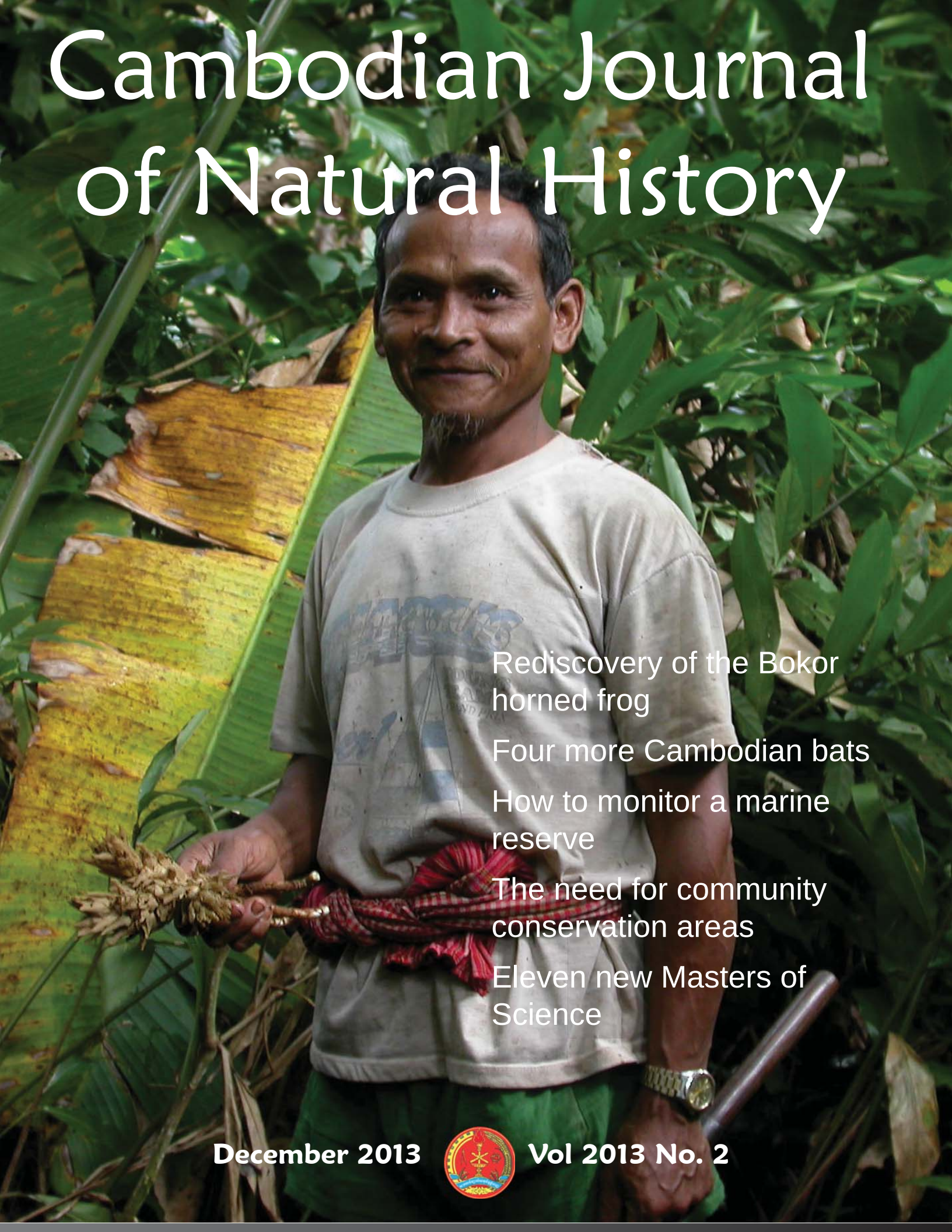
Cambodian Journal of Natural History



Rediscovery of the Bokor horned frog

Four more Cambodian bats

How to monitor a marine reserve

The need for community conservation areas

Eleven new Masters of Science

December 2013 Vol 2013 No. 2

Cambodian Journal of Natural History

ISSN 2226–969X

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

Cover photo: Wild cardamoms *Amomum kravanh* have long been harvested from evergreen forests that are traditionally managed and protected by the indigenous people of O'Som Commune, Veal Veaeng District, Pursat Province (© Lonnie McCaskill, Disney's Animal Kingdom). In this issue, Grazia Borrini-Feyerabend and Jeremy Ironside explore the significance and challenges of community-managed conservation areas in Cambodia.

Editorial—The University Capacity Building Project and Centre for Biodiversity Conservation: the Project Manager's perspective

Nicholas J. SOUTER

Centre for Biodiversity Conservation, Room 415, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia.

Fauna & Flora International, Cambodia Programme, PO Box 1380, #19, Street 360, Boeng Keng Kang I, Chamkarmon, Phnom Penh, Cambodia.

Email nick.souter@fauna-flora.org

In February 2013, I became "the new Neil", taking over from Dr Neil Furey as Project Manager of the University Capacity Building Project (UCBP) with Fauna & Flora International in Cambodia. Although I had worked extensively in the government, higher education and private consulting in Australia, I was new to Southeast Asia and to international conservation NGOs. In this editorial I offer my perspective on the UCBP and the Centre for Biodiversity Conservation at the Royal University of Phnom Penh through a discussion of our publications, the Masters of Science degree in Biodiversity Conservation, the Centre's conservation research, and the future.

The UCBP Project Manager wears many hats: academic, administrator, scientist, personnel manager, fund-raiser and publisher. Linked to the last of these, I am very pleased to have become one of the four editors of the *Cambodian Journal of Natural History*. Published both in print and on-line, the journal is the most visible of UCBP's activities and makes peer-reviewed studies of Cambodia's natural environment readily accessible. Whilst the *Cambodian Journal of Natural History* publishes studies specific to Cambodia, its production and quality are of an international standard. I have heard a number of very well qualified scientists comment positively on the quality and breadth of the journal and its content, and as a new editor I will work to maintain and improve this standing. This is also a source of pride for Cambodia's young scientists, who see publishing their work in the journal as a highly desirable goal. Despite its title, the journal's scope goes well beyond natural history. This issue, for instance, contains papers ranging from the rediscovery of a long lost frog (Neang *et al*., 2013) to the social and legislative aspects of community protected areas (Borrini-Feyerabend & Ironside, 2013).

One of the first tasks we carried out at the start of 2013 was a 'needs assessment' that sought the views of Cambodia's environmental sector on all aspects of our programme, including the *Cambodian Journal of Natural History*, the Masters of Science degree in Biodiversity Conservation, the Centre for Biodiversity Conservation and its reference collections. Respondents rated community-based natural resource management and livelihood issues, climate change, freshwater issues and biodiversity as the topics they would most like to see in the journal. I wonder whether a change of name (perhaps to the *Cambodian Journal of the Environment*?) might better reflect this journal's wide scope and attract even more authors and readers, further cementing its pre-eminent role in Cambodian science.

If the *Cambodian Journal of Natural History* is more than its name suggests, so too is the Masters of Science (MSc) degree in Biodiversity Conservation. Delivering the degree course through the Royal University of Phnom Penh's Biology Department is the UCBP's biggest activity. Established in 2005, the two-year degree—one year of course work and a second year thesis—provides a solid grounding in the scientific method and covers a range of topics from conservation basics, such as wildlife surveys and species conservation, to integrated natural resources management, geographic information systems (GIS) and managing projects. However two notable absences from the original curriculum are freshwater ecology and forest ecology. I believe both of these topics need to be incorporated—and not only because my background lies in freshwater ecology and floodplain forest conservation! An understanding of freshwater ecology is essential to Cambodia because of the economic and social significance of its inland fisheries (Cooperman *et al.*, 2012), the incredible biodiversity of the Mekong River, and the vast area of the country that becomes a wetland mosaic during the rainy season. Equally, a grasp of forest ecology is crucial in a country where forest products provide essential resources for many

poor rural Cambodians (Koy *et al.*, 2011) and where vital ecosystem services and globally important biodiversity are now threatened by the rapid loss of forest cover. Our needs assessment also found that while most of the course's current topics were still relevant, further tools for examining the social and economic aspects of conservation were also desired. This is not surprising, as conservation biology is developing into a holistic conservation science.

I was pleased to learn that the MSc degree is highly regarded in Cambodia and a high percentage of its graduates now work in government agencies, conservation NGOs and the Centre for Biodiversity Conservation (CBC). Now recruiting its 9th cohort, and with its 10th anniversary just around the corner, the MSc programme is entering a new and challenging phase. When the MSc curriculum was established, almost all of the courses were developed and taught by visiting foreign academics. Now, the first year courses are almost exclusively taught by Cambodians, many of whom are themselves graduates of the MSc in Biodiversity Conservation. Some of the lecturers are university staff, while others come from Cambodian government departments and NGOs. All are sessional lecturers and are thus paid in addition to their normal salaries. An unfortunate downside of engaging practitioners is they are sometimes unavailable due to their other work commitments. This is a hurdle that can hopefully be overcome through increasing the number of full-time university staff that lecture and teach in the programme.

The UCBP's progression from international to national trainers shows how far we have come in building capacity. Even though the MSc course is delivered in English, the students can understand the Cambodian lecturers much more readily than my obscure South Australian English accent, and the local lecturers can also explain complex points in Khmer where necessary. I can, however, see a continued place for overseas academics to assist in teaching, perhaps with courses taught in conjunction with overseas universities. This will help our curriculum to continue to keep pace with the technology and approaches used in other countries, and allow local lecturers to exchange experiences with international peers.

The number of students undertaking the MSc degree has increased in recent years. Eleven students have just submitted theses (see pages 109–124 for their abstracts), whilst a record 16 will be preparing theses in 2014. Every year, around 30 candidates apply for the course. This highlights local interest and recognition of the importance of biodiversity conservation, natural resource management and the overall educational value of the course. One of the factors that has helped the student numbers to grow is the generous provision of scholarships from other organisations such as the USAID HARVEST programme, WorldFish Centre, International Crane Foundation and the Kanitha Fund. Such scholarships pay student fees, support their thesis research or provide a living stipend, or a combination of all three. The modest income from student fees goes some way to supporting the costs of teaching and administering the MSc degree. However, the growing number of students can create difficulties in securing adequate guidance and supervision for their thesis studies, because every student requires at least one supervisor. In many countries, the primary supervisor is usually an experienced faculty academic, but while some Cambodian university staff have PhDs, the breadth of available expertise in Cambodian universities is still limited. Thus, supervision has largely come from outside, mostly from people working with international conservation NGOs based in Cambodia. I would be very pleased to hear from readers who feel they have the time and expertise to supervise one or more of our MSc students, especially in the fields of freshwater ecology and fisheries. External supervision introduces many of our students to future employers: I am often asked by leaders of the larger NGOs when the next batch of students will be finishing so they can seek out new recruits!

Thus far, the UCBP's diverse activities have been developed and delivered with funding from a range of philanthropic donors. Whilst student fees are starting to make a difference, they are not enough to cover the full costs of delivering the MSc course, let alone our wider capacity building programme. International grants have limited life spans and indeed our current major sponsor hopes to see substantial moves towards sustainable funding within the next few years. The MSc in Biodiversity Conservation was the first degree of its kind to be established at the Royal University of Phnom Penh. The university now offers three other MSc and runs 14 Masters programmes in total, funded in various ways. The challenges the MSc in Biodiversity Conservation faces in securing recurrent funding are likely to be faced by many of the other degree programmes. The most obvious sources of funding for these degree courses in the future are: a Royal Government of Cambodia allocation, the establishment of a well-funded foundation, support from other universities in delivering certain courses, and corporate sponsorship. All of these potential sources

are being explored. Yet another option is the delivery of shorter vocational courses, derived from the MSc modules, to fee-paying conservation and natural resource management professionals. This was trialled in 2013 by allowing a number of Fauna & Flora International's Cambodian staff to attend the GIS course and provide feedback, which I am pleased to say was positive. The needs assessment identified Integrated Natural Resources Management, Climate Change, Research Methods and Statistics, and GIS as the most requested subjects for vocational training.

Another important element of our project is developing the research capacity of the Centre for Biodiversity Conservation at the Royal University of Phnom Penh. The present CBC scientists have expert knowledge of reptiles, amphibians, bats, birds, butterflies and rotifers, and the necessary skills and equipment to survey them. The CBC zoological museum has significant collections of these animal groups, which have already contributed a great deal to our understanding of the variety of animal species in Cambodia. Research projects carried out by the CBC further help to advance the skills of MSc graduates, many of whom have gone on to pursue PhDs with institutions overseas. Whilst of enormous benefit to these individuals, and ultimately Cambodia, we risk losing qualified staff for several years if they chose to pursue their further studies abroad. Fortunately, we are training many worthy replacements every year through the MSc course. The CBC postgraduates have undertaken a number of pioneering research projects funded by Bat Conservation International, Zoos Victoria, the Conservation Leadership Programme and the Critical Ecosystem Partnership Fund. The CBC has also in turn provided financial and technical support to the National Herbarium of Cambodia, which is based in adjoining rooms in the Royal University of Phnom Penh, and I believe we should do more to develop this important resource.

In addition to applied research, environmental consulting could provide a source of funding for the CBC and its scientists. This year, the CBC carried out a zoological survey for an ecotourism development in Thmor Rung, and a number of similar companies have expressed interest in our services. This line of work requires caution, however, because the CBC team do not wish to be seen to endorse any developments that merely expect an EIA 'rubber stamp' or that might harm the reputation of the CBC and its partners for objective, high quality science.

Finally, and returning to the subject of publications, the CBC will produce three 'best practice' manuals and field guides in 2014 and 2015. The first, as advertised in the previous issue, is the landmark '*The Birds of Cambodia: an Annotated Checklist*'. Whilst the remaining titles are under development, we are planning two diverse publications that will showcase the breadth of the CBC's expertise and provide valuable information for Cambodia's conservationists and natural scientists.

From my perspective, perhaps the most important long term goal is to see a Cambodian scientist take over the management of the University Capacity Building Project. With more Cambodians being trained and increasingly exposed to the management of complex programmes, I hope and believe that this can occur sooner rather than later. This project is as relevant and important now as when it was established in 2005. Cambodia's rapid and expansive economic development is placing unprecedented pressures on its rich natural resources and irreplaceable biodiversity. Whilst the complete solutions to these challenges are well beyond the scope of this project, I believe that training more Cambodian environmental professionals and communicating their discoveries, experiences and advice is crucial if the natural resources that so many people depend upon are to be managed sustainably and if the nation's unique biodiversity is to be conserved for future generations.

References

Borrini-Feyerabend, G. & Ironside, J. (2013) Communities and biodiversity in Cambodia—options for policies and action whose time has come. *Cambodian Journal of Natural History*, **2013,** 95–108.

Cooperman, M.S., So N., Arias, M., Cochrane, T.A., Elliott, V., Hand, T., Hannah, L., Holtgrieve, G.W., Kaufman, L., Koning, A.A., Koponen, J., Kum V., McCann, K.S., McIntyre, P.B., Min B., Ou C., Rooney, N., Rose, K.A., Sabo, J.L. & Winemiller, K.O. (2012) A watershed moment for the Mekong: newly announced community use and conservation areas for the Tonle Sap Lake may boost sustainability of the world's largest inland fishery. *Cambodian Journal of Natural History*, **2012,** 101–106.

Koy R, Lonn P., Yem D., Jiao, X. & Smith-Hall, C. (2011) *Towards Understanding Household Level Forest Reliance in Cambodia: Study Sites, Methods, and Preliminary Findings*. Forest & Landscape Working Papers no. 60-2011, Forest & Landscape Denmark, University of Copenhagen, Copenhagen, Denmark.

Neang T., Chhin S., Meang M. & Hun S. (2013) Confirmation of three species of megophryid frogs (Amphibia: Megophryidae) from the Cardamom Mountains of Southwest Cambodia, with the rediscovery of a long lost species. *Cambodian Journal of Natural History*, **2013,** 66–72.

News

51st Annual Meeting of the Association for Tropical Biology and Conservation (ATBC 2014)

Planning for the 51st Annual Meeting of the Association for Tropical Biology and Conservation (ATBC 2014) is moving into the advanced stages as the dates for the meeting in Cairns, Australia (20–24 July 2014) rapidly approach.

Given that ATBC celebrated its 50th anniversary in 2013 with an outstanding meeting in Costa Rica, the conference theme for next year, entitled *The Future of Tropical Biology and Conservation*, will provide an exciting forum to look ahead at the big challenges to be faced over the next 50 years. Conference Organising Committee Chair, Dr Steve Turton of James Cook University, has been very pleased with the high level of interest shown in the conference, as evidenced by a substantial number of hits on the conference website and strong registrations of interest from ATBC members and non-members alike.

James Cook University has signed up as the Conference Partner and 10 organisations have joined the growing list of sponsors. The conference organisers will continue to seek further sponsorship to ensure conference registration fees are kept in line with those at recent ATBC meetings in developing countries.

Calls for symposia closed recently, with 34 proposals submitted to the Science Committee, ably chaired by Dr William Laurance of James Cook University. The list of symposia is now available on the conference website. In addition to symposia there will be opportunities for delegates to present papers in open sessions that will be scheduled across the four days. An outstanding line-up of keynote speakers has been put together for the conference, including Senator Christine Milne, Leader of the Australian Greens Party. We will update details of speakers on the web site as arrangements are finalised.

As with previous ATBC meetings, there will be pre- and post-conference workshops, satellite meetings and scientific field excursions to the Wet Tropics of Queensland and Great Barrier Reef World Heritage Areas.

For more details, the conference website is at www.atbc2014.org

Steve TURTON, Conference Organising Committee Chair, James Cook University, Australia.
Email info@atbc2014.org

Development of a standardised national methodology for coral reef surveys

The sustainable use of fisheries resources is a primary concern of the Royal Government of Cambodia's Fisheries Administration (FiA), and it is their aim to determine the current health status of coral reef ecosystems around the Cambodian coast. Monitoring the state of Cambodian coral reefs is important for tracking progress towards national and international targets for marine protection and to inform reef protection measures, such as the establishment of Cambodia's first Marine Fisheries Management Area (MFMA), which is currently under development in the Koh Rong Archipelago. In order to determine the success of such conservation initiatives, continual monitoring of constituting reefs is paramount.

Throughout the Cambodian coastline there are numerous non-governmental organisations and private sector companies undertaking research to assess the health of coral reef communities. Each of these organisations is currently using independent monitoring strategies, thus rendering their collected data incomparable from location to location. The FiA therefore requested the development of a standardised national methodology for surveys across Cambodian reefs to facilitate data comparisons.

