom Peninsula now amounts to 74 species and the presence of *Onychargia atrocyana* in Cambodia is also onfirmed. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2019) On Odonata of Phnom Tumpor (Cambodia) in the late dry season (March 2019). *Journal of the International Dragonfly Fund*, **132**, 1–26.

This report presents data on Odonata collected from different habitats on Phnom Tumpor in Pursat Province. These include the first records of two species in Cambodia: *Polycanthagyna erythromelas* and *Macromia* sp. cf. *pinratani*. Author: kosterin@bionet.nsc.ru

Matalin, A.V. (2018) New records of tiger beetles (Coleoptera, Carabidae: Cicindelinae) from Cambodia. *Far Eastern Entomologist*, **356**, 9–16.

Matalin, A.V. (2018) Review of the tiger beetle genus *Naviauxella* Cassola, 1988, with the description of a new species from Cambodia (Coleoptera, Carabidae, Cicindelinae). *Entomologisch Blätter und Coleoptera*, **114**, 293–299.

Papers not seen.

Murdoch, M.L., Grismer, L.L., Wood Jr, P.L., Neang T., Poyarkov, N.A., Ngo V.T., Nazarov, R.A., Aowphol, A., Pauwels, O.S.G., Nguyen H.N. & Grismer, J.L. (2019) Six new species of the *Cyrtodactylus intermedius* complex (Squamata: Gekkonidae) from the Cardamom Mountains and associated highlands of Southeast Asia. *Zootaxa*, **4554**, 0–62.

The authors present an integrated taxonomic analysis of specimens belonging to the *Cyrtodactylus intermedius* complex. They identify eight species-level lineages within the complex which are discretely diagnosable and occur in specific areas, including five in Cambodia which are described as new to science: *C. auralensis* sp. nov. endemic to Phnom Aural, *C. bokorensis* sp. nov. endemic to the Bokor Plateau, *C. cardomomensis* sp. nov. from the main block of the Cardamom Mountains, *C. thylacodactylus* sp. nov. endemic to Phnom Dalai and *C. laangensis* sp. nov. endemic to the Phnom Laang karst formation. Author: mmurdoch@villanova.edu

Choi J.B., Choi E.U., Lee H., Hwang J.H., Kim E. & Park J.K. (2019) Note on new records of the carabid beetles (Coleoptera: Carabidae) in Cambodia. *Journal of Asia-Pacific Biodiversity*, **12**, 320–323.

This short communication presents the first records for four species of carabid beetles in Cambodia, including diagnostic characters, collection information and photographs. Author: entopark@knu.ac.kr

Vermeulen, J.J., Luu H.T., Theary K. & Anker, K. (2019) New species of land snails (Mollusca: Gastropoda: Caenogastropoda and Pulmonata) of the Mekong Delta Limestone hills (Cambodia, Vietnam). *Folia Malacologica*, **27**, 1–35.

The authors describe 22 species of land snail new to science from a series of small and medium-sized limestone hills along the Cambodian and Vietnamese coasts. Relatively few species of land snail occur on these hills, but these exhibit high rates of endemism with 62 of the 113 species (55%) so far known being potentially endemic. This raises a conservation concern because the hills are being quarried for limestone by four large and several smaller cement factories, in addition to many local entrepreneurs. Author: jk.artandscience@gmail.com

Wiesner, J. & Constant, J. (2019) Records of tiger beetles (Coleoptera: Cicindelidae) collected in Cambodia, with description of a new species. 149. Contribution towards the knowledge of the Cicindelidae. *Insecta Mundi*, **700**, 1–12.

The authors describe a new species of tiger beetle to science from Cambodia: *Naviauxella varians* n. sp. They also present the first records of four species for the country and first records of additional species for several provinces. Author: juergen.wiesner@wolfsburg.de

## Biodiversity inventories

Jocque, M., Clause, J.K., Emsens, W.J., Mittermeier, J.C., Sandvig, E.M., Stone, M., Puls, S., Stock W. & van Berkel, T. (2018) *The Kdan Mekong expedition: a biological assessment of two*

*potential wildlife sanctuaries in Kratie Province, Cambodia. Biodiversity Express Survey Report 7.0 (22 June 2018)*. Biodiversity Inventory for Conservation, Belgium. Https://www.binco.eu/wp-content/uploads/2018/09/BES7_Prelim_27_June_2018.pdf.