In November 2013, Coral Cay Conservation, in collaboration with the FiA and Fauna & Flora International (FFI), delivered a workshop involving key organisations that are currently collecting, or planning to collect, coral reef data (Frontier, Shallow Waters, Song Saa Foundation, and Save Cambodian Marine Life, amongst others). A unified national survey method was proposed and agreed upon, including the compilation of a target indicator species list. Since

then, this methodology has been approved by the FiA and is now in operation.

It is hoped that this will be an important first step towards the creation of a national coral reef database. This will help gauge the success of the proposed and future MFMAs, and allow the FiA to make detailed assessments of coral reef health nationwide.

We thank the Blue Moon Fund and Darwin Initiative for funding the workshop.

Benjamin V. THORNE and Kate LONGHURST, Coral Cay Conservation, Puttenham, Surrey, UK.

Email cambodia_el@coralcay.org and headofscience@coralcay.org

Confirmation of three species of megophryid frogs (Amphibia: Megophryidae) from the Cardamom Mountains of Southwest Cambodia, with the rediscovery of a long lost species

NEANG Thy[1,2,*], CHHIN Sophea[2], MEANG Moeun[2] and HUN Seiha[2]

[1] Fauna & Flora International, Cambodia Programme, #19, Street 360, Boeng Keng Kang I, Chamkarmorn, Phnom Penh, Cambodia.

[2] Centre for Biodiversity Conservation, Room 415, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia.

*Corresponding author. Email thy.neang@fauna-flora.org

Paper submitted 14 October 2013, revised manuscript accepted 20 December 2013.

មូលន័យសង្ខេប

កង្កែបស្នែងស្រដៀងគ្នាបីប្រភេទនៃអំបូរMegophyridaeត្រូវបានរាយការណ៍ពីតំបន់ជួរភ្នំក្រវាញ ភាគនិរតីនៃប្រទេសកម្ពុជា។ ប្រភេទទាំងបីមានលក្ខណៈខុសគ្នាដោយសារប្រវែងដងខ្លួននៃភេទទាំងពីរ បង្គោលធ្មេញ ទំហំម្រាមជើងមុខនិងបាតម្រាមជើងក្រោយ និងផ្ទៃគ្រើមៗនៅផ្នែកខ្នងខាងក្រោយ។ កង្កែបស្នែង *Megophrys auralensis* មានប្រវែងម្រាមជើងមុខ IV<II<I<III មិនមានបន្ទះស្បែកចំហៀងនៃម្រាមជើងក្រោយ មានធ្មេញនៅលើបង្គោលធ្មេញតូចជាងនិងខ្លីជាង ដែលចំពោះកង្កែបខ្លះមានធ្មេញនេះ និងខ្លះទៀតមិនមានធ្មេញនេះទេ។ ប្រភេទនេះត្រូវបានប្រទះឃើញតែនៅដែនជម្រកសត្វព្រៃភ្នំឱរ៉ាល់ និងនៅព្រៃការពារតំបន់ជួរភ្នំក្រវាញកណ្តាលប៉ុណ្ណោះ។ ប្រភេទកង្កែបស្នែងមួយប្រភេទទៀតគឺ *M. damrei* ត្រូវបានរកឃើញសារជាថ្មីនៅឧទ្យានជាតិព្រះមុនីវង្ស "បូគោ" គឺអស់រយៈពេលជិតមួយសតវត្ស បន្ទាប់ពីវាត្រូវបានគេប្រមូលបាននៅទីនេះ នៅឆ្នាំ១៩១៤។ ប្រភេទកង្កែបស្នែងទីបីគឺ *M. lekaguli* ត្រូវបានរាយការណ៍ជាលើកដំបូងនៅកម្ពុជាពីដែនជម្រកសត្វព្រៃភ្នំសំកុស។

Abstract

Three morphologically similar horned frogs of the family Megophyridae are reported from the Cardamom Mountains of Southwest Cambodia. The three species can be distinguished by the snout-vent lengths of both sexes, vomerine ridges, sizes of finger and toe pads, and asperities on the posterior dorsum. The endemic *Megophrys auralensis* has relative finger lengths of IV<II<I<III, lacks lateral fringes on its toes, has vomerine teeth on smaller and shorter ridges present in some individuals and absent in others, and is known to occur only in Phnom Aural Wildlife Sanctuary and the Central Cardamoms Protected Forest. Another endemic species, *M. damrei,* is rediscovered in Bokor National Park, nearly a century after it was first collected there in 1914. The third species, *M. lekaguli,* is reported for the first time in Cambodia, in Phnom Samkos Wildlife Sanctuary.

Keywords

Cambodia, Cardamom Mountains, frog, *Megophrys*, national parks, wildlife sanctuary.

CITATION: Neang T., Chhin S., Meang M. & Hun S. (2013) Confirmation of three species of megophryid frogs (Amphibia: Megophryidae) from the Cardamom Mountains of Southwest Cambodia, with the rediscovery of a long lost species. *Cambodian Journal of Natural History*, **2013,** 66–72.

Introduction

The horned frogs of the family Megophryidae are currently represented by 10 genera and 171 species (Frost, 2013), many of which occur in Southeast Asia and some extend westward to India and Pakistan (Nguyen *et al.,* 2009; Mahony *et al.,* 2013). Megophryid frogs are nocturnal and cryptic in colouration and morphology. The presence of pectoral and femoral glands are characteristic of this family and some species have fleshy horns to mimic leaf litter on the forest floor (Ohler *et al*., 2002; Grismer, 2011; Stuart *et al*., 2006a,b; Neang & Holden, 2008).

Many species in the megophryid genus *Megophrys* Kuhl and van Hasselt, 1822 have been placed in the genus *Xenophrys* Günther, 1864 (44 species) (Frost, 2013). We follow Mahony (2011) and Mahony *et al.* (2013) in retaining the species named in *Megophrys* as they were originally described (Mahony, 2011; Ohler *et al*., 2002; Stuart *et al*., 2006a), giving a total of 49 *Megophrys* species. Within the genus *Megophrys*, two species (*M. auralensis* and *M. damrei*) have been described from Cambodia's Cardamom Mountains previously (Ohler *et al*., 2002; Mahony, 2011). *Megophrys lekaguli* was described from Chanthaburi and Sakaeo provinces in Southeast Thailand (Stuart *et al*., 2006a) and this paper reports its discovery in Cambodia for the first time. These three species appear almost identical morphologically, but can be distinguished by several differences (below).

The Cardamom Mountains cover an area of approximately 20,000 km^2 in Southwest Cambodia and encompass Phnom Samkos Wildlife Sanctuary, Central Cardamoms Protected Forest, Phnom Aural Wildlife Sanctuary, the Southwest Elephant Corridor (Southern Cardamoms Protected Forest), and the Botum Sakor, Kirirom and Bokor National Parks (Fig. 1). The Cardamom Mountains lie approximately 225 km from the mountainous Khao Soi Dao Wildlife Sanctuary in Southeast Thailand (Grismer *et al*., 2008; Holden & Neang, 2009).

During herpetological studies in the Cardamom Mountains, 10 specimens of *Megophrys* were collected in various parts of Phnom Samkos Wildlife Sanctuary (Tumpor Mountain in May 2007; Dalai Mountain in November 2009 and June 2010; Khnorng Tracheak in June 2013) and initially referred to *M. auralensis*. A further 11 specimens collected in January 2012 on Phnom Aural were similarly assigned to this species. In addition, specimens collected in October 2012 in Bokor National Park were initially identified as *M. damrei*, a new species described in 2011 from two specimens collected from Bokor in 1914. This species had never been photographed in life. Other species of amphibians and reptiles were also collected during these surveys, but are reported elsewhere.

Because later examinations revealed that instead of two species, these specimens represent three distinct *Megophrys* species, we provide morphological evidence of their identity, briefly remark on their natural history and distribution, and discuss variation within *M. auralensis*. All of the specimens we examined are listed in Appendix 1.

Methods

Fieldwork was undertaken in protected areas within the Cardamom Mountains landscape between May 2007 and June 2013. Specific dates and localities of each species are shown in Appendix 1. Frogs were found by opportunistic searches at night and captured by hand. Specimens were photographed prior to euthanasia with tricaine methanesulphonate (Finquel MS-222®, Argent Chemical Laboratories Inc., Redmond, USA) and fixed in 10% formalin in the field. Frog specimens were soaked in water for 12 hours upon arrival at the museum before being transferred to 70% ethanol for longer term storage in the zoological collection of the Royal University of Phnom Penh. Measurements of morphological characters followed Mahony (2011), Ohler *et al.* (2002) and Stuart *et al.* (2006a). Measurements were taken to the nearest 0.1 mm using dial callipers under a Nikon SMZ645 stereoscopic microscope. The abbreviations used to denote where specimens were deposited are CBC—Centre for Biodiversity Conservation (Royal University of Phnom Penh, Cambodia), NCSM—North Carolina Museum of Natural Sciences (Raleigh, USA) and FMNH—Field Museum of Natural History (Chicago, USA).

Results

***Megophrys auralensis* Ohler, Swan & Daltry, 2000** (Fig. 2)

Eleven males (snout to vent length, SVL, 60.1–74.2 mm) from Phnom Aural Wildlife Sanctuary agree with the original description for *M. auralensis* in lacking white bands on the upper lip, head broad, tibia long, and tympanum well developed (Ohler *et al.,* 2002). However, all of our specimens have relative finger lengths of IV<II<I<III (vs II<I<IV<III

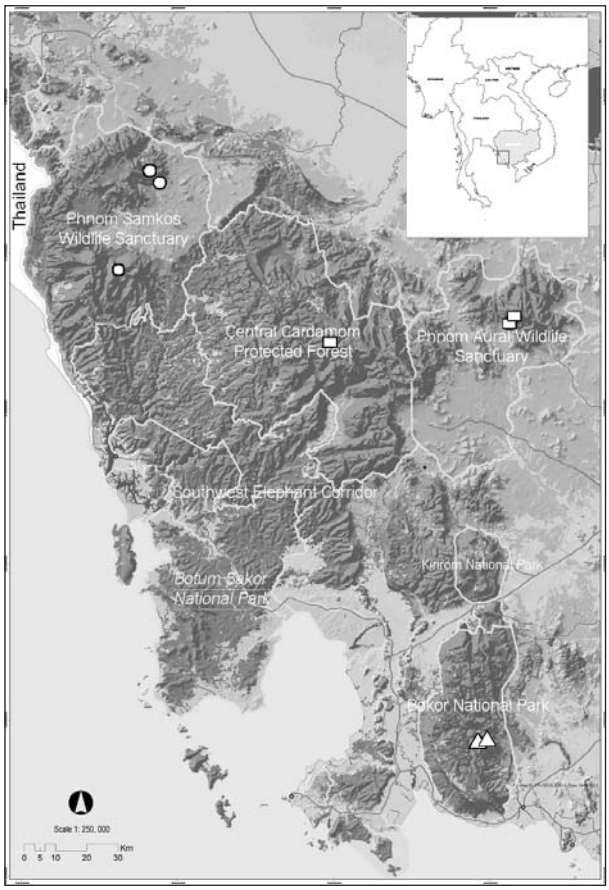


Fig. 1 Map of the Cardamom Mountains showing the localities of our female *M. lekaguli* (white circles), male *M. auralensis* (white rectangles) and male *M. damrei* (white triangles).

in specimens examined by Ohler *et al.*, 2002) and lack lateral fringes on toes (vs these being present), except toe V. An additional difference between our specimens and those reported by Ohler *et al.* (2002) is the presence of vomerine teeth in some specimens CBC01916, CBC01919–20, NCSM79557, NCSM79559 and NCSM79561, although vomerine teeth are absent from the specimens CBC001917–18, NCSM79556, NCSM79558 and NCSM79560.

The frogs were encountered at night on rocks, mostly in cascade sections of a fast-moving 2 metre wide stream in disturbed semi-evergreen at 476 metres above sea level (m.a.s.l.) and in primary evergreen forest at 1,058 m.a.s.l.

Megophrys auralensis has also been found on Knorng Louk Mountain in the Central Cardamom Mountains, at 11°53′29.5″N, 103°40′21.0″E, 1,200 m.a.s.l. (Stuart & Emmett, 2006).

***Megophrys damrei* Mahony 2011** (Fig. 3)

All six male specimens (SVL 47.7–54.5 mm) from Bokor National Park correspond well with the original description for *M. damrei* in having vomerine teeth, relative finger lengths of IV<II<I<III and lacking lateral fringes on toes (Mahony, 2011). This species has a light greyish brown dorsum with dark brown hourglass-shaped lines, dorsolateral ridges and a dark brown heart-shaped mark between the eyes; lighter greyish brown on forehead; two dark brown blotches at the edges of the upper eyelid; large black streak below the eye; darker marbled grey on the posterior dorsum and upper surface of thighs and shanks; yellowish orange on the upper arms and inguinal region; sparse small black blotches on flanks; dark patch covering the truncate snout and nostrils; dark tympanic region; throat and chest dark brown with darker blotches and small white mottling; belly, under surface of thighs, tibia, lower arms, and tarsus white with dark blotches; humeral region with large black blotch; black bars on front of lower arms, surface of fingers II & III; and upper surface of finger pads with yellowish orange.

Megophrys damrei was encountered at night in October 2012 on various substrates. Some individuals were spotted on leaf litter, at the base of ferns, and sitting on stream banks and rock boulders in cascade sections and near water seepages along a swift-moving, rocky stream. Many more individuals were heard calling from leaf litter in forest approximately 10 m from rocky streams in hill evergreen forest from 428–540 m.a.s.l.

Our record of *M. damrei* from Bokor National Park is significant because it marks the rediscovery of this species nearly a century after the last specimens were collected at 1,000 m.a.s.l. on the Bokor Plateau by Malcolm A. Smith in 1914. Searches for this "lost" species by Stephen Mahony in July 2010 were unsuccessful (Mahony, 2011).

***Megophrys lekaguli* Stuart, Chuaynkern, Chan-ard & Inger 2006** (Fig. 4)

Two males (SVL 41.0–44.2 mm) and eight females (SVL 58.6–83.2 mm) from Phnom Samkos Wildlife Sanctuary match the original description of *M. lekaguli* from eastern Thailand in having vomerine teeth, relative finger lengths of IV<II<I<III and lacking lateral fringes on their toes (Stuart *et al.*, 2006a).

Both males were found in May while calling from leaf litter on the bank of rocky, swift-moving stream at night in pristine hill evergreen forest. The females were found in June and November, sitting upon bare

Fig. 2 A male *M. auralensis* from Phnom Aural Wildlife Sanctuary (specimen CBC001916) (© Neang Thy).

Fig. 3 A male *M. damrei* from Bokor National Park (specimen CBC02250) (© Neang Thy).

Fig. 4 A female *M. lekaguli* from Phnom Samkos Wildlife Sanctuary (specimen CBC02235) (© Neang Thy).

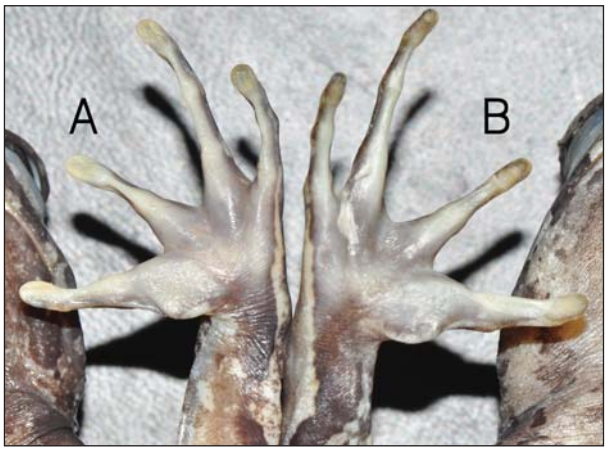


Fig. 5 Ventral view of finger pads: A. the enlarged finger pads of a male *M. auralensis* (specimen CBC01919); B. the slender finger pads of a female *M. lekaguli* (specimen CBC02235) (© Neang Thy).

soil on or under leaf litter during the day, and at night along forest trails and elsewhere in the forest. Some were found after heavy rain. One female (CBC02233) was encountered with a large grasshopper in its mouth while sitting on depressed soil beneath a tree seedling at the edge of a forest trail after light rain in the late afternoon. All of the frogs were encountered in primary evergreen forest areas between 900–1,290 m.a.s.l.

Megophrys lekaguli and *M. auralensis* may occur in broad sympatry between Phnom Samkos Wildlife Sanctuary and the Central Cardamom Protected Forest, although such populations might still be locally isolated from one another. Our record of *M. lekaguli* is the first record of this species for Cambodia. If this is correct (see discussion below), this invalidates the previous assignment of specimens from Phnom Samkos Wildlife Sanctuary to *M. auralensis* (Neang & Holden, 2008; Neang *et al*., 2010).