This report describes the results of surveys of mammals, birds, herpetofauna and selected invertebrate groups within the Preaek Prasab Wildlife Sanctuary and Sambour Wildlife Sanctuary in Kratie Province in 2018. As well as confirming the presence of hog deer *Axis porcinus annamiticus* and Indochinese silvered langur *Trachypithecus germaini*, 220 bird species and over 50 amphibian and reptile species were recorded. All areas surveyed were found to have experienced varying levels of anthropogenic impacts. Author: merlijn.jocque@binco.eu

## Species ecology & status

Chhin S., Souter, N.J., Ngoprasert, D., Browne, S.J. & Savini, T. (2018) Population density and habitat loss of chestnut-headed partridge *Arborophila cambodiana* in south-west Cambodia. *Bird Conservation International*. DOI 10.1017/S095927091800045X

Thirty-two percent of bird species in Southeast Asia are at risk of extinction by the end of this century. The authors used line transects and camera traps to estimate population densities of chestnut-headed partridge in the Cardamom Mountains and assessed its current distribution and broad scale habitat changes from 1996 to 2016. They found that the species occurred at a density of 1.23 calling males/km$^2$ in evergreen and semi-evergreen forest above 400 m in elevation and that total evergreen forest cover in the Cardamom Mountains decreased by 20%. They conclude that the chestnut-headed partridge has a very restricted range within which the habitat has been fragmented and propose that the species be considered as Near Threatened. Author: sopheachhin@gmail.com

Choden, K.S., Ravon, S., Epstein, J.H., Hoem T., Furey, N.M., Gely, M., Jolivot, A., Hul V., Neung C., Tran A. & Cappelle, J. (2019) *Pteropus lylei* primarily forages in residential areas in Kandal, Cambodia. *Ecology and Evolution*. DOI 10.1002/ece3.5046

Circulation of Nipah virus has been reported in *Pteropus lylei* in Cambodia, but little is known about the distribution of this flying fox nationally and the associated implications for public health. The authors deployed GPS collars on 14 *P. lylei* in Kandal Province to study their movements and foraging behaviour. Most foraging locations were in residential areas (54%), followed by plantations (27%), and the maximum distance travelled each night ranged from 6.9–105 km and averaged 28.4 km. The use of residential and agricultural areas may create opportunities for *P. lylei* to interact with humans and livestock and suggests that anthropogenic habitats may be important for the species. Author: julien.cappelle@cirad.fr

Davis, E.O., Crudge, B., Lim T., O'Connor, D., Roth V., Hunt, M. & Glikman, J.A. (2019) Understanding the prevalence of bear part consumption in Cambodia: A comparison of specialised questioning techniques. *PLOS ONE*, **14**, e0214392.

The trade in bear parts poses a conservation challenge throughout Asia. Studies suggest that legislation alone cannot prevent illegal hunting and trade and that the demand for bear parts and products must also be addressed. The authors employed four survey techniques to determine the key motivators for individuals to consume bear parts and assess whether specialised questioning techniques are helpful in this regard. Their results suggest that the efficacy of different methods varies greatly in certain contexts, but also indicate that individuals in Cambodia are under-reporting their consumption of bear parts when directly asked. They further estimate that the prevalence of bear part use in Cambodia may be as high as 15% of the population, presenting a significant conservation challenge. Author: eoneitadavis@gmail.com

Gonzalez-Monge, A. & Behie, A.M. (2019) The effects of selective logging on the habitat use of the Annamese silvered langur (*Trachypithecus margarita*) in northeast Cambodia. In *Primate Research and Conservation in the Anthropocene* (eds A. Behie, J. Teichroeb & N. Malone), pp. 101–119). Cambridge University Press, Cambridge, UK.

Paper not seen.