Discussion

Megophrys auralensis, M. lekaguli and *M. damrei* from the Cardamom Mountains of Cambodia are identical in their relative finger lengths (IV<II<I<III, except the female holotype of *M. damrei* has IV<I<II<III: Mahony, 2011), usually have vomerine teeth (although these are absent in some individuals of *M. auralensis*) and lack lateral fringes on all toes. The three species also have very similar colouration (Figs 2–4), except *M. damrei* has yellowish orange on the upper arms and dark

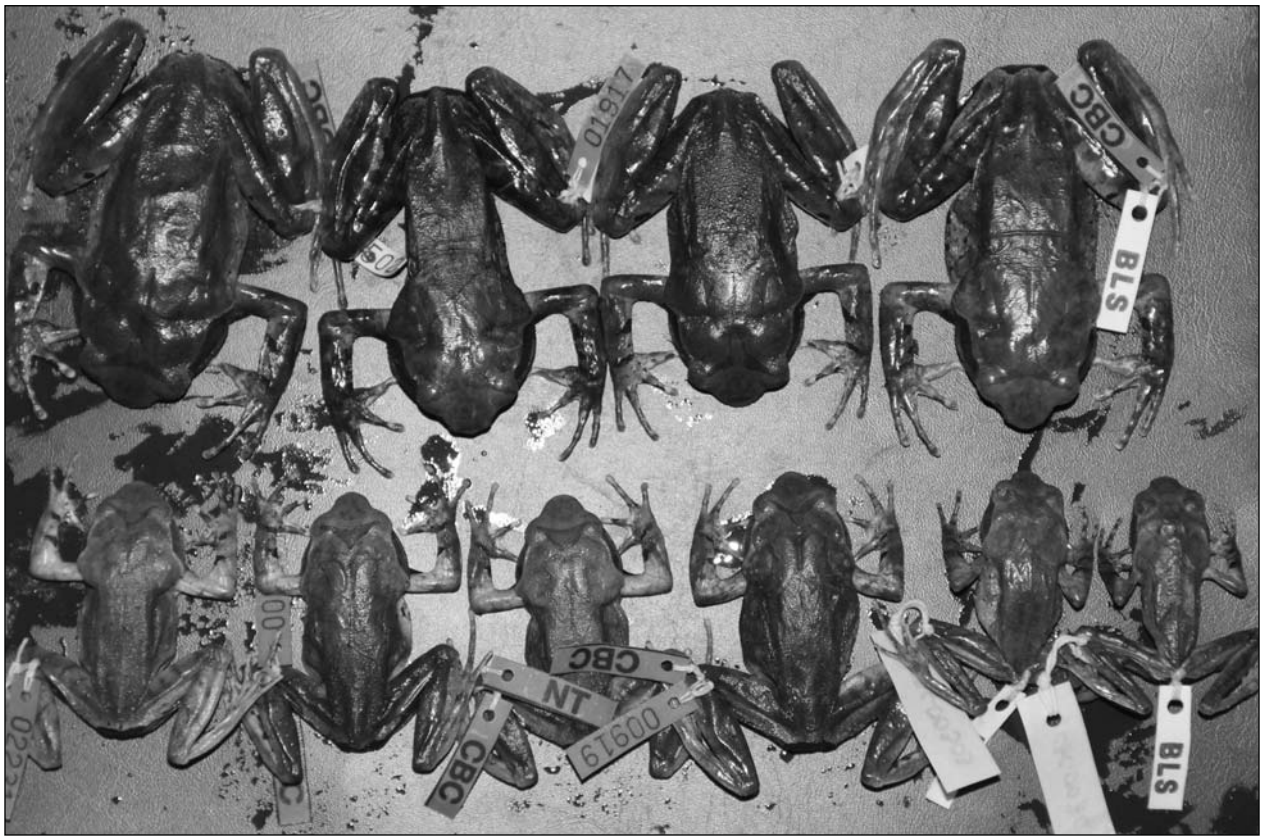


Fig. 6 Males of all three *Megophrys*: top row, *M. auralensis*; bottom left, *M. damrei*; bottom right, *M. lekaguli* (© Neang Thy). Note the marked difference in body size between *M. auralensis* and the other two species.

marbled grey on the posterior dorsum, upper surface of thighs and shanks. However, *M. auralensis* differs from *M. lekaguli* in that males of *M. auralensis* typically attain a larger body size: *M. auralensis* SVL 60.1–74.2 mm, *n* = 11 (our specimens); SVL 71.0–76.9 mm, *n* = 9 (Ohler *et al.*, 2002) vs *M. lekaguli* SVL 41.0–44.2 mm, *n* = 2 (our specimens from Cambodia); SVL 56.6–66.6 mm, *n* = 8 (*M. lekaguli* from Southeast Thailand, Stuart *et al.*, 2006a). Also, the vomerine teeth that are present in six out of 11 *M. auralensis* from Phnom Aural are on smaller and shorter ridges than those in *M. lekaguli* from Phnom Samkos, despite the larger body sizes of the *M. auralensis* examined by us and Bryan Stuart (pers. comm.). *Megophrys auralensis* has more enlarged pads on its fingers and toes, while those of *M. lekaguli* are slender (Fig. 5). Our male *M. lekaguli* from Cambodia's Phnom Samkos display a smaller and more slender body shape than *M. lekaguli* from Thailand (Fig. 6), however, which could cast doubt over whether they belong to the same species. Additional male specimens of *M. lekaguli* from Phnom Samkos are therefore needed to allow further comparisons between specimens from Cambodia and Thailand.

Megophrys auralensis is also separated from *M. damrei*, which has smaller males: SVL 47.7–54.5 mm, *n* = 6 (our specimens); SVL 57.1 mm, *n* = 1 (Mahony, 2011). *Megophrys damrei* has fine, dark brown and denser asperities with white edges on a dark marbled grey posterior dorsum vs fine white asperities mixed with sparse dark brown asperities in *M. auralensis*. Both *M. lekaguli* and *M. damrei* have vomerine teeth in all specimens examined by us and specimens reported by Stuart *et al.* (2006a) vs being absent in five of 11 specimens of *M. auralensis*. This unusual variation in vomerine teeth in *M. auralensis* suggest that molecular analysis should be carried out to determine whether this group is composed of more than one species.

Furthermore, *M. lekaguli* can be differentiated from *M. damrei* in having generally larger females: *M. lekaguli* SVL 58.6–83.2 mm, *n* = 8 (our specimens); and SVL 71.8–94.0 mm, *n* = 4 (Stuart *et al.*, 2006a) vs *M. damrei* SVL 69.1 mm, *n* = 1 (Mahony, 2011). *Megophrys*

lekaguli also has a narrower head (*M. lekaguli* head width/SVL = 0.34–0.36 in our specimens vs *M. damrei* head width/SVL = 0.38–0.41) and a lighter brown posterior dorsum with fewer fine white asperities on both males and females (vs dark brown and denser asperities with white edges on a dark marbled grey posterior dorsum in *M. damrei)*. These two species are allopatric in that *M. lekaguli* occurs in eastern Thailand and the westernmost end of Cambodia's Cardamom Mountains, whereas *M. damrei* is still known only from Bokor National Park in the southeastern part of the Cardamom Mountains.

Increased field sampling efforts and more detailed examination of specimens held in museums is helping to verify and correct the misidentification of cryptic species (Stuart *et al.*, 2006a; Mahony *et al.*, 2013). This study has raised the known number of species in the family Megophryidae in Cambodia to 10—*Leptobrachium mouhoti*, *Leptolalax melicus*, *Leptolalax* sp., *Megophrys auralensis, M. damrei*, *M. lekaguli*, *Ophryophryne hansi, O. poilani, O. synoria* and *Xenophrys major* (Ohler *et al.*, 2002; Stuart *et al.*, 2006a,b; Neang & Holden, 2008; Rowley *et al.*, 2010; Stuart *et al.*, 2010; Mahony, 2011). Three species in the genus *Megophrys* are now confirmed in the Cardamom Mountains, including our rediscovery of the long "lost" *M. damrei* after 98 years (1914–2012). Ensuring such species are identified correctly is the first step towards enabling conservationists, protected areas managers and other practitioners to better understand the status of species in their respective geographical areas and guide their in-situ conservation.

Acknowledgements

The authors would like to thank to H.E. Chay Samith for permission to undertake field work in Phnom Samkos Wildlife Sanctuary, Phnom Aural Wildlife Sanctuary and Bokor National Park. We also thank Bryan Stuart for examining specimens, Sim Sovannarun for preparing Figure 1, and Neil Furey and Jenny Daltry for English corrections. Our studies were made possible by grants provided to Neang Thy from the Rufford Small Grants Foundation (Grant No. 08.01.10), to Fauna & Flora International (Cambodia) from the Zoological Parks and Gardens Board of Victoria (Australia), Darwin Initiative (DEFRA, UK: 14-037 & EIDPO028) and the John D. and Catherine D. MacArthur Foundation (US: 09-92411-000-GSS), and to Chhin Sophea from the Conservation Leadership Programme (Grant No. 03101612). We also thank the reviewers for spending their valuable time reviewing this paper and providing constructive comments.

References

Frost, D.R. (2013) *Amphibian Species of the World: an Online Reference, Version 5.6*. American Museum of Natural History, New York, USA. Http://research.amnh.org/herpetology/amphibia/index.html [accessed 12 December 2013].

Grismer, L.L. (2011) *Lizards of Peninsular Malaysia, Singapore and Their Adjacent Archipelagos*. Edition Chaimira, Frankfürt am Main, Germany.

Grismer, L.L., Neang T., Chav T., Wood, Jr. P.L., Oaks, J.R., Holden, J., Grismer, J.L, Szu, T.R. & Youmans, T.M. (2008) Additional amphibians and reptiles from the Phnom Samkos Wildlife Sanctuary, northwestern Cardamom Mountains, Cambodia, with comments on their taxonomy and the discovery of three new species. *Raffles Bulletin of Zoology*, **56,** 161–175.

Holden, J. & Neang T. (2009) Small carnivore records from the Cardamom Mountains, southwestern Cambodia. *Small Carnivore Conservation*, **40,** 16–21.

Mahony, S. (2011) Two new species of *Megophrys* Kuhl & van Hasselt (Amphibia: Megophryidae), from western Thailand and southern Cambodia. *Zootaxa*, **2734,** 23–39.

Mahony, S., Teeling, E.C. & Biju, S.D. (2013) Three new species of horned frogs, *Megophrys* (Amphibia: Megophryidae), from Northeast India, with a resolution to the identity of *Megophrys boettgeri* populations reported from the region. *Zootaxa*, **3722,** 143–169.

Neang T. & Holden, J. (2008) *A Field Guide to the Amphibians of Cambodia.* Fauna & Flora International Cambodia Programme, Phnom Penh, Cambodia.

Neang T., Grismer, L.L., Chan K.O., Grismer, J.L., Wood Jr., P.L. & Youmans, T.M. (2010) First report of the herpetofauna of Dalai Mountain in Phnom Samkos Wildlife Sanctuary, southwestern Cardamom Mountains, Cambodia. *Cambodian Journal of Natural History*, **2010,** 127–143.

Nguyen V.S., Ho T.C. & Nguyen Q.T. (2009) *Herpetofauna of Vietnam*. Edition Chimaira, Frankfurt am Main, Germany.

Ohler, A., Swan, S.R. & Daltry, J.C. (2002) A recent survey of the amphibian fauna of the Cardamom Mountains, southwest Cambodia with descriptions of three new species. *The Raffles Bulletin of Zoology*, **50,** 465–481.

Rowley, J.J.R., Stuart, B.L., Neang T. & Emmett, D.A. (2010) A new species of *Leptolalax* (Anura: Megophryidae) from northeastern Cambodia. *Zootaxa*, **2567,** 57–68.

Stuart, B.L. & Emmett, D.A. (2006) A collection of amphibians and reptiles from the Cardamom Mountains, southwestern Cambodia. *Fieldiana Zoology*, **109,** 1–27.

Stuart, B.L., Chuaynkern, Y., Chan-ard, T. & Inger, R.F. (2006a) Three new species of frogs and a new tadpole from

eastern Thailand. *Fieldiana Zoology*, **111,** 1–19.

Stuart, B.L., Sok K. & Neang T. (2006b) A collection of amphibians and reptiles from hilly eastern Cambodia. *The Raffles Bulletin of Zoology*, **54,** 129–155.

Stuart, B.L., Rowley, J.L., Neang T., David, A.E. & Som S. (2010) Significant new records of amphibians and reptiles from Virachey National Park, northeastern Cambodia. *Cambodian Journal of Natural History*, **2010,** 38–47.

Appendix 1

Specimens with a code number beginning CBC are deposited in the zoological collection of the Centre for Biodiversity Conservation, Royal University of Phnom Penh. Specimens denoted by NCSM are deposited in the North Carolina Museum of Natural Sciences, Raleigh, USA. Specimens denoted by FMNH are deposited in the Field Museum of Natural History, Chicago, USA.

Megophrys auralensis. Material examined: CBC01916–18 and NCSM79556–58, males, collected 24 January 2012, 12°00′18.9″N, 104°08′15.8″E, 476 m.a.s.l.; CBC01919–20 and NCSM795559–61, males, collected 28 January 2012, 12°01′18.3″N, 104°08′42.7″E, 1058 m.a.s.l. All of these specimens were collected in Phnom Aural Wildlife Sanctuary, Cambodia, by Neang Thy and Bryan Stuart.

Megophrys lekaguli. Material examined: CBC00303–04, males, collected by Neang Thy and Jeremy Holden, 29 May 2007, 12°22′55.8″N, 103°03′26.0″E, 1,100 m.a.s.l., O'Kran, Tumpor Mountains; CBC00553, female, collected by Neang Thy, 18 November 2009, 12°26′29.7″N, 103°04′38.7″E, 1,009 m.a.s.l.; CBC01711 and CBC01713, females, collected by Neang Thy, 17 June 2010, around 12°24′53.6″N, 103°06′12.1″E, 1,106 m.a.s.l., Dalai Mountain; CBC02233–36, females, collected by Neang Thy & Hun Seiha, 11 June 2013, 12°09′58.0″N, 102°58′33.7″E, 900 m.a.s.l.; CBC02237, female, collected by Neang Thy and Hun Seiha, 12 June 2013, Khnorng Tracheak, 12°09′21.8″N, 102°59′18.7″E, 1,290 m.a.s.l. All of the aforementioned specimens were collected in Phnom Samkos Wildlife Sanctuary, Cambodia. Other specimens examined: FMNH213947–48, Khao Soi Dao Wildlife Sanctuary, Chanthaburi Province, Thailand; FMNH265956 and FMNH265959, Pang Si Da National Park, Sa Kaeo Province, Thailand.

Megophrys damrei. Material examined: CBC02230–31, males, collected 24 October 2012, 10°47′40.8″N, 104°04′12.5″E, 428 m.a.s.l; CBC02248–51, males, collected 23 October 2012, 10°47′28.2″N, 104°03′10.1″E, 540 m.a.s.l. All of the specimens were collected in Bokor National Park, Cambodia, by Neang Thy, Meang Moeun, Hun Seiha and Chhin Sophea.

Further new country records of four bat species (Chiroptera) from Cambodia and a call for information

CHHEANG Sarak[1], Paul J.J. BATES[2], Katherine BOUGHEY[3], Gabor CSORBA[4], Ben HAYES[5], ITH Saveng[1], Alistair MOULD[5], PHAUK Sophany[1] and Neil M. FUREY[1,6,*]

[1] Centre for Biodiversity Conservation, Room 415, Department of Biology, Faculty of Science, Royal University of Phnom Penh, Confederation of Russia Boulevard, Phnom Penh, Cambodia.

[2] Harrison Institute, Centre for Systematics and Biodiversity Research, Bowerwood House, St Botolph's Road, Sevenoaks, Kent, TN13 3AQ, United Kingdom.

[3] Bat Conservation Trust, Quadrant House, 250 Kennington Lane, London, SE11 5RD, United Kingdom.

[4] Department of Zoology, Hungarian Natural History Museum, Baross u. 13, H-1088 Budapest, Hungary.

[5] Integrated Solutions Asia Cooperation, #15, Street 278, Boeng Keng Kang I, Phnom Penh, Cambodia.

[6] Fauna & Flora International, Cambodia Programme, PO Box 1380, #19, Street 360, Boeng Keng Kang I, Chamkarmon, Phnom Penh, Cambodia.

*Corresponding author. Email neil.furey@fauna-flora.org

Paper submitted 21 August 2013, revised manuscript accepted 13 December 2013.

មូលន័យសង្ខេប

យោងតាមឯកសារវិទ្យាសាស្ត្រ មានសត្វប្រចៀវចំនួន៦៦ប្រភេទហើយត្រូវបានកត់ត្រា នៅក្នុងបញ្ជីសត្វប្រចៀវកម្ពុជា។ តាមការវិភាគរូបសាស្ត្រលើសំណាកដែលប្រមូលបានពីឆ្នាំ២០០៧ដល់ឆ្នាំ២០១៣ យើងរកឃើញប្រចៀវបួនប្រភេទបន្ថែមទៀត ដែលជាកំណត់ត្រាថ្មីសម្រាប់កម្ពុជា រួមមាន*Cynopterus horsfieldii, Coelops frithii, Rhinolophus pearsonii* និង *Falsistrellus affinis*។ ពីរប្រភេទខាងដើមត្រូវបានគេទាយទុកជាមុនថាមាននៅក្នុងប្រទេសកម្ពុជា។ កំណត់ត្រាប្រភេទទាំងបួនត្រូវបានធ្វើឡើងតាមរយៈការស្រាវជ្រាវថ្មីៗនៅតាមតំបន់ជាច្រើនក្នុងប្រទេសកម្ពុជា ដោយប្រើឧបករណ៍អន្ទាក់មង (mist net) និងអន្ទាក់រាំង (harp trap)។ ក្នុងចំណោមប្រភេទទាំងបួន មិនមានប្រភេទណាមួយត្រូវបានចាត់ទុកជាប្រភេទរងគ្រោះសកលទេ ទោះបីជា*F. affinis* (ជាសំណាកដំបូងបង្អស់ក្នុងតំបន់ភាគខាងកើតនៃប្រទេសភូមា) ជាប្រភេទកម្រនិងគួរទទួលបានការយកចិត្តទុកដាក់បន្ថែមក៏ដោយ។ បច្ចុប្បន្ន កម្ពុជាមានសត្វប្រចៀវចំនួន៧០ប្រភេទហើយដែលបានត្រូវចុះក្នុងបញ្ជីរបស់ខ្លួន ហើយចំនួននេះនឹងកើនឡើងជាប្រាជាកក្នុងការស្រាវជ្រាវនាពេលអនាគត។ ដើម្បីលើកកម្ពស់ការស្រាវជ្រាវនិងអភិរក្ស យើងសូមអំពាវនាវស្វែងរកឈ្មោះសត្វប្រចៀវជាសាធារណៈនៅក្នុងប្រទេសកម្ពុជា។

Abstract

Sixty-six bat species were confirmed in the scientific literature for Cambodia. Through a morphological review of specimens collected from 2007 to 2013, we document the occurrence of four additional species: *Cynopterus horsfieldii*, *Coelops frithii, Rhinolophus pearsonii* and *Falsistrellus affinis*. The first two species were previously predicted for Cambodia, and all four were recorded during recent surveys using harp traps and mist nets in sites around the country. None of the newly recorded species are presently regarded as being of global conservation concern, although *F. affinis* (which represents the first record of this species eastwards of Myanmar) is very

CITATION: Chheang S., Bates, P.J.J., Boughey, K., Csorba, G., Hayes, B., Ith S., Mould, A., Phauk S. & Furey, N.M. (2013) Further new country records of four bat species (Chiroptera) from Cambodia and a call for information. *Cambodian Journal of Natural History*, **2013,** 73–82.

rarely encountered and deserves further attention. The national list for Cambodia now contains 70 bat species, and future field surveys will undoubtedly reveal additional taxa. To assist such research, and allied conservation efforts, we conclude by appealing for public information on significant bat roosts throughout the country.

Keywords

Cambodia, bat taxonomy, new records.

Introduction

Thirteen years on from being described as "one of the least explored countries" in terms of its bat fauna (Kock, 2000), the number of taxa documented for Cambodia has more than doubled with 66 species confirmed in the peer-reviewed literature by Furey *et al.* (2012). Additional bat species were reported for Cambodia by Simmons (2005) and Francis (2008) without details. The purpose of this note is to further this growth in knowledge by confirming two such species and documenting the occurrence of two other previously unreported species by means of a morphological review of recently collected specimens. All four species were encountered during an ongoing series of nationwide field surveys to determine the composition, biogeography and status of Cambodian bats and identify priorities for conservation action. Notes on the distribution of each species are provided and current knowledge of Cambodia's bats is briefly reviewed.