Leroux, N., Roth B. & Marx, N. (2019) The reintroduction of captive-born pileated gibbons (*Hylobates pileatus*) into the Angkor Protected Forest, Siem Reap, Cambodia. *Primate Conservation*, **33**, 1–11.

This paper describes the reintroduction of pileated gibbons sourced from the Phnom Tamao Wildlife Rescue Centre into the Angkor Protected Forest following a period of acclimatization and supplementary feeding. Post-release monitoring indicated that the first two pairs of gibbons, including three captive-born individuals raised by their mother, reverted easily to life in the forest and bore four infants within the first five years. A third pair, which was hand-raised, proved inappropriate and was recaptured after ten days. This was replaced by a young, captive-born and mother-raised pair, which is undergoing acclimatization in Angkor. The authors suggest that mother-raised and captive-born gibbons that have had minimal interactions with people are more appropriate for release into natural habitats than infants that have been rescued from trade and hand-raised. Author: nicole.andre.leroux@gmail.com

Pruvot, M., Cappelle, J., Furey, N., Hul V., Heng H.S., Duong V., Dussart, P. & Horwood, P. (2019) Extreme temperature event and mass mortality of insectivorous bats. *European Journal of*

 

*Wildlife Research*, **65**, 41.

The authors describe their investigation of a mass mortality event of *Chaerephon plicatus* and *Taphozous theobaldi* bats which occurred during a heat wave in April 2016 in Cambodia. Field evidence, clinical signs and gross pathology findings were consistent with a heat stress hypothesis, though the detection of novel bat paramyxovirus raises questions about its possible role as a contributing factor or a coincidental finding. Author: mpruvot@wcs.org

## Coasts, wetlands & aquatic resources

Boonroumkaew, P., Sanpool, O., Rodpai, R., Sadaow, L. Somboonpatarakun, C., Laymanivong, S., Aung, P.P.W., Un, M., Laummaunwai, P., Intapan, P.M. & Maleewong, W. (2019) Molecular identification and genetic diversity of *Gnathostoma spinigerum* larvae in freshwater fishes in southern Lao PDR, Cambodia, and Myanmar. *Parasitology Research*, **118**, 1465–1472.

Gnathostomiasis, an emerging food-borne parasitic zoonosis in Asia, is mainly caused by *Gnathostoma spinigerum*. Consumption of raw meat or freshwater fish in endemic areas is the major risk factor. The authors provide the first molecular evidence that *G. spinigerum* occurs in freshwater fish and specifically the snakehead fish (*Channa striata*) in Cambodia, Laos and Myanmar. They recommend that public authorities advise people living in or travelling to these areas to avoid eating raw or undercooked freshwater fish. Author: wanch_ma@kku.ac.th

Chea P., Tey S., Suvedi, M. & Ghimire, R. (2018) Assessment of community fish refuge management practice in the Siem Reap province of Cambodia. *Environments*, **6**, 1.

Community Fish Refuges (CFR) are a conservation measure which aim to provide dry season refuges for fish and improve the productivity of rice field fisheries. The authors interviewed 120 to examine the socio-economic impacts of CFRs in the Srey Snam district of Siem Reap Province. Households involved in CFRs were found to benefit significantly in terms of savings and incomes from fish production, although illegal fishing and financial constraints to implementing CFRs also presented issues. The authors conclude by outlining measures that could help to strengthen and sustain CFRs in Cambodia. Author: suvedi@msu.edu

Oeurng C., Cochrane, T.A., Chung S., Kondolf, M.G., Piman, T. & Arias, M.E. (2019) Assessing climate change impacts on river flows in the Tonle Sap Lake Basin, Cambodia. *Water*, **11**, 618.