Methods

Study Areas

From May 2007 to May 2013, specimens were collected during field studies by the authors and associates in several parts of Cambodia, as summarised below (Fig. 1). Four-bank harp traps and mist nets of varying sizes were employed in the surveys and sampling locations focused largely on water bodies and flyways in forest areas, such as trails, watercourses and natural linear breaks in the vegetation. Specimens from these studies were deposited in the Centre for Biodiversity Conservation (CBC, Zoological Collection, Royal University of Phnom Penh) (Appendix 1).

In late May 2007, Vorn Vichheka sampled bats in a plantation near the Teuk Thla pagoda in Khan Sensok District, Phnom Penh municipality.

In July and October 2007, bat surveys were conducted in the Seima Protected Forest by Va Vuthy and Gabor Csorba. Seima Protected Forest is in the low-lying Eastern Plains of Cambodia (Mondulkiri Province) and covers an area of 292,690 ha. The site is characterised by a complex mosaic of forest types varying from fully deciduous to almost fully evergreen, with large areas of open grassland and numerous water sources (O'Kelly *et al.*, 2012).

In October and November 2009, Ith Saveng, Gabor Csorba and Neil Furey undertook a brief survey in the Phnom Tbeng Forest Area in the northern Cambodian plains (Preah Vihear Province). Phnom Tbeng is an isolated escarpment southwest of Tbeng Meanchey Town that rises to *circa* 580 m above sea level (a.s.l.) and supports semi-evergreen forest on the escarpment face and dry dipterocarp forest on the plateau. The site is in a region more generally dominated by dry dipterocarp forest and grasslands, interspersed with patches of semi-evergreen forest (Walston & Bates, 2001).

In November 2009 and December 2010, field surveys were undertaken by Ith Saveng and Neil Furey on the Dalai and Samkos mountains in Phnom Samkos Wildlife Sanctuary. The wildlife sanctuary covers 332,566 ha in the Pursat, Battambang and Koh Kong provinces of Southwest Cambodia and has an elevation range of 100–1,717 m.a.s.l., including large areas of lowland evergreen forest, dry dipterocarp forest and hill evergreen forest (Daltry & Momberg, 2000).

From April to July 2010, Phauk Sophany and Phen Sarith undertook bat surveys in the Kbal Spean region of Phnom Kulen National Park in Siem Reap Province. Bat surveys were also carried out in the national park from February to April 2013 by Alistair Mould, Ben Hayes and Katherine Boughey. Phnom Kulen National Park covers 37,350 ha and includes lowland areas and sandstone hills which culminate in two plateaus reaching 450 m a.s.l. Habitats include evergreen and semi-evergreen forest on hillsides and plateaus, while lowland areas include small degraded areas of dry dipterocarp forest (Neou *et al.*, 2008).

In May 2010, a single night of mist-netting was undertaken by Neil Furey and several MSc students

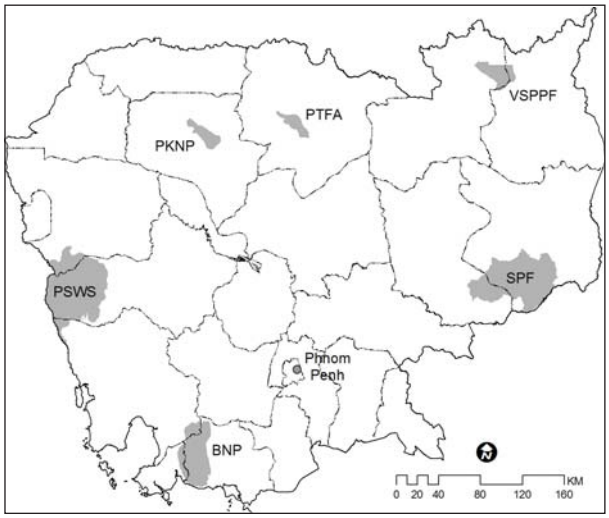


Fig. 1 Location of bat survey areas in Cambodia. BNP—Bokor National Park, PKNP—Phnom Kulen National Park, PSWS—Phnom Samkos Wildlife Sanctuary, PTFA—Phnom Tbeng Forest Area, SPF—Seima Protected Forest, VSPPF—Veun Sai Proposed Protected Forest.

in a small grove of woodland fringing an artificial lake in front of the Faculty of Science within the grounds of the Royal University of Phnom Penh.

In August 2010, studies were undertaken in the Veun Sai Proposed Protected Forest by Ith Saveng, Neil Furey and Tamas Gorfol. The proposed protected forest covers approximately 55,000 ha in Veun Sai District, Ratanakiri Province, and Siem Pang District, Steung Treng Province, in Northeast Cambodia. Habitats include lowland evergreen and semi-evergreen forest between 100 and 400 m a.s.l., with more northerly areas mountainous and southern parts characterized by grasslands (Ben Rawson, pers. comm.).

From October 2012 to May 2013, bats were surveyed in Bokor National Park by Chheang Sarak, Ith Saveng and Neil Furey. The national park is located in the coastal province of Kampot and covers 140,000 ha. The site centres on a sandstone massif, with an extensive plateau at *circa* 1,000 m.a.s.l. Habitats include large areas of semi-evergreen and evergreen forest, while the plateau is dominated by dwarf evergreen forest with small areas of grassland (Seng *et al.*, 2003).

Morphological assessment

Age and reproductive status were assessed following Anthony (1988) and Racey (1988). External measurements were taken from alcohol-preserved specimens to the nearest 0.1 mm, while craniodental and bacula measurements were taken to the nearest 0.01 mm using digital callipers under a stereo microscope. Measurements reported herein include only those taken from non-juveniles, as indicated by the presence of fully ossified metacarpal-phalangeal joints.

Definitions for external measurements were as follows: FA: forearm length—from the extremity of the elbow to the extremity of the carpus with the wings folded; HB: head and body length—from the tip of the snout to the anal opening; T: tail length—from the anal opening to the tip of the tail; E: ear length—from the lower border of the external auditory meatus to the tip of the pinna, excluding any hair; TIB: tibia length—from the knee joint to the ankle; HF: hindfoot—from the tip of the longest digit, excluding the claw, to the extremity of the heel, behind the os calcis. Illustrations of these measurements are provided by Bates & Harrison (1997).

All specimens had their skulls extracted for examination. Definitions for craniodental measurements were as follows: GTL: greatest length of skull—greatest antero-posterior length of the skull, taken from the most projecting point at each extremity regardless of what structure forms these points; CBL: condylobasal length—from the exoccipital condyle to the anterior rim of the alveolus of the first upper incisor; CCL: condylo-canine length—from the exoccipital condyle to the most anterior part of the canine; ZYW: zygomatic width—the greatest width of the skull across the zygomatic arches; MAW: mastoid width—the greatest distance across the mastoid region; CM^3L: maxillary toothrow length—from the front of upper canine to the back of the crown of the third molar; C^1C^1W: width across the upper canines—greatest width, taken across the outer borders of upper canines; M^3M^3W: width across the upper molars—greatest width, taken across the outer crowns of the last upper molars; ML: mandible length—from the anterior rim of the alveolus of the first lower incisor to the most posterior part of the condyle; CM_3L: mandibular toothrow length—from the front of the lower canine to the back of the crown of the third lower molar; CPH: least height of the coronoid process—from the tip of the coronoid process to the apex of the indentation on the inferior surface of the ramus adjacent to the angular process.

Species sequence and nomenclature follow Simmons (2005). A full list of the specimens examined is given in Appendix 1.

Systematic Description

***Cynopterus horsfieldii* Gray, 1843** (Fig. 2)

Material examined: two males from Seima Protected Forest, three females from Phnom Penh, one male and one female from Phnom Tbeng Forest Area, one male and one female from Phnom Samkos Wildlife Sanctuary, one female from Veun Sai Proposed Protected Forest and one male from Phnom Kulen National Park (Fig. 1, Appendix 1).

The above specimens were referred to *C. horsfieldii* on the basis of the following characters: dorsal hair of varying shades of grey-brown; ventral hair lighter; darker collar, varying from reddish brown, brown to grey in males, somewhat paler in females; ears and wing bones edged in white; external and craniodental measurements (Table 1 & 2) according with published ranges (Kingston *et al.*, 2006; Francis, 2008), though generally close to lower limit; cheek teeth broad, sometimes squarish in occlusal view; presence of variably developed central cusps or ridges on the lower posterior premolar (P_4) and first lower molar (M_1) (Fig. 6).

In Seima, two bats were caught in semi-evergreen forest areas surrounded by grassland. In Phnom Penh, three bats were captured in woodland, including one at 1830 h. On Phnom Tbeng, two bats were encountered in disturbed semi-evergreen forest next to grasslands at 1900 h and 1930 h. In Phnom Samkos, two bats were captured in hill evergreen forest at 1900 and 2030 h. In Veun Sai, one bat was caught in a dry river basin in a semi-evergreen forest area at 2010 h. In Phnom Kulen, one bat was caught over a stream in semi-evergreen forest. All were captured in mist nets.

Cynopterus horsfieldii has been infrequently recorded in Laos, South Vietnam and West Thailand, and also occurs in Peninsular Thailand, West Malaysia, Borneo, Java, Sumatra and adjacent islands (Simmons, 2005; Thomas *et al.*, 2013). One record from the Kompong Thom region in Cambodia (Klein, 1970) was apparently rejected by Kock (2000), but accepted by Hendrichsen *et al.* (2001a), Matveev (2005) and Simmons (2005). *Cynopterus horsfieldii* was listed for Cambodia by Francis (2008), but not included in range maps. It would appear from our records that the species actually occurs at low to high elevations throughout the country. Other species in the genus *Cynopterus* known to occur in Cambodia include *C. sphinx* and *C. brachyotis* (Kingsada *et al.*, 2011).

***Rhinolophus pearsonii* Horsfield, 1851** (Fig. 3)

Material examined: four males and five females from Bokor National Park (Fig. 1, Appendix 1).

Possessing a wide-based sella with a characteristic middle constriction, the nine specimens were readily identified as members of the *pearsonii*-group which presently comprises four similar species: *R. pearsonii, R. yunanensis, R. chiewkweeae* and *R. thailandensis*. *Rhinolophus chiewkweeae* could be excluded because it is known only from the Sundaic subregion south of the Isthmus of Kra, in Peninsular Malaysia (Yoshiyuki & Lim, 2005), while *R. thailandensis* was excluded due to its larger size in almost all respects (Wu *et al.*, 2009). Because *R. pearsonii* and *R. yunanensis* are strikingly similar and differ primarily in size, species identification was based on the mensural ranges provided by Csorba *et al.* (2003). Some measurements from our specimens (FA, ZYW, MAW) were within the known areas of overlap between the two species (Table 1 and 2), but skull length (*sensu* Csorba *et al.*, 2003), CM^3L, ML and CM_3L measurements for individual specimens were almost exclusively below the lower limit for *R. yunanensis* and within the range for *R. pearsonii*. Therefore the specimens were identified as the latter species.

Four of the above bats were caught in harp traps in evergreen forest from 1800–1900 h and another was caught in a harp trap overnight. The remaining four were caught in mist nets in evergreen forest at 1830 h. Time-expanded (x10) echolocation calls with a frequency of maximum energy of 53.6 kHz were recorded from a single individual (CBC02161, a juvenile female) held motionless in the hand. *Rhinolophus pearsonii* occurs from North India eastwards through Nepal, Bhutan to South China and southwards through Myanmar, Thailand, Vietnam and Laos (Csorba *et al.*, 2003; Yoshiyuki & Lim, 2005). The above bats represent the first records for *R. pearsonii* from Cambodia, whereas *R. yunanensis* was recorded from the Cardamom Mountains of Cambodia by Ith *et al.* (2011).

***Coelops frithii* Blyth, 1848** (Fig. 4)

Material examined: two females from Phnom Kulen National Park (Fig. 1, Appendix 1).

The two individuals exhibit the features diagnostic of the genus and *C. frithii* described by Tate (1941) and Bates & Harrison (1997), including a rudimentary tail; short and broadly rounded ears with a large antitragal lobe; anterior leaf divided into two halves by a deep median notch and emphasized by two elongated,

Fig. 2 *Cynopterus horsfieldii*: CBC01126, Veun Sai Proposed Protected Forest (© N. Furey).

Fig. 3 *Rhinolophus pearsonii*: CBC02161, Bokor National Park (© N. Furey).

Fig. 4 *Coelops frithii*: CBC02138, Phnom Kulen National Park (© T. Yon).

Fig. 5 *Falsistrellus affinis*: CBC02133, Phnom Kulen National Park (© B. Hayes).

Fig. 6 Right lower toothrows of *Cynopterus horsfieldii* (top: CBC00453, Phnom Tbeng; below: CBC01046, Phnom Penh) (© N. Furey).

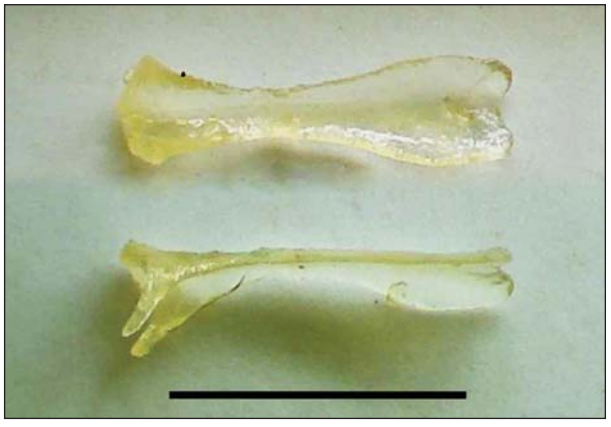


Fig. 7 Baculum of *Falsistrellus affinis* (v, l): CBC02158, Phnom Kulen (© N. Furey). Scale bar = 2 mm.

Table 1 Selected external measurements. Values are given as mean, SD (if $n \geq 5$), (min–max) n. Abbreviations and definitions for measurements are explained in the text.

Species	FA	HB	T	E	TIB	HF
Cynopterus horsfieldii	69.5, 2.1 (66.5–72.2) 11	83.8, 5.0 (75.0–90.4) 11	13.4, 1.9 (10.9–17.5) 11	18.9, 0.8 (17.8–20.0) 11	27.0, 0.8 (25.8–28.2) 11	14.5, 0.6 (12.9–15.2) 11
Rhinolophus pearsonii	52.6, 0.7 (51.5–53.6) 8	52.6, 1.4 (50.0–54.0) 8	19.2, 1.6 (18.0–22.2) 8	26.4, 1.0 (24.6–28.0) 8	26.3, 0.9 (24.8–27.6) 8	10.6, 0.6 (9.8–11.6) 8
Coelops frithii	– (38.8, 38.8) 2	– (34.7, 35.5) 2	– –	– (7.5, 7.7) 2	– (15.4, 15.7) 2	– (13.5, 13.9) 2
Falsistrellus affinis	36.5, 0.8 (35.7–37.9) 7	45.3, 1.6 (43.3–47.2) 7	34.6, 2.6 (30.5–39.3) 7	14.1, 0.2 (13.8–14.3) 7	13.9, 0.4 (13.4–14.6) 7	6.6, 0.7 (5.7–7.4) 7

narrow and forwardly projecting lappets (as opposed to the wide, rounded lappets of *C. robinsoni*); intermediate leaf with a moderate median process; posterior leaf not divided by vertical septa, but pocketed posteriorly and possessing a median eminence. At 38.8 mm (Table 1), the forearm lengths (FA) of both animals fall within the known ranges for *C. frithii* (Bates & Harrison, 1997) and exceed those of *C. robinsoni* (Francis, 2008). Similar to some Vietnamese specimens (Hendrichsen *et al.*, 2001b; N. Furey, unpublished data), the two individuals from Phnom Kulen are slightly smaller in some cranial measurements (Table 2) than those measured by Bates & Harrison (1997), although cranial and dental features closely match descriptions for *C. frithii* in both the latter publication and Corbet & Hill (1992).

The above bats were caught at 1845 h and 1950 h in harp traps set at two cave entrances surrounded by scrubland and semi-evergreen forest respectively. As currently recognised, *C. frithii* is a widespread species, occurring from Bangladesh and Northeast India eastwards to South China and Taiwan, and southwards through Myanmar, Thailand, Laos and Vietnam as far as western Malaysia, Sumatra, Java and Bali (Simmons, 2005). Despite its extensive distribution, the species is seldom recorded in field surveys and consequently appears scarce throughout its range (Francis, 2008). However, the lack of records could be partly explained by its use of high echolocation frequencies (Ho *et al.*, 2013) and capacity for highly manoeuvrable flight (Furey, 2009), which may allow the species to detect and elude even harp traps. The above individuals confirm Francis's (2008) prediction that the species occurs in Cambodia.

***Falsistrellus affinis* (Dobson, 1871)** (Fig. 5)

Material examined: six males and one female from Phnom Kulen National Park (Fig. 1, Appendix 1).

The seven individuals from Phnom Kulen closely resemble two specimens from Mon State, Myanmar, which Bates *et al.* (2005) referred to *Pipistrellus affinis* (placed in *Falsistrellus* by Simmons, 2005) in the following regards: collectively overlapping in all external mensural characters (Table 1); dorsal hairs long and dark brown, individual scattered hairs with pale tips lending a slightly grizzled appearance; ventral hairs dark brown at base with lighter tips that vary among individuals from grey-brown, yellow-brown to white; hairs on lower abdomen and near the anus uniformly of the latter colours; braincase low; rostrum broad with median and lateral depressions; zygoma robust with weak to moderately developed postorbital processes; collectively overlapping or nearly so in all craniodental measurements (Table 2); first upper incisor (I^2) bicuspid; first upper premolar (P^2) often slightly displaced internally and approaching I^2 in crown area; first lower premolar (P_2) in toothrow and occupying about half the crown area of second lower premolar (P_4); lower molars myotodont; baculum short (length 2.5–2.7 mm, n = 6), proximally widened and ventrally deeply fluted, narrowing in mid-extent and broadening distally in spatulate form with a slightly concave tip—virtually identical (albeit shorter) in several specimens to that of HZM.2.35125 from Myanmar (depicted in Fig. 1G of Bates *et al.*, 2005), whereas some specimens differ slightly in being straighter in lateral view with a more distinct tip concavity (Fig. 7).

Aside from a single male individual caught at 1915 h in a harp trap set in evergreen forest, the

Table 2 Selected craniodental measurements. Values are given as mean, SD (if $n \geq 5$), (min–max) n. Abbreviations and definitions for measurements are explained in the text.