The Tonle Sap is the most fertile and diverse freshwater ecosystem in Southeast Asia, receiving nurturing water flows from the Mekong and its immediate basin. In addition to rapid development in the Tonle Sap basin, climate change may threaten natural flow patterns that sustain its diversity. The authors evaluated impacts of climate change on river flows in 11 sub-basins contributing to the lake to quantify the potential magnitude of future hydrological alteration. Their models indicate that future decrease in wet and dry season flows is likely. Mean annual projected flow reductions ranged from 9 to 29%, 10 to 35% and 7 to 41% for projections until the 2030s, 2060s and 2090s, respectively. A decrease in extreme river flows was also found, implying that there could be a decline in flood magnitudes and an increase in drought occurrences throughout the basin. Author: tom.cochrane@canterbury.ac.nz

Tha T., Chung S. & Oeurng C. (2019) Integrated modelling to assess flow changes due to future dam development and operation in Stung Sen River of Tonle Sap Lake Basin, Cambodia. *Journal of Water & Climate Change*. DOI 10.2166/wcc.2019.115

Plans to build additional hydropower dams in Cambodia have raised concerns that these will change seasonal flow regimes and negatively affect fisheries and biodiversity downstream. This paper models how a multi-purpose dam on the Stung Sen River would affect downstream water flows under three operational scenarios. Daily and seasonal flows changed significantly in their full-level and seasonal variation scenarios, with an average increase of 42% in dry season flow and an average decrease of 46% in wet season flow at the outlet of the Stung Sen basin. The authors conclude that dam construction on the Stung Sen River would significantly change its natural flow regime. Author: chantha@itc.edu.kh

## Forests & forest resources

Debonnea, N., van Vlieta, J. & Verburg, P. (2019) Future governance options for large-scale land acquisition in Cambodia: impacts on tree cover and tiger landscapes. *Environmental Science and Policy*, **94**, 9–19.

This study investigated how large-scale land acquisitions (LSLAs) can be governed to avoid underuse and spare room for other land uses, specifically nature conservation. The authors mapped converted and unconverted areas within LSLAs in Cambodia using remote sensing and examined the effects of three policy scenarios for managing LSLA underuse on overall land use until 2040. They found that interventionist policies performed best in limiting tree cover loss and preserving natural areas, whereas preventative measures led to less fragmentation. Their results suggest that only preventative policies can

reconcile LSLAs with tiger reintroduction in the Eastern Plains and that tigers are unlikely to survive there in the absence of these and well-enforced protected areas. Author: n.debonne@vu.nl

Kong R., Diepart, J-C., Castella, J-C. Lestrelin, G., Tivet, F., Belmain, E. & Bégué, A. (2019) Understanding the drivers of deforestation and agricultural transformations in the Northwestern uplands of Cambodia. *Applied Geography*, **102**, 84–98.

The authors analysed land use cover changes in four upland districts in northwestern Cambodia using Landsat data from 1976 to 2016 and identify drivers of deforestation using demographic data and qualitative information from local actors and other stakeholders. They found that forest cover declined by 65% over a period of 15 years due to conversion by smallholders into agricultural land for maize and cassava cultivation. They further investigate the mechanisms underlying this land use change to understand the diversity of individual farm trajectories and decision-making processes in relation to land conversion. Author: radakong@yahoo.com

Lonn P., Mizoue N., Ota T., Kajisa T. & Yoshida, S. (2019) Using forest cover maps and local people's perceptions to evaluate the effectiveness of community-based ecotourism for forest conservation in Chambok (Cambodia). *Environmental Conservation*, **46**, 111–117.

Increased attention has been given to evaluating the effectiveness of forest conservation projects, but it is not well known whether different methods provide similar results when evaluating changes in forest resources. The authors compared the use of forest cover maps and local perceptions for evaluating the effectiveness of an ecotourism initiative at Chambok. Forest cover maps suggested that the programme was effective at reducing deforestation, whereas local perceptions concurred, in that 64% of people perceived that forest resources increased and 75% felt the community could protect its own forest resources. The authors conclude that the initiative at Chambok has supported forest conservation and suggest that mixed-method approaches are essential for evaluating the effectiveness of conservation programmes. Author: mizoue@agr.kyushu-u.ac.jp

*The Recent Literature section was compiled by Neil Furey, with contributions from Oleg Kosterin, Jaap Vermeulen, Leonid Averyanov and Jenny Daltry.*

# Instructions for Authors

## Purpose and Scope

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

The *Cambodian Journal of Natural History* publishes original work by:

- Cambodian or foreign scientists on any aspect of Cambodian natural history, including fauna, flora, habitats, management policy and use of natural resources.
- Cambodian scientists on studies of natural history in any part of the world.