Species	GTL	CBL	CCL	ZYW	MAW	CM^3L	C^1C^1W	M^3M^3W	ML	CM_3L	CPH
Cynopterus horsfieldii	31.12, 1.00 (29.17–33.18) 11	29.13, 1.49 (25.42–31.10) 11	28.58, 1.43 (25.00–30.33) 11	18.95, 1.30 (15.70–20.25) 11	12.64, 0.49 (12.03–13.40) 11	10.56, 0.37 (10.06–11.18) 11	6.46, 0.37 (5.73–6.78) 11	9.07, 0.31 (8.60–9.69) 11	23.69, 0.95 (22.24–25.11) 11	11.66, 0.39 (11.26–12.32) 11	11.94, 1.02 (9.89–13.23) 11
Rhinolophus pearsonii	25.30, 0.24 (24.90–25.63) 8	22.28, 0.21 (22.05–22.60) 8	21.67, 0.22 (21.30–22.02) 8	12.33, 0.27 (11.93–12.77) 8	11.14, 0.15 (10.85–11.31) 8	9.87, 0.11 (9.73–10.04) 8	6.28, 0.16 (6.09–6.56) 8	9.18, 0.33 (8.45–9.48) 8	17.07, 0.08 (16.94–17.15) 8	10.61, 0.16 (10.36–10.82) 8	3.70, 0.09 (3.56–3.81) 8
Coelops frithii	– (16.22, 16.64) 2	– (14.47, 14.72) 2	– (14.06, 14.37) 2	– (6.67, 6.78) 2	– (6.98, 6.99) 2	– (5.87, 5.94) 2	– (3.13, 3.14) 2	– (5.29, 5.37) 2	– (9.42, 9.76) 2	– (6.09, 6.17) 2	– (2.20, 2.23) 2
Falsistrellus affinis	14.51, 0.21 (14.32–14.90) 7	13.41, 0.23 (13.11–13.64) 7	13.09, 0.30 (12.67–13.45) 7	9.22, 0.19 (8.95–9.42) 7	8.04, 0.16 (7.86–8.24) 7	5.04, 0.10 (4.92–5.18) 7	4.63, 0.12 (4.49–4.80) 7	6.21, 0.14 (5.98–6.43) 7	10.39, 0.14 (10.19–10.54) 7	5.53, 0.12 (5.41–5.71) 7	3.03, 0.07 (2.93–3.13) 7

individuals were caught at a southwest-facing cave entrance mostly in harp traps (two in mist nets) from 1850–1900 h in an area of semi-evergreen forest with rocky outcrops and boulders. According to Simmons (2005), *F. affinis* occurs in Northeast Myanmar, Yunnan (China), India, Nepal and Sri Lanka. Like the specimens from Mon State in Myanmar (Bates *et al.*, 2005), however, the Phnom Kulen specimens also differ from Indian specimens, which are larger, have darker underparts and a differently shaped baculum and may represent a different taxon (Hill & Harrison, 1987; Bates & Harrison, 1997). As the holotype of *F. affinis* from Kachin State in Northeast Myanmar does not have a baculum, detailed morphological and molecular comparisons with the type or topotype material are required to determine whether this is the case, and if so, which form the name *F. affinis* actually belongs to. Pending resolution of these taxonomic and nomenclatural questions, we tentatively identify the Phnom Kulen specimens as *F. affinis*, and they represent the first records east of Myanmar of a very rarely encountered and poorly known species.

Discussion

Our confirmation of four additional bat species for Cambodia increases the total number of bats presently confirmed in this country to 70. Notwithstanding the recent spate of new records and species new to science from Cambodia (e.g. Ith *et al.*, 2011; Csorba, 2011; Csorba *et al.*, 2011; Furey *et al.*, 2012), future surveys will inevitably reveal additional taxa because numerous species are known from neighbouring territories that have yet to be found in Cambodia.

While none of the newly recorded species are currently regarded as being of global conservation concern (IUCN, 2013), the species we identify as *F. affinis* is evidently very rare and deserving of conservation attention. In Cambodia it is currently known only from a single cave roost in Phnom Kulen National Park.

In a broader context, more information is needed to adequately determine conservation priorities for Cambodia's bats, though it is evident that several of the known roosts of *Pteropus lylei* and *Chaerephon plicatus* are of outstanding national importance by virtue of their large size. To improve existing knowledge and allied conservation efforts, we appeal to the general public for information on significant bat roosts throughout the country.

Acknowledgements

The authors are grateful to Chhin Sophea, Hun Seiha and Hon Naven for their invaluable help in the field, as well as to many staff working in the study sites visited. We are also grateful to Phal Des and Meak Kamerane (Royal University of Phnom Penh), Seng Bunra (Conservation International), Ben Rawson (Fauna & Flora International), Hugo Rainey (Wildlife Conservation Society), Markus Handschuh and Dave Ware (Angkor Centre for Conservation of Biodiversity), Yang Phearum, Suy Thea and Sy Ramony (Ministry of Environment), Tan Setha (Forestry Administration),

Seng Daravuth and Tony Yon (Integrated Solutions Asia Cooperation) and J.-B. Chevance, David Sandilands, Stephane De Greef and Pich Seu (Archaeology and Development Foundation) for facilitating fieldwork and permissions with the authorities in Cambodia. We are indebted to Paul Racey (University of Exeter), Tigga Kingston (Texas Tech) and Dave Waldien (Bat Conservation International) for their steadfast support. We also thank Choun Phirom for preparing Figure 1. The work of Gabor Csorba and Neil Furey was supported by a SYNTHESYS Integrated Infrastructure Initiative Grant, that of Ben Hayes, Alistair Mould and Katherine Boughley by the Rufford Foundation, and that of Chheang Sarak, Phauk Sophany and Ith Saveng by the Darwin Initiative (14-011; 14-037; 18-002; EIDPO028), John D. and Catherine D. MacArthur Foundation (US: 09-92411-000-GSS), Zoological Parks and Gardens Board of Victoria (Australia), Conservation Leadership Programme (Grant No. 03101612), Bat Conservation International and SE Asian Bat Conservation and Research Unit (National Science Foundation Grant No. 1051363). Further support for field studies in Cambodia was graciously provided by the John D. and Catherine D. MacArthur Foundation (through grant No. 09-92460-000-GSS provided to Conservation International) and the Critical Ecosystem Partnership Fund. Lastly, we thank the four anonymous reviewers who provided very helpful comments on the original draft of this paper.

References

Anthony, E.L.P. (1988) Age determination in bats. In *Ecological and Behavioral Methods for the Study of Bats* (ed. T.H. Kunz), pp. 47–58. Smithsonian Institution Press, Washington, D.C., USA.

Bates, P.J.J. & Harrison, D.L. (1997) *Bats of the Indian Subcontinent*. Harrison Zoological Museum, Kent, UK.

Bates, P.J.J., Tin Nwe, Si Si Hla Bu, Khin Mie Mie, Khin Maung Swe, Nyo Nyo, Aye Aye Khaing, Nu Nu Aye, Yin Yin Toke, Naing Naing Aung, Mar Mar Thi & Mackie, I. (2005) A review of the genera *Myotis, Ia, Pipistrellus, Hypsugo,* and *Arielulus* (Chiroptera: Vespertilionidae) from Myanmar (Burma), including three species new to the country. *Acta Chiropterologica*, **7,** 205–306.

Corbet, G.B. & Hill, J.E. (1992) *The Mammals of the Indomalayan Region.* Natural History Museum and Oxford University Press, Oxford, UK.

Csorba, G., Ujhelyi, P. & Thomas, N. (2003) *Horseshoe Bats of the World (Chiroptera: Rhinolophidae)*. Alana Ecology Ltd, UK.

Csorba, G. (2011) A new species of *Glischropus* from the Indochinese Subregion (Mammalia: Chiroptera: Vespertilionidae). *Zootaxa*, **2925,** 41–48.

Csorba, G., Son N.T., Ith S. & Furey, N.M. (2011) Revealing cryptic bat diversity: three new *Murina* and redescription of *M. tubinaris* from Southeast Asia. *Journal of Mammalogy*, **92,** 891–904.

Daltry, J.C. & Momberg, F. (eds.) (2000) *Cardamom Mountains Biodiversity Survey 2000*. Fauna & Flora International, Cambridge, UK.

Francis, C.M. (2008) *A Guide to the Mammals of Southeast Asia.* Princeton University Press, Princeton, New Jersey, USA.

Furey, N.M. (2009) *Bat assemblages in Vietnamese karst: diversity, reproduction, echolocation and ecomorphology.* PhD thesis, Aberdeen University, UK.

Furey, N.M., Phauk S., Phen S., Chheang S., Ith S., Bates, P.J.J. & Csorba, G. (2012) New country records for five bat species (Chiroptera) from Cambodia. *Cambodian Journal of Natural History,* **2012,** 141–149.

Hendrichsen, D.K., Bates, P.J.J. & Hayes, B. (2001a) Recent records of bats (Chiroptera) from Cambodia. *Acta Chiropterologica*, **31,** 21–32.

Hendrichsen, D.K., Bates, P.J.J., Hayes, B. & Walston, J.L. (2001b) Recent records of bats (Mammalia: Chiroptera) from Vietnam with seven species new to the country. *Myotis*, **39,** 35–122.

Hill, J.E. & Harrison, D.L. (1987) The baculum in the Vespertilioninae (Chiroptera: Vespertilionidae) with a systematic review, a synopsis of *Pipistrellus* and *Eptesicus*, and the descriptions of a new genus and subgenus. *Bulletin of the British Natural History Museum (Zoological)*, **52,** 225–305.

Ho, Y.-Y., Fang, Y.-P., Chou, C.-H., Cheng, H.-C. & Chang, H.-W. (2013) High duty cycle to low duty cycle: echolocation behaviour of the hipposiderid bat *Coelops frithii. PLOS ONE*, **8,** e62938. doi:10.1371/journal.pone.0062938

Ith S., Csorba, G., Bates, P.J.J. & Furey, N.M. (2011) Confirmation of seven bat species for Cambodia. *Cambodian Journal of Natural History*, **2011,** 93–103.

IUCN (2013) *IUCN Red List of Threatened Species. Version 2012.1*. Http://www.iucnredlist.org [accessed 08 August 2013].

Kingsada, P., Douangboubpha, B., Ith S., Furey, N., Soisook, P., Bumrungsri, S., Satasook, C., Vu D.T., Csorba, G., Harrison, D., Pearch, M., Bates, P. & Thomas, N. (2011) A checklist of bats from Cambodia, including the first record of the intermediate horseshoe bat *Rhinolophus affinis* (Chiroptera: Rhinolophidae), with additional information from Thailand and Vietnam. *Cambodian Journal of Natural History,* **2011,** 49–59.

Kingston, T., Liat, L.B. & Akbar, Z. (2006) *Bats of Krau Wildlife Reserve*. Penerbit Universiti Kebangsaan Malaysia, Bangi, Malaysia.

Klein, J.M. (1970) Faune de Nycteribiidae du Cambodge (Dipt. Pupipara). *Bulletin de la Société Entomologique de France*, **75,** 48–55.

Kock, D. (2000) On some bats (Chiroptera) from southern Cambodia with a preliminary checklist. *Zeitschrift fur Saugetierkunde*, **65,** 199–208.

Matveev, V. (2005) Checklist of Cambodian bats (Chiroptera), with new records and remarks on taxonomy. *Russian Journal of Theriology*, **4,** 43–62.

Neou B., Khou E. & Touch S. (2008) *Preliminary Study of the Kulen National Park for Development of a Botanical Garden.* Ministry of Environment, Royal Government of Cambodia.

O'Kelly, H.J., Evans, T.D., Stokes, E.J., Clements, T.J., Dara A., Gately, M., Nut M., Pollard, E., Men S. & Walston, J. (2012) Identifying conservation successes, failures and future opportunities: assessing recovery potential of wild ungulates and tigers in eastern Cambodia. *PLOS ONE*, **7,** e40482. doi:10.1371/journal.pone.0040482

Phauk S., Phen S. & Furey, N.M. (2013) Cambodian bat echolocation: a first description of assemblage call parameters and assessment of their utility for species identification. *Cambodian Journal of Natural History,* **2013,** 16–26.

Racey, P. A. (1988) Reproductive assessment in bats. In *Ecological and Behavioural Methods for the Study of Bats* (ed. T.H. Kunz), pp. 31–45. Smithsonian Institution Press, Washington, D.C., USA.

Simmons, N.B. (2005) Order Chiroptera. In *Mammal Species of the World: a Taxonomic and Geographic Reference, Third Edition* (eds D.E. Wilson & D.M. Reeder), pp. 312–529. Johns Hopkins University Press, Baltimore, USA.

Seng K.H., Pech B., Poole C., Tordoff A., Davidson P. & Delattre E. (2003) *Directory of Important Bird Areas in Cambodia: Key Sites for Conservation*. Department of Forestry and Wildlife, Department of Nature Conservation and Protection, Cambodia, BirdLife International in Indochina and the Wildlife Conservation Society Cambodia Program, Phnom Penh, Cambodia.

Tate, G.H.H. (1941) Results of the Archbold Expeditions, no. 36: remarks on some old world leaf-nosed bats. *American Museum Novitates*, **1140,** 1–11.

Thomas, N.M., Duckworth, J.W., Douangboubpha, B., Williams, M. & Francis, C. (2013) A checklist of bats (Mammalia: Chiroptera) from Lao PDR. *Acta Chiropterologica*, **15,** 193–260.

Walston, J. & Bates, P.J.J. (2001) The discovery of Wroughton's free-tailed bat *Otomops wroughtoni* (Chiroptera: Molossidae) in Cambodia. *Acta Chiropterologica,* **3,** 249–252.

Wu, Y., Harada, M. & Motokawa, M. (2009) Taxonomy of *Rhinolophus yunanensis* Dobson, 1872 (Chiroptera: Rhinolophidae) with a description of a new species from Thailand. *Acta Chiropterologica*, **11,** 237–246.

Yoshiyuki, M. & Lim, B.L. (2005) A new horseshoe bat, *Rhinolophus chiewkweeae* (Chiroptera: Rhinolophidae), from Malaysia. *Bulletin of the National Science Museum of Tokyo*, **31A,** 29–36.

About the authors

CHHEANG SARAK is a Cambodian national born in Prey Veng Province. Following his studies of the taxonomy of rhinolophid bats, he graduated with an MSc from the Royal University of Phnom Penh in 2011. He currently works part time for the Centre for Biodiversity Conservation at the university and his interests include taxonomy and building conservation awareness.

PAUL BATES has spent much of the last 30 years researching the bats and small mammals of Southern and Southeast Asia. Initially studying the mammal fauna of India and Sri Lanka, in 1997 he began working in Vietnam and Cambodia which led to research and training projects throughout Southeast Asia. More recently, he has helped develop a network of Southeast Asian taxonomists working on mammals, birds and amphibians.

KATHERINE BOUGHEY is an ecologist from the UK. She gained a doctorate from the University of East Anglia focusing on distribution modelling and landscape ecology of bats, and has studied bats in the UK, the USA and Cambodia. She currently works for the Bat Conservation Trust, developing practical applications of species distribution information.

GABOR CSORBA is responsible for development of vertebrate collections in the Hungarian Natural History Museum where he has worked for almost 30 years. He travels regularly to the Old World tropics to study bat systematics and populations in protected areas and also has a special interest in the conservation biology of European mammals.

BENJAMIN HAYES has worked as a conservation biologist in Southeast Asia and Africa since 1992 and studied the biogeography of Tanzanian bats for his MSc. Much of his work involves baseline and environmental impact surveys and management planning for protected areas. He currently manages biodiversity surveys in Phnom Kulen National Park and directs alternative livelihood projects in Cambodia and Tanzania.

ITH SAVENG is a Cambodian national born in Kampong Speu Province and has worked for Fauna & Flora International (Cambodia) as a zoological curator since 2006 and as a lecturer at Royal University of Phnom Penh since 2010. He is currently undertaking a doctorate focusing on Southeast Asian bat taxonomy at the Prince Songkla University in Thailand and has special interest in systematics, ecology and biogeography.

ALISTAIR MOULD has worked for wildlife conservation and alternative livelihood projects in Cambodia since 2009. A conservation biologist by training, he has supervised research projects in Phnom Kulen National Park for the Angkor Centre for Conservation of Biodiversity and currently works for Indochine Exploration, an adventure tour company providing resources for wildlife conservation and village development projects.

PHAUK SOPHANY is originally from Sihanoukville and has worked as national coordinator for the Centre for Biodiversity Conservation at the Royal University of Phnom Penh since 2011. He studied the use of acoustic approaches for identification of Cambodian bat species for his MSc degree and has a special interest in the ecology of cave-dwelling bats and flying foxes.

NEIL FUREY has worked in Southeast Asia since 1997, spending a decade in Vietnam and completing various assignments in Cambodia, China, India, Indonesia and Myanmar. A biologist by training, he studied the ecology of Vietnamese bat populations for his doctorate and has a special interest in community ecology and systematics. Much of his work in Southeast Asia focuses on strengthening conservation and research capacity.

Appendix 1

Cynopterus horsfieldii: CBC00453, CBC00455, male and female, in spirit, skulls removed, collected by Neil Furey on 29 October 2009, Phnom Tbeng Forest Area (Preah Vihear), 13°45.845′N, 104°51.553′E, 360 m a.s.l.; CBC00454, female, in spirit, skull removed, collected by Ith Saveng on 20 November 2009, Mount Dalai, Phnom Samkos Wildlife Sanctuary, 12°26.674′N, 103°04.582′E, 1,033 m a.s.l.; CBC00472, male, in spirit, skull removed, collected by Va Vuthy on 24 July 2007, Seima Protected Forest, 12°11.000′N, 107°01.000′E, 308 m a.s.l.; CBC00473, male, in spirit, skull removed, collected by Va Vuthy on 2 October 2007, Seima Protected Forest, 12°12.000′N, 107°01.000′E, 295 m a.s.l.; CBC00474, CBC00476, two females, in spirit, skulls removed, collected by Vorn Vichheka on 25 May 2007, Khan Sensok District, Phnom Penh, 11°33.818′N, 104°52.908′E, 68 m a.s.l.; CBC00893, male, in spirit, skull removed, collected by Phen Sarith and Phauk Sophany on 21 April 2010, Phnom Kulen National Park, 12°46.714′N, 103°28.042′E, 205 m a.s.l.; CBC01046, female, in spirit, skull removed, collected by Neil Furey on 19 May 2010, Royal University of Phnom Penh, 11°34.065′N, 104°53.395′E, 15 m a.s.l.; CBC01126, female, in spirit, skull removed, collected by Neil Furey on 16 August 2010, Veun Sai Proposed Protected Forest, 14°00.833′N, 103°01.334 E; CBC01206, male, in spirit, skull removed, collected by Neil Furey on 13 December 2010, Mount Samkos, Phnom Samkos Wildlife Sanctuary, 12°09.615′N, 103°00.191′E, 1,281 m a.s.l.