The Journal especially welcomes material that enhances understanding of conservation needs and has the potential to improve conservation management in Cambodia. The primary language of the Journal is English. For full papers, however, authors are encouraged to provide a Khmer translation of their abstract.

## Readership

The Journal's readers include conservation professionals, academics, government departments, non-governmental organisations, students and interested members of the public, both in Cambodia and overseas. In addition to printed copies distributed in Cambodia, the Journal is freely available online from: http://www.fauna-flora.org/publications/cambodian-journal-of-natural-history/ or http://rupp.edu.kh/cjnh

## Manuscripts Accepted

The following types of manucripts are accepted:

- Full papers (2,000–7,000 words, excluding references)
- Short communications (300–2,000 words, excluding references)
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- Letters to the editor (<650 words)

## Full Papers and Short Communications

Full Papers (2,000–7,000 words, excluding references) and Short Communications (300–2,000 words, excluding references) are welcomed on topics relevant to the Journal's focus, including:

- Research on the status, ecology or behaviour of wild species.
- Research on the status or ecology of habitats.
- Checklists of species, whether nationally or for a specific area.
- Discoveries of new species records or range extensions.
- Reviews of conservation policy and legislation in Cambodia.
- Conservation management plans for species, habitats or areas.
- The nature and results of conservation initiatives, including case studies.
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The Journal does not normally accept formal descriptions of new species, new subspecies or other new taxa. If you wish to submit original taxonomic descriptions, please contact the editors in advance.

## News

Concise reports (<300 words) on news of general interest to the study and management of Cambodia's biodiversity. News items may include, for example:

- Announcements of new initiatives; for example, the launch of new projects, conferences or funding opportunities.
- Summaries of important news from an authoritative published source; for example, a new research technique, or a recent development in conservation.

## Letters to the Editors

Informative contributions (<650 words), usually in response to material published in the Journal.

## Recent Literature

Copies or links to recent (<18 months) scientific publications concerning Cambodian biodiversity and the management of natural resources. These may include journal papers, project technical reports, conference posters and student theses.

## How to Submit a Manuscript

Manuscripts are accepted on a rolling basis each year and should be submitted by email to the editors (**Editor.CJNH@gmail.com, Editor.CJNH@rupp.edu.kh).** In the covering email, the lead (corresponding) author should provide the names and contact details of at least three suitably qualified reviewers (whom the editors may or may not contact at their discretion) and confirm that:

- The submitted manuscript has not been published elsewhere,
- All of the authors have read the submitted manuscript and agreed to its submission, and
- All research was conducted with the necessary approval and permit from the appropriate authorities.

Authors are welcome to contact the editors at any time if questions arise before or after submitting a manuscript.

## Preparation of Manuscripts

Authors should consult previous issues of the journal for general style, and early-career authors are encouraged to consider guidance provided by:

Fisher, M. (2012) Editorial – To shed light on dark corners. *Cambodian Journal of Natural History*, **2012**, 1–2.

Daltry, J., Fisher, M. & Furey, N.M. (2012) Editorial – How to write a winning paper. *Cambodian Journal of Natural History*, **2012**, 97–100.

Manuscripts should be in English and use UK English spelling (if in doubt, Microsoft Word and similar software should be set to check spelling and grammar for 'English (UK)' language). Lines should be double-spaced. Submissions can be in 'doc', 'docx' or 'rtf' format, preferably as a single file attached to one covering email.

The order of sections in the manuscript should be: cover page, main text, references, short biography of each author, tables and figures (including photographs). All pages should be numbered consecutively.

*Cover page:* This should contain the institutions and full mailing addresses of all authors and the email address of the corresponding author.

*Title:* A succinct description of the work, in no more than 20 words.