Coelops frithii: CBC02137, female, in spirit, skull removed, collected by Alistair Mould and Katherine Boughey on 28 February 2013, Phnom Kulen National Park, 13°32.136′N, 104°08.924′E, 373 m a.s.l.; CBC02138, female, in spirit, skull removed, collected by Alistair Mould on 28 March 2013, Phnom Kulen National Park, 13°32.543 N , 104°07.753′E, 359 m a.s.l.

Rhinolophus pearsonii: CBC02006, female, in spirit, skull removed, collected by Cheang Sarak on 30 October 2012, Bokor National Park, 10°50.526′N, 104°04.789′E, 409 m a.s.l.; CBC02016, CBC02018, two females, in spirit, skulls removed, collected by Ith Saveng and Chheang Sarak on 4 December 2012, Bokor National Park, 10°41.174′N, 104°03.033′E, 819 m a.s.l.; CBC02020, CBC02022, CBC02023, CBC02024, one female and three males, in spirit, skulls removed, collected by Ith Saveng and Chheang Sarak on 6 December 2012, Bokor National Park, 10°40.861′N, 104°02.759′E, 792 m a.s.l.; CBC02122, male, in spirit, skull removed, collected by Chheang Sarak on 15 February 2013, Bokor National Park, 10°43.431′N, 103°55.834′E, 393 m a.s.l.; CBC02161, juvenile female, in spirit, skull removed, collected by Neil Furey and Chheang Sarak on 30 April 2013, Bokor National Park, 11°09.210′N, 104°04.275′E, 351 m a.s.l.

Falsistrellus affinis: CBC00917, male, in spirit, skull removed, collected by Phen Sarith and Phauk Sophany on 21 April 2010, Phnom Kulen National Park, 12°46.714′N, 103°28.042′E, 205 m a.s.l. (= *Hypsugo* sp. A. in Phauk *et al*., 2013); CBC02133, CBC02136, two males, in spirit, skulls removed, collected by Alistair Mould and Katherine Boughey on 26 February 2013, Phnom Kulen National Park, 13°30.699′N, 104°07.375′E, 359 m a.s.l.; CBC02153, CBC02156, CBC02157, CBC02158, one female and three males, in spirit, skulls removed, collected by Alistair Mould and Ben Hayes on 21 April 2013, Phnom Kulen National Park, 13°30.699′N, 104°07.375′E, 359 m a.s.l.

Abundance and diversity of marine flora and fauna of protected and unprotected reefs of the Koh Rong Archipelago, Cambodia

Jessica M. SAVAGE*, Patrick E. OSBORNE and Malcolm D. HUDSON

Centre for Environmental Sciences, Faculty of Engineering and the Environment, University of Southampton, Hampshire, SO17 1BJ, United Kingdom.

*Corresponding author. Email j.savage@soton.ac.uk

Paper submitted 22 April 2013, revised manuscript accepted 4 November 2013.

មូលន័យសង្ខេប

ការការពារសមុទ្រកំពុងត្រូវបានយកចិត្តទុកដាក់យ៉ាងឆាប់រហ័សនៅក្នុងប្រទេសកម្ពុជា។ ហើយឧទាហរណ៍មួយនៃការគ្រប់គ្រងជាឯកជនដែលមិនស្ថិតក្នុងតំបន់ការពារអាចត្រូវបានប្រទះឃើញមាននៅតាមប្រជុំកោះរុង។ ការសិក្សានេះមានគោលបំណងកំណត់ពីប្រសិទ្ធភាពនៃការរក្សាទុកកោះសង្ឃារសម្រាប់អភិរក្សប្រភេទសត្វ និងកំណត់វិធីសាស្ត្រសិក្សាសមស្របសម្រាប់ការគ្រប់គ្រងនិងការត្រួតពិនិត្យប្រកបដោយប្រសិទ្ធភាព។ តំបន់នានាដែលនៅក្នុង នៅក្បែរ និងនៅដាច់ចេញពីតំបន់ការពារសមុទ្រត្រូវបានសិក្សាដោយប្រើពិធីសារណែនាំពិនិត្យតាមដានក្នុងតំបន់ថ្មប៉ប្រះទឹក រួមជាមួយនឹងវិធីសាស្ត្រពិនិត្យតាមដានផ្សេងទៀតសម្រាប់ធ្វើការប្រៀបធៀប។ បរិមាណលើសលុប និងនានាភាពនៃប្រភេទត្រូវបានវិភាគដោយប្រើវិធីអាណូវ៉ាឯកទិស (one-way ANOVA)។ លទ្ធផលបានបង្ហាញនូវបម្រែបម្រួលខ្លាំងនៃដង់ស៊ីតេសត្វឥតឆ្អឹងកង ($F_{2,27}$ = 4.16, P = 0.027) ជាពិសេសប្រភេទតាអន់បន្លាវែង(*Diadema* sp.) ប៉ុន្តែមិនមានស្ថិតិខុសប្លែកគ្នាច្រើនក្នុងចំណាមទីតាំងសិក្សាទេ។ ការវិភាគវិធីសាស្ត្រផ្សេងៗគ្នាបានបង្ហាញថា បច្ចេកទេសពិនិត្យតាមដានក្នុងតំបន់ថ្មប៉ប្រះទឹកបានរកឃើញនានាភាព និងបរិមាណលើសលុបនៃប្រភេទប្រសើរជាងវិធីសាស្ត្រថតរូបតាមក្រឡាបន្ទាត់និងការរាប់តាមចំណុចកំណត់ ប៉ុន្តែការវិភាគនេះមិនបានគិតទៅដល់ភាពជាក់លាក់និងដំណោះស្រាយទៅលើទិន្នន័យដែលប្រមូលបានទេ។ ការវាយតំលៃនេះត្រូវបានដំណើរការតែ៦ឆ្នាំ បន្ទាប់ពីតំបន់ការពារសមុទ្រនៃកោះសង្ឃារត្រូវបានគេបង្កើតឡើងប៉ុណ្ណោះដែលជាពេលវេលាមួយមិនគ្រប់គ្រាន់សម្រាប់រំពឹងទុកពីការផ្លាស់ប្តូរសមាសភាពប្រភេទ។ យ៉ាងណាក៏ដោយ ការសិក្សានេះបានផ្តល់ឱកាសដើម្បីវិភាគការប្រែប្រួលបន្តនៃតំបន់ការពារសមុទ្រ និងបង្កើតទិន្នន័យជាមូលដ្ឋានសំរាប់ជាឯកសារយោងនៃការសិក្សានាពេលអនាគត។

Abstract

Marine protection is advancing rapidly in Cambodia and an example of a privately managed no-take protected area can be found in the Koh Rong Archipelago. This study aimed to determine the efficacy of the Song Saa reserve for conserving species and to identify suitable survey methodologies for effective monitoring and management. Sites within, near and geographically isolated from the marine protected area were surveyed using Reef Check monitoring protocols, with additional monitoring techniques used for comparison. Species abundance and diversity were analysed using a one-way ANOVA. Results indicated significant variation in the density of invertebrates ($F_{2,27}$ = 4.16, P = 0.027), particularly long-spined sea urchins (*Diadema* sp.), but no other statistically significant differences were detected among the study sites. Analysis of different survey methodologies found that the Reef Check techniques detected significantly higher species diversity and abundance than photo-quadrats and static

CITATION: Savage, J.M., Osborne, P.E. & Hudson, M.D. (2013) Abundance and diversity of marine flora and fauna of protected and unprotected reefs of the Koh Rong Archipelago, Cambodia. *Cambodian Journal of Natural History*, **2013,** 83–94.

point counts, but this analysis did not consider the precision and resolution of the data collected. This assessment was conducted only six years after the Song Saa marine protected area was established, which was not long enough to expect significant changes in species composition. However this study offered the opportunity to analyse the progress of the marine protected area and establish baseline data for future reference.

Keywords

Coral reefs, Koh Rong, marine monitoring, Song Saa Private Island.

Introduction

Cambodia's coastal zone extends 435 km between the borders of Thailand and Vietnam (Fig. 1), with 69 islands and territorial waters covering 55,600 km^2 (Nelson, 1999). After episodes of civil war, Cambodia is currently experiencing large-scale development and transformation. The coastal zone is being targeted by national and international investors, attracted by the tourism potential of the coastline and nearby islands. Resource extraction, particularly fishing, represents the main economic benefit that coral reefs provide to the country (Ministry of Environment, 2005; Fisheries and Aquaculture Organisation, 2011). Cambodia's coral reefs are mostly fringing reefs along the mainland and around many islands (Chou *et al.,* 2003). Knowledge of Cambodia's reef habitats is limited, but most systems are considered to be under high threat, with impacts including overfishing, pollution, coral extraction, bleaching, increased sedimentation due to coastal development, and reef damage caused by destructive fishing methods (Van Bochove *et al.,* 2011). In the past, surveys and assessments were sporadic, relying on international NGOs and researchers. In recent years, however, marine assessments have become much more frequent and organised.

Marine protected areas (MPAs) are designed to limit human activities in particular areas or at particular times. Rules, regulations and management regimes are site-specific, incorporating seasonal or catch limitations depending on the needs of habitats and societies. MPAs are often implemented to conserve or restore species, fisheries, ecosystems and ecological functions (Fox *et al.,* 2012). Other benefits may include poverty alleviation (Gjertsen, 2005) and climate change adaptation or mitigation (McLeod & Leslie, 2009). For the purpose of this investigation, the IUCN definition of an MPA is used to minimise confusion in an international context: "Any area of intertidal or sub tidal terrain, together with its overlying water and associated flora, fauna, historical or cultural features, which has been reserved by law or other effective means to protect all or part of the enclosed environment" (Kelleher & Ketchington, 1992).

Individual MPAs are developed and managed for different purposes and protection can have varying effects on particular taxa. One of the main impacts of effective MPAs on marine organisms is the prevention of harvesting, reducing mortality, and in turn, generating larger body sizes, increasing abundance and fecundity (Mora *et al.,* 2006). As such, MPAs often result in excess fish and other animals migrating into unprotected waters, commonly known as the "spill-over effect" (Christie, 2004). This benefits marine environments and the human populations who depend on their resources.

In 2003, the World Parks Congress recommended 20–30% of all major ecosystems be managed within strictly protected reserves by 2012 (Mora *et al.,* 2006). In October 2010, however, the 193 parties to the Convention on Biological Diversity aimed to protect and effectively manage a mere 10% of the seas in MPAs by 2020 (Toropova *et al.,* 2010). Unfortunately, the existing marine reserves are considered insufficient for the protection of coral reef diversity—only 18.7% of the world's coral reefs are under protection (1.4% within no-take zones), with only 2% of management regimes considered effective (Mora *et al.,* 2006).

The government of Cambodia has been working in collaboration with several international NGOs to establish the country's first large-scale MPA around the Koh Rong Archipelago. Currently the efficacy of this MPA is unknown, but an understanding of its success or failure is essential to guide future management.

Effective management requires the collection of appropriate, detailed information. Various monitoring techniques are available. The monitoring programme developed by the international NGO Reef Check (Hodgeson *et al.,* 2004) is currently being used by NGOs and other conservation bodies in Cambodia. Reef Check's methods were developed to enable

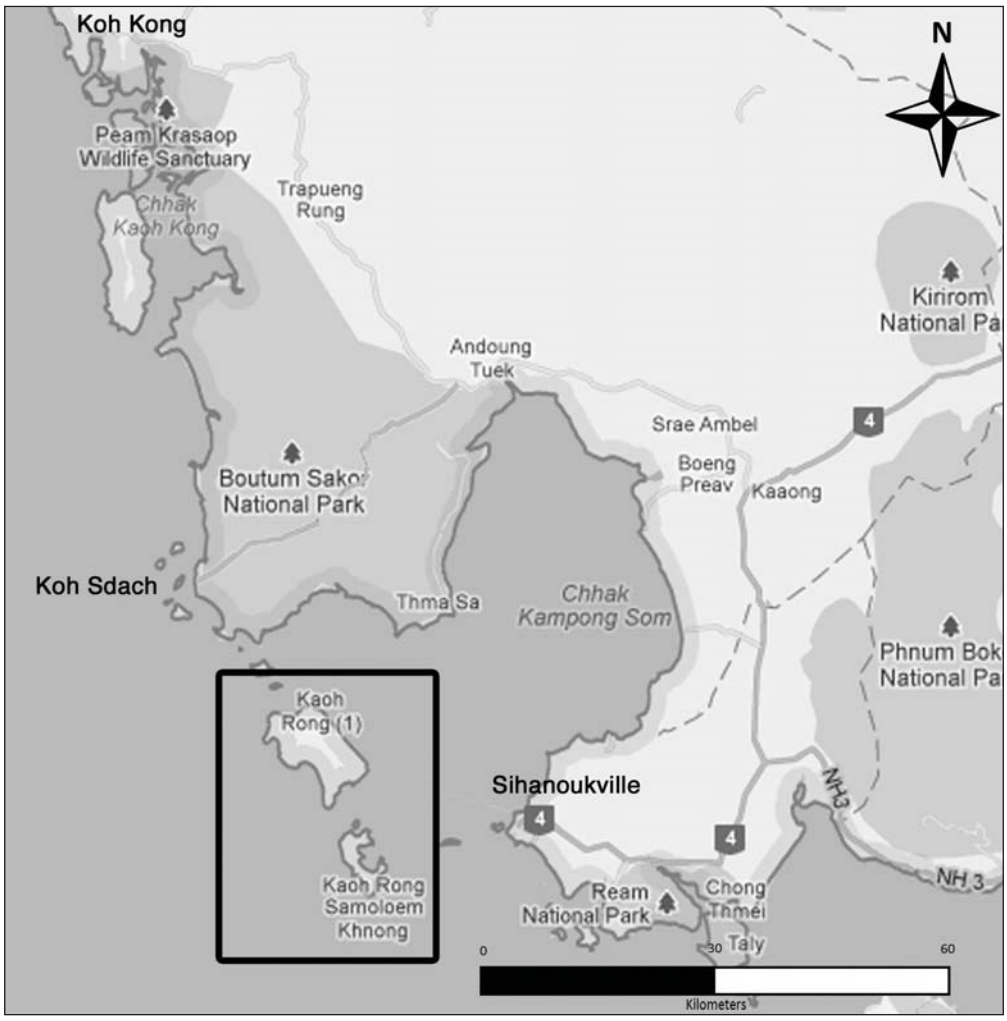


Fig. 1 Map of the Cambodian Coastal Zone. The Koh Rong Archipelago is outlined.

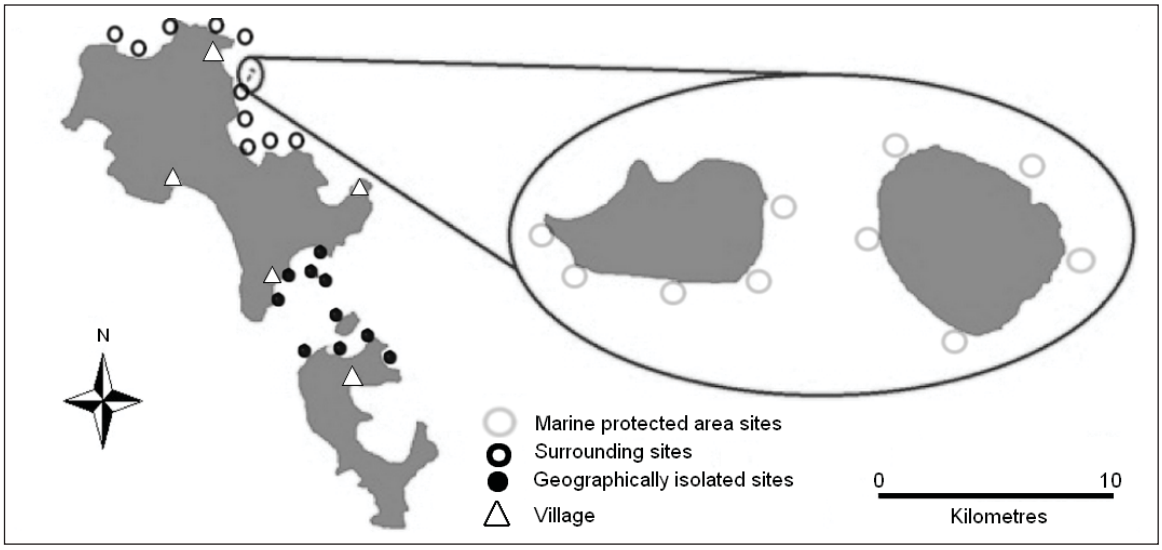


Fig. 2 Map showing the Koh Rong Archipelago and survey locations (circles, categorised by protection level). The oval indicates the location of the Song Saa Private Island Resort and its marine protected area.

the collection of large amounts of coral reef data for minimal time and costs, and allow organisations to utilise volunteers who can be trained relatively quickly to collect data on reef health. The Reef Check protocols can provide useful information on reef status and the causes of reef degradation, but are short on detail. To gather data at medium to high resolution, management-oriented monitoring relies on staff with scientific training (Hill & Wilkinson, 2004). Issues arise, however, when considering the scale of the survey area. Can a monitoring programme that was designed to collect large amounts of low-resolution data be used to accurately monitor the status of coral reefs in smaller geographic areas, such as small MPAs? Adequate sampling can be especially challenging in areas with low coral coverage, small coral colonies and high water turbidity (Segal & Castro, 2001).

The main aim of this study was to investigate the progress of the 5.5-hectare Song Saa MPA (Fig. 2) with regards to the diversity and abundance of key indicator species, posing the questions:

- Does the protection offered by the MPA have an effect on the abundance and diversity of fish when compared with unprotected areas?
- Does the protection offered by the MPA have an effect on the abundance and diversity of macro-invertebrates when compared with unprotected areas?
- Does the protection offered by the MPA have an effect on the composition of substrate communities when compared with unprotected areas? In particular with reference to reef health indicators such as percentage cover of live coral, recently killed coral (RKC) and nutrient indicator algae (NIA).

Considering the small size of the study area and the need for sampling with appropriate detail, the additional aims of this investigation were to identify the most suitable survey techniques for future long-term monitoring programmes here:

- Do stationary fish plots detect more fish than belt transects?
- Do photo-quadrats provide more accurate detail on substrate composition than line point transects?

Meeting these aims will provide an understanding of the efficacy of current marine management procedures and aid future management decisions in Cambodia.

Methods

Site description

The island of Koh Rong (Fig. 2) is located 34 km north-west of the mainland port of Sihanoukville. Koh Rong is the second largest island in Cambodia, covering an area of approximately 74 km^2 (Sophat & Reasey, 2010), and is one of the six islands of the Koh Rong Archipelago.

This study was carried out in the Song Saa Private Island Resort, which is based on two small islands in the northern Koh Rong Archipelago (Fig. 2). The Song Saa resort privately manages a 5.5-hectare no-take zone surrounding the islands of Koh Ouen and Koh Bong. The MPA is home to many shallow (< 5 m) fringing coral reefs and several patchy reefs composed of species of hard corals, soft corals and inhabited by various invertebrate and fish species.

The Song Saa MPA was originally established to protect the surrounding coral reefs and associated fauna, and has been protected by Royal Decree since 2007. However, at present there are no specific management objectives or targets. Additionally, this area is recognized by the Fisheries Administration as part of the surrounding Community Fisheries Organisation (CFO) of Prek Svay.

The area is a strict no-take zone, meaning that no resources of any type can be removed. This area is open to local boat traffic, but no anchoring of boats is permitted at any time. Wardens were employed to patrol the area when it was first established, but after approximately one year, local knowledge and understanding of the rules and regulations of the MPA meant that constant patrolling was no longer required. Due to the visibility of the MPA from the resort, the area is constantly observed by resort staff and boats sent out as necessary. Snorkelling by resort guests is permitted within the MPA. Reef education programmes have been established and snorkelling supervisors or guides are often used.

Due to a lack of reliable historical data for the area, it is not possible to examine how the biodiversity within this area has changed over time. Instead, this study used sites surrounding the MPA for comparison. Geographically isolated sites were also incorporated, to allow comparisons on a regional scale. The "surrounding sites" were all located along the northern coast of Koh Rong in the vicinity of Prek Svay Village, and the "geographically isolated sites" were at the southern end of Koh Rong and the

northern tip of Koh Rong Saloem (Fig. 2). All of the areas in this investigation are under the protection of a CFO: either the Prek Svay CFO (for the MPA and surrounding sites) or the M'Pai Bai CFO, based on Koh Rong Saloem (for the geographically isolated sites).

Data collection

The methodology used in this investigation was based on the Reef Check Survey Programme (Hodgeson *et al.*, 2004), but some modifications were made to fit the specifications of the Song Saa MPA. Within the MPA, two additional survey techniques were used to help determine the most effective means of quantifying species diversity and abundance.

The Reef Check Survey Programme comprises three main transect techniques: 5 m wide fish belt transects, 5 m wide macro-invertebrate belt transects, and line point transects at 50 cm intervals for assessing substrate communities. Because the high level of patchiness of the reefs in the survey areas rendered the standard 100 m survey length impractical, the length of these transects was reduced to 50 m. In accordance with the Reef Check Survey Programme, each transect was split into 20 m sections, separated by a 5 m interval (i.e. 0–20 m and 25–45 m), to allow comparisons with Reef Check data from other projects and locations. The results from individual surveys were combined to give species data for one 40 m length of transect per survey site.

All survey methods were conducted successively by two observers using the same transect line. Fish counts were conducted first, followed by the assessment of macro-invertebrates and substrates. The Reef Check Survey Programme provided a list of target species. Some species require size estimates, including parrotfish (Scarinae), groupers (Epinephelinae) and giant clams (*Tridacna* sp.), which were grouped into size categories at 10 cm intervals. For the purposes of this investigation, and to develop a species inventory for the area, additional economically valuable species such as mullet (Muglidae) and needlefish (Belonidae) were also recorded.

Photo-quadrats were used as an alternative means of assessing substrate communities. A 25 x 25 cm quadrat was photographed at 2.5 m intervals along the original transect line, giving a total of 20 quadrats and a survey area of 1.25 m^2.

Static fish counts were also incorporated for the purposes of comparison to fish belt transects. They entailed two (one randomly selected area in each half of the 50 m transect line) static fish population counts of five minutes each, giving a total measure of 10 minutes per survey.

A total of 30 sites were surveyed at a depth of 1–5 m using the Reef Check methods. Ten sites were surveyed in each of the following protection levels: within the Song Saa MPA (MPA); surrounding the MPA (SS) (judged as less than one hour travel time from the MPA by local fishing boat); and geographically isolated sites (GI) (judged as greater than one hour's travel). Sites were selected based on their accessibility and local weather conditions, depth, turbidity (a minimum of 5 m visibility was required for the surveys to be completed), and the presence of rocky coral substrates. The photo-quadrat and static fish count techniques were applied only in the MPA survey sites.

Data analysis

Prior to analysis, data were tested for satisfying the assumptions of analysis of variance (ANOVA) (Field, 2000). Comparative assessments were made of species diversity and the abundance of fish, invertebrates and substrate species under the three levels of protection (MPA, SS, GI). In addition, the number of long-spined sea urchins (*Diadema* sp.) was analysed, due to their high abundance in this region (Van Bochove *et al.*, 2011).

The abundance of substrate species was measured as the mean species count of live corals and the number of live coral points recorded along the transects in each site. The number of occurrences per transect of nutrient indicator algae (NIA) and recently killed coral (RKC) were recorded as a measure of coral health and damage respectively. These data were analysed using a one-way ANOVA with Bonferroni adjustment (α = 0.05) to assess differences within and between areas under different levels of protection (i.e. MIA, SS and GI).

Species diversity was calculated for each survey site using the Simpson's Diversity Index (D) (Magurran, 2004). This index's orientation towards the more common species gives a more accurate description of species composition. Index values were then compared using one-way ANOVA and Tukey's honest significant difference test (a post-hoc test).

Data from the MPA, SS and GI sites were also analysed using the Bray-Curtis index of similarity (Bray & Curtis, 1957). This measure was used to create

a rank similarity matrix which was used to construct a Multidimensional Scaling (MDS) plot to look at overall trends in community similarity across sites (Clarke, 1993).

Photo-quadrats recorded within the MPA were analysed with random point count techniques applied using Coral Point Count with Excel extension (CPCe) software (Kohler & Gill, 2006). One hundred stratified random identification points were overlaid onto each photo-quadrat. Prior to data collection, the software was validated using a comparative visual assessment of substrates to ensure compatibility with the study site. Comparisons were then made using a one-sample *t*-test (Field, 2000) of percentage cover estimates of live coral, RKC and NIA between the photo-quadrats and the line point transect data for each of the sites within the MPA.

Also to compare the results obtained from different survey methods, a one-sample *t*-test was used to compare the number of fish species and individuals detected using stationary fish plots and fish belt transects, and to compare substrate species composition detected using line point transect and photo-quadrat methods. When attempts to transform data for normality were unsuccessful, the Wilcoxon signed-rank test (a non-parametric test) was applied instead.

Results

The total number of individuals observed within each of the major taxonomic groups surveyed are shown in Table 1 (fish and invertebrates) and Table 2 (corals), highlighting the abundance and diversity of taxa in areas under different levels of protection (MPA, SS and GI).

No significant variation was found among the sites under different levels of protection in terms of either substrate composition or diversity of species (Table 3). There was a significant variation in the number of individual invertebrates ($F_{2,27}$ = 4.157, P = 0.027), but this variation was not significant when counts of *Diadema* sp. were excluded from the analysis ($F_{2,27}$ = 1.071, P = 0.357).

Following this, the abundance of *Diadema* sp. in sites under different levels of protection was assessed using a one-way ANOVA, which detected a significant difference across the three groups of sites ($F_{2,27}$ = 3.893, P = 0.033). Post-hoc comparisons using Tukey's honest significant difference test showed the number of *Diadema* was significantly higher in GI sites (mean = 151.5) than SS sites (mean = 33.5, S = 37.054, P = 0.040), but no significant differences were detected between the MPA sites (mean = 56.6) and the SS or GI sites. The proportion of *Diadema* making up each invertebrate community was also analysed using a one-way ANOVA, which indicated no significant differences between the three groups ($F_{2,27}$ = 0.863, P = 0.433).

A Bray-Curtis similarity test was conducted on the substrate composition data, incorporating all forms of substrate including rock, sand, RKC, NIA, live corals and all other biotic and abiotic substrates. A multidimensional scaling (MDS) plot indicated that while all sites showed at least 40% similarity in substrate composition, the MPA sites differed in species composition from both the SS and GI sites (Fig. 3). Variation among survey sites within the same protection level was also evident: sites within both the MPA and GI groups varied in substrate composition, ranging from 40–60% similarity, while sites in the SS category showed 60–80% similarity.

Transects vs stationary monitoring

The effectiveness of fish survey methodologies was examined using one sample *t*-tests. More individuals (t_9 = 11.972, P = < 0.001) and more species (t_9 = 8.354, P = < 0.001) were detected using the fish belt transect method than the stationary fish plot method.

Transects vs photo-quadrats

The line point transect method recorded a significantly higher percentage cover of live coral (mean = 33.5%) than the photo-quadrat method (mean = 21.7%; paired sample *t*-test: t = -3.624, P = 0.006). The line point transect method also recorded a significantly higher percentage cover of recently killed coral (mean = 7.12%) than the photo-quadrat method (mean = 1.77%; Wilcoxon signed-rank test Z = -2.668, P = 0.008). However, there was no significant difference in the percentage cover of nutrient indicator algae recorded using the line point transect method (mean = 9.25%) and the photo-quadrat method (mean = 5.08%; t = -1.921, P > 0.05).

Discussion

The implementation of marine management systems is now underway across Cambodia in an attempt to restore fish stocks. Present efforts are focussed on the establishment of MPAs as a means of boosting fish diversity and abundance with a view to ensuring long-term food security for the people of Cambodia.

Table 1 Total abundance (number of individuals per hectare) of all fish and invertebrate taxa in areas under different levels of protection.

Taxa		Marine Protected Area (MPA) *n* = 10	Surrounding Sites (SS) *n* = 10	Geographically Isolated Sites (GI) *n* = 10
Fish				
Chaetodontidae	Butterflyfish	220	400	770
Pomacanthidae	Angelfish	–	–	20
Siganidae	Rabbitfish	1,200	280	310
Pomacentridae	Damselfish	3,800	5,230	6,080
Lutjanidae	Snapper	430	460	230
Nemipteridae	Spinecheeks	240	80	790
Sphyraena sp.	Barracuda	10	10	200
Epinephelinae	Groupers	290	290	270
Labridae	Wrasse	350	840	720
Caesionidae	Fusiliers	340	–	240
Lethrinidae	Emperors	170	–	10
Ephippidae	Batfish	–	–	10
Holocentridae	Soldierfish	100	110	560
Apogonidae	Cardinalfish	1,140	440	780
Gobiidae	Goby	60	80	100
Blennioidei	Blenny	10	–	60
Scorpaenidae	Scorpionfish	–	10	20
Mullidae	Goatfish	10	–	50
Pempheridae	Sweepers	10	–	340
Monacanthidae	Filefish	–	10	30
Diodontidae sp.	Porcupinefish	10	–	30
Plectorhinchus sp.	Sweetlips	–	10	–
Chiloscyllium plagiosum	Bamboo shark	–	–	10
Taeniura lymma	Blue-spot ribbon-tail ray	–	–	30
Scarinae	Parrotfish	110	390	150
Mugilidae	Mullet	490	–	–
	Other	–	10	–
Sub-total: Fish		**8,990**	**8,650**	**11,810**
Invertebrates				
Phoronida/ Platyhelminthes	Worms	5,300	1,900	5,400
Crustacea	Crustaceans	1,000	700	700
Gastropoda	Gastropods	2,050	3,200	2,800
Tridacna gigas	Giant clams	7,200	2,650	1,300
Cephalapoda	Cephalapods	50	–	750
Echinodermata	Sea stars	1,200	1,350	64,750
Echinodermata	Urchins	27,800	16,800	5,200
Echinodermata	Sea cucumber	7,150	2,600	1,300
Sub-total: Invertebrates		**51,750**	**29,200**	**82,200**

Table 2 Mean percentage cover of coral species in areas under different levels of protection.

Taxa	Marine Protected Area (MPA), *n* = 10	Surrounding Sites (SS), *n* = 10	Geographically Isolated Sites (GI), *n* = 10
Faviidae	2.5	6.25	6.25
Massive *Porites*	195	65	93.75
Echinopora sp.	–	–	5
Galaxea sp.	8.75	2.5	2.5
Goniopora/ Alveopora	3.75	2.5	6.25
Pavona decussata	–	–	5
Porites rus	2.5	1.25	–
Turbanaria sp.	15	27.5	3.75
Lobophyllia sp.	7.5	2.5	8.75
Favia sp.	17.5	3.75	2.5
Favites sp.	45	12.5	7.5
Diploastrea heliopora	–	22.5	11.25
Astreopora sp.	–	–	1.25
Ctenactis echinata	1.25	12.5	63.75
Montipora sp.	–	–	2.5
Pseudosiderastrea sp.	1.25	–	3.75
Acropora sp.	6.25	3.75	2.5
Soft corals	1.25	–	–

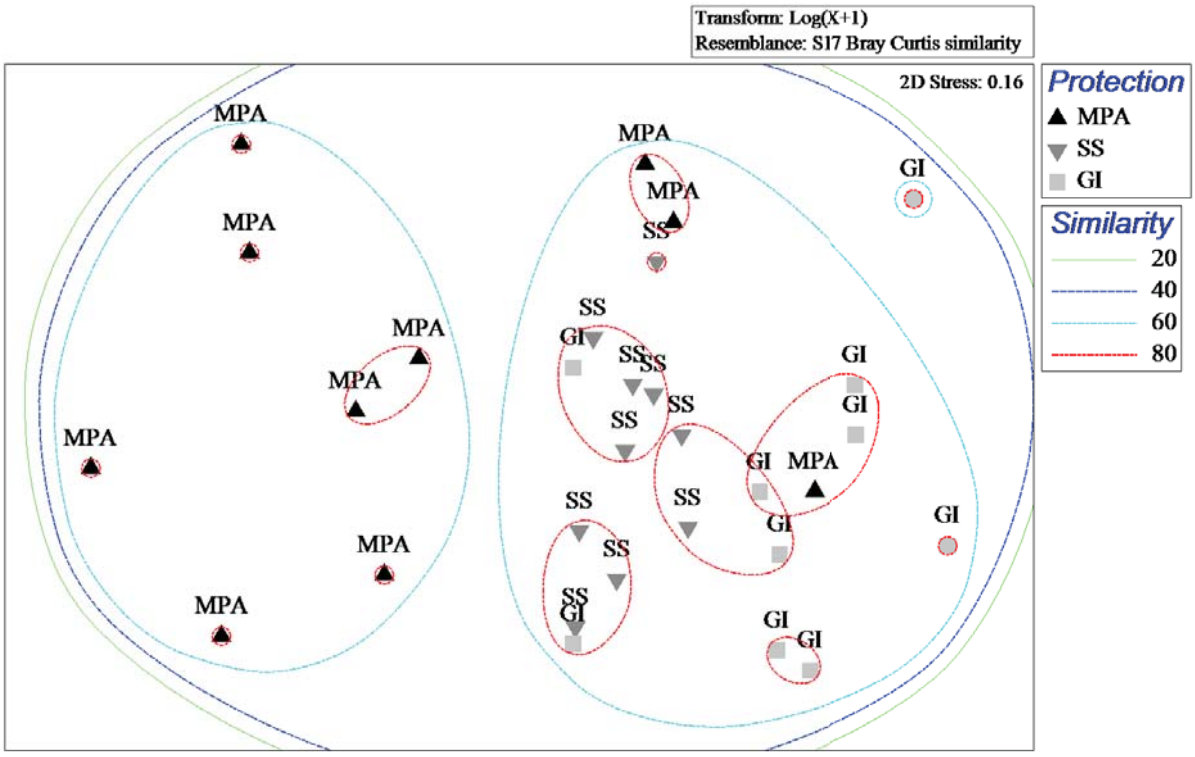


Fig. 3 Two-dimensional Multidimensional Scaling (MDS) representation of substrate communities sampled across three protection levels: MPA = Marine Protected Area, SS = Surrounding Sites, GI = Geographically Isolated Sites.

Table 3 Mean percentage cover of substrates and mean diversity of samples from areas under different levels of protection. Data in parentheses show one standard deviation. Data were tested using a one-way ANOVA with Bonferroni adjustment ($\alpha = 0.05$). NS indicates the probability values (P) are not statistically significant.

	Marine Protected Area (MPA)	Surrounding Sites (SS)	Geographically Isolated Sites (GI)	One-way ANOVA	
	$n = 10$	$n = 10$	$n = 10$	F	P
Substrate composition (%)					
Live coral species	35.5 (±12.34)	17.4 (±17.10)	27.4 (±18.46)	2.53	NS
Nutrient indicator algae	9.3 (±8.50)	27.3 (±15.79)	8.8 (± 18.12)	2.05	NS
Recently killed coral	7.1 (±8.29)	5.0 (±4.97)	5.1 (±5.25)	0.85	NS
Simpson's Index $^{(I\text{-}D)}$					
Fish	0.76 (±0.08)	0.73 (±0.12)	0.71 (±0.04)	0.58	NS
Invertebrates	0.44 (±0.22)	0.59 (±0.22)	0.40 (±0.19)	2.30	NS
Coral	0.51 (±0.18)	0.43 (±0.29)	0.41 (±0.29)	0.43	NS

The three-way comparison of sites used in this investigation provides an alternative to a "before/after" assessment of the impact of establishing the Song Saa MPA. This was necessary due to the lack of reliable data on the status of the reefs surrounding the Song Saa islands prior to the MPA's establishment. However there are inherent problems in this assumption. It is important to consider that other biophysical and management based variables could be responsible for any variation between sites.

Discussions with local fishermen suggest that the establishment of the MPA has benefitted the local communities. Mr Keo Som, a representative of the Koh Rong Council, explained "Our fishermen understand the benefits of the Song Saa conservation area because they've noticed that their fishing resources have increased since we established this area." Further socio-economic analysis is required to determine whether these views reflect those of the whole community.

Similarly, the Head of Conservation at Song Saa Private Island Resort, Barnaby Olson (pers. comm.) described having seen a great improvement in the quality and diversity of the reefs surrounding the resort over the last three years, particularly in comparison to the surrounding areas. This suggests that the sites surrounding and within the Song Saa MPA were in a similar or comparable condition prior to the establishment of the MPA. This was confirmed by the owners of the Song Saa resort, Rory and Melita Hunter (pers. comm.), who pinpointed the poor condition of the reefs in the area being one of the reasons for establishing the MPA.

From a management perspective, the views and opinions of key stakeholders regarding changes in marine communities are important. Research suggests that social factors, not biological or physical variables, are the primary determinants of MPA success or failure (McClanahan, 1999). Despite the results of this study not providing any definitive evidence of environmental change within the Song Saa MPA, stakeholder perceptions are important to the ongoing management programmes because without stakeholder support, such management regimes will likely fail (Mascia, 2003). This effect is further compounded by the fact that the effects of MPAs can take many years to be recognized and quantified (Micheli *et al.,* 2004). Positive public perceptions and support are required to reinforce the rules and regulations surrounding reserve design, implementation and management.