*Abstract:* (Full papers only). This should describe, in no more than 250 words, the aims, methods, major findings and conclusions. The abstract should be informative and intelligible without reference to the text, and should not contain any references or undefined abbreviations. Cambodian authors are strongly encouraged to submit a Khmer translation of the English abstract.

*Keywords:* (Full papers only). Up to eight pertinent words, in alphabetical order.

*Main text:* (Short communications). This should avoid the use of headed sections or subsections.

*Main text:* (Full papers). This should comprise the following sections in order: Introduction, Methods, Results, Discussion and Acknowledgements. Subsections may be included in the Methods, Results and Discussion sections if necessary. Conclusions and recomendations should be included in the Discussion.

*References:* These should be cited in the text in the form of Stuart & Emmett (2006) or (Lay, 2000). For three or more authors, use the first author's surname followed by *et al.*; for example, Rab *et al.* (2006) or (Khou *et al.*, 2005). Multiple references should be in chronological order, for example, Holloway & Browne (2004); Kry & Chea (2004); Phan (2005); Farrow (2006).

The reference list should be presented in alphabetical order. Cambodian, Vietnamese and other authors who typically write their family name first are presented in the form <surname> <initials> without a comma (thus, Sin Sisamouth becomes Sin S.). Western author names are presented in the form <surname> <comma> <initials> (thus Charles Robert Darwin becomes Darwin, C.R.).

The titles of articles and journals should be written in full.

The following are examples of house style:

*Papers:*

Berzins, B. (1973) Some rotifers from Cambodia. *Hydrobiologia,* **41,** 453–459.

Neang T. (2009) Liquid resin tapping by local people in Phnom Samkos Wildlife Sanctuary, Cambodia. *Cambodian Journal of Natural History,* **2009,** 16–25.

Tanaka S. & Ohtaka A. (2010) Freshwater Cladocera (Crustacea, Branchiopoda) in Lake Tonle Sap and its adjacent waters in Cambodia. *Limnology,* **11,** 171–178.

*Books and chapters:*

Khou E.H. (2010) *A Field Guide to the Rattans of Cambodia.* WWF Greater Mekong Cambodia Country Programme, Phnom Penh, Cambodia.

MacArthur, R.H. & Wilson, E.O. (1967) *The Theory of Island Biogeography*. Princeton University Press, Princeton, USA.

Rawson, B. (2010) The status of Cambodia's primates. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 17–25. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

*Reports:*

Lic V., Sun H., Hing C. & Dioli, M. (1995) *A Brief Field Visit to Mondolkiri Province to Collect Data on Kouprey* (Bos sauveli), *Rare Wildlife and for Field Training.* Unpublished report to Canada Fund and IUCN, Phnom Penh, Cambodia.

*Theses:*

Yeang D. (2010) *Tenure rights and benefit sharing arrangements for REDD: a case study of two REDD pilot projects in Cambodia*. MSc thesis, Wageningen University, Wageningen, The Netherlands.

*Websites:*

IUCN (2010) 2*010 IUCN Red List of Threatened Species.* Http://www.redlist.org [accessed 1 December 2010].

*About the Author(s)*: This section is optional for Full Papers and Short Communications. It should describe the main research interests of each author (<150 words each), apart from what is obvious from the subject of the manuscript and the authors' affiliations.

*Tables and figures (including plates):* All tables and figures should be cited in the text and placed at the end of the manuscript. These should be self-explanatory, have an appropriate caption and be placed on separate pages. Figures, including maps, should ideally be in black and white. Plates (photographs) should be included only if they are of good quality and form part of evidence that is integral to the study (e.g. a camera trap photograph of a rare species).

*Appendices*: Long tables and other supporting materials, such as questionnaires, should be placed in Appendices.

*Species names*: The first time a species is mentioned, its scientific name should follow without intervening punctuation: e.g., Asian elephant *Elephas maximus*. English names should be in lower case throughout except where they incorporate a proper name (e.g., Asian flycatcher, Swinhoe's minivet, long-billed vulture).

*Abbreviations*: Full expansion should be given at first mention in the text.

*Units of measurement*: Use metric units for measurements of area, mass, height, etc.

## Review and Editing

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