Typically, MPAs suffer because benefits are hard to quantify and slow to materialise (Micheli *et al.,* 2004). A long-term study in the Philippines, in sites with similarly high fishing pressure, indicated that the recovery of certain key fish species could take 15–40 years (Russ & Alcala, 2004). The present study was conducted only six years after the establishment of the Song Saa MPA. It would therefore be unrealistic to expect any major changes in community structure over such a short time frame (Micheli *et al.,* 2004). This could help to explain the similarity in fish abundance and diversity found in this MPA and other sites in this archipelago (Table. 1). Conversely, research has

shown that the duration of protection may not always be indicative of fish recovery (McClanahan & Arthur, 2001). Some reef species, particularly fish of commercial value, may or may not respond rapidly to a decrease in fishing pressure when species interactions prevent their recovery (McClanahan, 1997a).

Considering the young age of the Song Saa MPA, the lack of variation in fish abundance and diversity between the three groups of sites examined is not surprising. However, this may be explained to a certain extent by the abundance of the long-spined sea urchin *Diadema* sp. in this region. A previous study in a recently created MPA, found that a high abundance of *Diadema* sp. suppressed fish population recovery over a four-year period (McClanahan, 1997b). Previous assessments in the area surrounding our geographically isolated sites described the abundance of *Diadema* sp. as "very high" (Van Bochove *et al.*, 2011). The abundance of *Diadema* sp. also had an impact on the total abundance of invertebrates across our survey sites, irrespective of their protection levels: When *Diadema* sp. was excluded from the analysis, it became clear that its high abundance had skewed the invertebrate counts.

Analysis of substrate community composition highlights some potential impacts of the MPA, particularly surrounding the percentage cover of live coral, nutrient indicator algae (NIA) and recently killed coral (RKC). Some variation across protection levels was detected, although these differences were not statistically significant. Firstly, the levels of RKC are marginally higher in the MPA than in the surrounding sites or geographically isolated sites. This may be as a result of the construction of the resort or damage prior to the designation of the MPA, which has yet to recover. Although this is only a marginal difference, it should be monitored to ensure that the amount of RKC does not increase. Secondly, the percentage cover of hard coral was much higher in the MPA that the surrounding sites, and marginally higher than the geographically isolated sites. Although not statistically significant, this is a reassuring sign and should be monitored in the future.

It is predicted that over time, community structure will continue to improve in the MPA, facilitating higher species diversity and abundance. Continued monitoring and management will be required to track these changes. Consequently, a more detailed understanding of the responses of fish populations to the elimination of fishing pressure is necessary (McClanahan & Arthur, 2001). This requires a multiple-factor approach, incorporating interactions such as species composition, duration of protection, the size of the protected area, reef type and habitat characteristics. Such a complex analysis was outside the scope of this study, owing to the lack of similar nearby reserves of different size, age, and reef characteristics. As such, this study was only able to focus on single-factor interactions in one protected area. Future work should therefore consider a multiple-factor analysis and cover larger geographic areas over a longer time-frame. This would provide a more accurate understanding of the complexities surrounding the protection of Cambodian coral reefs and marine systems.

Survey techniques

The assessment of methodologies for assessing fish species composition within the MPA found fish belt transects produced higher counts than stationary fish plots. The area covered using each technique can explain this result. Time spent counting fish was used as a measure of effort, with an average of 10 minutes swimming the length of each fish belt transects and a total of 10 minutes spent on the two stationary fish plots. However, the stationary fish plots assess an area of 109.8 m^3 (calculated using average depth of 2.8 m) whereas the fish belt transects assess 1,000 m^3. It therefore stands to reason that the method assessing the largest volume is more capable of detecting the highest abundance and diversity of fish populations.

Stationary fish plots are considered to cause less disturbance to fish populations than fish belt transects (Bohnsack & Bannerot, 1986), therefore offering an interesting comparison for this study. Considering the differences in area covered, 20 stationary fish plots per transect would have been necessary for a more accurate comparison of the effects of observer disturbance. This was not possible within the scope of this investigation, and also would not be an appropriate means of long-term monitoring for the Song Saa MPA management team owing to the 20-fold increase in effort. Therefore, in view of the requirements of the Song Saa MPA and management team, fish belt transects are the recommended means of assessing fish populations.

With regard to the methodologies for measuring substrate cover, it was apparent that the line point transect method recorded a higher percentage of live coral cover and RKC than the photo-quadrat methodology. This is despite the photo-quadrats assessing a greater area and at a higher resolution (Preskitt *et al.*, 2004) and with greater precision. Considering the number of samples used in the analysis (800 line

point transects and 2,000 photo-quadrats), the photo-quadrat methodology should be more accurate in recording the true substrate composition. However, previous research into these research methodologies suggests that photo-quadrats tend to underestimate the percentage cover of substrate communities, while line point transect typically overestimate (Leujak & Ormond, 2007). The results of this investigation appear to fit this pattern, with the line point transect describing a significantly higher percentage cover of hard corals than the photo-quadrats. However, a benefit of the photo-quadrat method is that it provides permanent visual record of substrate composition for future comparison (Bohnsack, 1979). Considering the long-term management goals of the Song Saa management team, photo-quadrats could give reliable long-term data, but additional methodological validations should be conducted to select the most suitable techniques. In this instance, Line Intercept Transects (Leujak & Ormond, 2007) could offer a valuable alternative, assessing 50 times the area of line point transect, while still using visual census techniques.

Management implications

The low number and sparse distribution of effectively protected MPAs, particularly in the tropics (McClanahan, 1999), has made it difficult to scientifically test the effects of fishing restrictions and reserve management (McClanahan & Arthur, 2001). Furthermore, the effectiveness of management regimes in conserving reef resources depends on more than whether resource-users adhere to rules and regulations (McClanahan *et al.*, 2006). Public perception can often hinder the application of marine management techniques.

Owing to the small size of the Song Saa MPA and the status of the resort, effective policing of the protected area is possible, combined with the work of the management team with local communities to encourage compliance and increase their understanding. Reserve design must also be considered when determining the regulations and management systems. The size of an MPA needs to be appropriate to be able to provide suitable benefits for the communities is supports, while still being of a size that can be managed effectively (Agardy *et al.*, 2011).

Social surveys should be conducted regularly within local communities surrounding proposed and active MPAs. This will increase understanding of the needs of local resource-users, and the findings should be used to boost compliance with marine management protocols (McClanahan *et al.*, 2006). This would be invaluable for the success of marine management systems, particularly in countries like Cambodia, where marine management is still very much in its infancy.

Once the proposed new MPAs are in place in Cambodia, the knowledge of the Song Saa MPA team and the results of this and future investigations, will be invaluable in ensuring success. However, this paper concludes that more time and effort is needed to discern any true effects of the Song Saa MPA, with previous studies suggesting it takes 15–40 years for fish populations to recover fully (Russ & Alcala, 2004). The methods used for monitoring should be appropriate to the needs of the management programme. Some of the best techniques are already incorporated into the Reef Check methodology, but this should be adapted according to the needs of the area, with the addition or replacement by alternative techniques to collect accurate and reliable data. In addition, this study highlights, as others have, the importance of baseline data to monitor changes reliably over time. This study provides an essential baseline for future research and assessments in the Koh Rong Archipelago.

Acknowledgements

Thanks to Song Saa Private Island and their team, particularly B. Olson and R. Major for their supervision, D. Funke of The Dive Shop Cambodia, and S. Herbert and J. Howe of the Cambodian Diving Group.

References

Agardy, M.T., Notarbartolo di Sciara, G. & Christie, P. (2011) Mind the gap: addressing the shortcomings of marine protected areas through large scale marine spatial planning. *Marine Policy*, **2011,** 226–232.

Bohnsack, J.A. (1979) Photographic quantitative sampling of hard-bottom benthic communities. *Bulletin of Marine Science*, **29,** 242–252.

Bohnsack, J.A. & Bannerot, S.P. (1986) *A Stationary Visual Census Technique for Quantitatively Assessing Community Structure of Coral Reef Fishes*. NOAA Technical Report NMFS 41, National Oceanic and Atmospheric Administration, US Department of Commerce, Springfield VA, USA.

Bray, J.R. & Curtis, J.T. (1957) An ordination of the upland forest communities of Southern Wisconsin. *Ecological Monographs,* **27,** 325–349.

Chou, L.M., Loh, T.L. & Tun, K.P.P. (2003) *Status of Coral Reefs of the Koh Sdach Group of Islands, Koh Kong Province,*

Cambodia: Part II. Marine Biology Laboratory, National University of Singapore, Singapore.

Christie, P. (2004) Marine protected areas as biological successes and social failures in Southeast Asia. *American Fisheries Society Symposium,* **42,** 115–164.

Clarke, K.R. (1993) Non-parametric multi-variate analysis of changes in community structure. *Australian Journal of Ecology,* **18,** 117–143.

FAO—Fisheries and Aquaculture Organisation (2011) *National Fishery Sector Overview—Cambodia.* Fishery and Aquaculture Country Profile Technical Report, Fisheries and Aquaculture Organisation, Phnom Penh, Cambodia.

Field, A. (2000) *Discovering and Using SPSS.* Sage, London, UK.

Fox, H.E., Mascia, M.B., Basturto, X., Costa, A., Glew, L., Heinemann, D., Karrer, L.B., Lester, S.E., Lombana, A.V., Pomeroy, R.S., Rechia. C.A., Roberts. C.M., Sanchirico, J.N., Pet-Soede, L. & White, A.T. (2012) Re-examining the science of marine protected areas: linking knowledge to action. *Conservation Letters,* **5,** 1–10.

Gjertsen, H. (2005) Can habitat protection lead to improvements in human wellbeing? Evidence from marine protected areas in the Philippines. *World Development,* **33,** 197–217.

Hill, J. & Wilkinson, C. (2004) *Methods for Ecological Monitoring of Coral Reefs.* Australian Institute of Marine Science, Townsville, Australia.

Hodgeson, G., Kiene, W., Mihaly, J., Liebeler, J., Shuman, C. & Maun, L. (2004) *Reef Check Instruction Manual: A guide to Reef Check Coral Reef Monitoring.* Reef Check, Institute of the Environment and University of California, Los Angeles, USA.

Kelleher, G. & Ketchington, R. (1992) *Guidelines for Establishing Marine Protected Areas: a Marine Conservation and Development Report.* IUCN, Washington DC, USA.

Kohler, K.E. & Gill, S.M. (2006) Coral Point Count with Excel extensions (CPCe): a visual basic program for the determination of coral and substrate coverage using random point count methodology. *Computer and Geosciences,* **32,** 1259–1269.

Leujak, W. & Ormond, R. (2007) Comparative accuracy and efficiency of six coral community survey methods. *Journal of Experimental Marine Biology and Ecology,* **351,** 168–187.

Magurran, A.E. (2004) *Measuring Biological Diversity.* Blackwell Science, Oxford, UK.

Mascia, M.B. (2003) The human dimension of coral reef marine protected areas: recent social science research and its policy implications. *Conservation Biology,* **17,** 630–632.

McClanahan, T.R. (1997a) Primary succession of coral-reef algae: differing patterns on fished versus unfished reefs. *Journal of Experimental Marine Biology and Ecology,* **218,** 77–102.

McClanahan, T.R. (1997b) Effects of fishing and reef structure on East African coral reefs. In *Proceedings of the 8th International Coral Reef Symposium: Volume 2* (eds H.A. Lessios and I.G. Macintyre), pp. 1533–1538. Smithsonian Tropical Research Institute, Panama City, Panama.

McClanahan, T.R. (1999) Is there a future for coral reef parks in poor tropical countries? *Coral Reefs,* **18,** 321–325.

McClanahan, T.R. & Arthur, R. (2001) The effect of marine reserves and habitat on populations of East African coral reef fishes. *Ecological Applications,* **11,** 559–569.

McClanahan, T.R., Marnane, M.J., Cinner, J.E. & Kiene, W.E. (2006) A comparison of marine protected areas and approaches to coral-reef management. *Current Biology,* **16,** 1408–1413.

McLeod, K. & Leslie, H. (2009) Ecosystem-based management for the oceans. *Environmental Conservation,* **36,** 262–263.

Micheli, F., Halpern, B.S., Botsford, L.W. & Warner, R.R. (2004) Trajectories and correlates of community change in no-take marine reserves. *Ecological Applications,* **14,** 1709–1723.

Ministry of Environment (2005) *State of the Coastal Environment and Socio-economy*. Ministry of Environment, Phnom Penh, Cambodia.

Mora, C. Andrefouet, S., Costello, M.J., Kranenberg, C., Rollo, A., Vernon, J., Gaston, K.J. & Myers, R.A. (2006) Coral reefs and the global network of marine protected areas. *Science,* **312,** 1750–1751.

Nelson, V. (1999) *State of Coral Reefs in Cambodia*. Environmental Coastal Zone Project, Ministry of Environment, Phnom Penh, Cambodia.

Preskitt, L., Vroom, P. & Smith, C. (2004) A Rapid Ecological Assessment (REA) quantitative survey method for benthic algae using photoquadrats with SCUBA. *Pacific Science*, **58,** 201–209.

Russ, G.R. & Alcala, A.C. (2004) Marine reserves: long-term protection is required for full recovery of predatory fish populations. *Oecologia,* **138,** 622–627.

Segal, B. & Castro, C.B. (2001) A proposed method for coral cover assessment: a case study in Abrolhos. *Brazil Bulletin of Marine Science,* **69,** 487–496.

Sophat S. & Reasey H. (2010) *Socio-economic Monitoring of Coral Reef in Koh Rong Island, Preah Sihanouk Province, Cambodia*. Fisheries Action Coalition Team (FACT), Phnom Penh, Cambodia.

Toropova, C., Meliane, I., Lafoley, D., Matthews, E. & Spalding, M. (2010) *Global Ocean Protection: Present Status and Future Possibilities*. IUCN, Gland, Switzerland.

Van Bochove, J.-W., McVee, M., Ioannou, N. & Raines, P. (2011) *Cambodia Coral Reef Conservation Project.* Coral Cay Conservation Technical Report. London, UK.

Communities and biodiversity in Cambodia—options for policies and action whose time has come

Grazia BORRINI-FEYERABEND[1],* and Jeremy IRONSIDE[2]

[1] ICCA Consortium, Rue de Bugnaux, 18 CH 1180 Bugnaux, Switzerland.

[2] 109 Tennyson Street, Christchurch, New Zealand.

*Corresponding author. Email gbffilter@gmail.com

Paper submitted 17 October 2013, revised manuscript accepted 20 January 2014.

មូលន័យសង្ខេប

អត្ថបទស្រាវជ្រាវនេះពិនិត្យឡើងវិញនូវករណីតំបន់ជីវៈចម្រុះសំខាន់ៗជាច្រើនក្នុងប្រទេសកម្ពុជា ដែលអាចនឹងទទួលបានប្រយោជន៍ពីកន្លែងសេសសល់ និងដែលស្ថិតនៅក្រោមការគ្រប់គ្រងនិងការថែរក្សារបស់ជនជាតិដើមភាគតិចនិងសហគមន៍មូលដ្ឋានដែលពាក់ពន្ធ័គាំងពីមុនមក។ តំបន់អភិរក្សសហគមន៍ត្រូវបានលើកឡើងក្នុងអនុសញ្ញាស្តីពីជីវៈចម្រុះ(CBD) និងអង្គការសហភាពអន្តរជាតិសម្រាប់អភិរក្សធម្មជាតិ(IUCN) ដែលអំពាវនាវអោយមានការគាំទ្រនិងទទួលស្គាល់តំបន់និងទឹកដីអភិរក្សដោយសហគមន៍ និងជនជាតិដើមភាគតិច(ICCAs)ជាអន្តរជាតិ។ប៉ុន្តែប្រទេសកម្ពុជាគឺពុំទាន់មានការទទួលស្គាល់និងគាំទ្រដល់សហគមន៍ទាំងនោះទេ ដែលគម្រាមកំហែងយ៉ាងខ្លាំងដល់ICCAs។ សហគមន៍មូលដ្ឋាននិងជនជាតិដើមភាគតិចដែលបាននិងកំពុងធ្វើអភិបាលកិច្ច គ្រប់គ្រងនិងអភិរក្សធនធានធម្មជាតិរបស់ពួកគេយ៉ាងស្ងៀតស្ងាញរាប់សតវត្សមកហើយ មានចំណេះដឹង ជំនាញ ការអនុវត្ត និងការបណ្តុះបណ្តាលដោយឡែករបស់ខ្លួន និងផ្តល់ឱកាសដោយឡែករបស់ខ្លួនក្នុងការរួមចំណែកក្នុងវត្តុបំណងអភិរក្សនៃប្រទេសណាមួយ។ នៅប្រទេសកម្ពុជា សម្ថភាពនៃអ្នកការថែរក្សាសហគមន៍ដើម្បីការពារICCAs នៅចំពោះមុខកម្លាំងនៃការផ្លាស់ប្តូរឥតឈប់ឈរ បានបង្ហាញលទ្ធផលចំរុះ ហើយតួនាទីអភិរក្សនិងការចិញ្ចឹមជីវិតមាននិរន្តរភាពរបស់ពួកគេមិនជាក់លាក់ឡើយ។ នៅក្នុងអត្ថបទស្រាវជ្រាវនេះ យើងពិពណ៌នាអំពីករណីICCAsមួយចំនួននិងស្ថានភាពដ៏លំបាករបស់វា បរិបទនិងសេចក្តីត្រូវការរបស់ពួកគេ ដើម្បីអោយមានការគាំទ្រនិងការទទួលស្គាល់សមរម្យ។ ទាំងអស់នេះផ្តល់នូវសញ្ញាឆ្ពោះទៅរកហេតុការណ៍អ្វីមួយ ដែលអាចរីករាលដាលទូលំទូលាយជាងអ្វីដែលយើងធ្លាប់ស្រមៃ។ ដើម្បីជម្រុញអោយមានការគាំទ្រនិងការទទួលស្គាល់ICCAs យើងបានលើកឡើងនូវជម្រើសគោលនយោបាយមួយចំនួន ដែលស្ថិតនៅក្នុងច្បាប់នាពេលបច្ចុប្បន្ន និងជម្រើសផ្សេងទៀតដែលទាមទារអោយមានកំណែប្រែច្បាប់បន្តិចបន្តួច។ រដ្ឋាភិបាលកម្ពុជា ទោះបីមានឬគ្មានការជួយពីដៃគូអភិរក្សនិងអភិវឌ្ឍក៏ដោយ ក៏អាចជ្រើសរើសជម្រើសគោលនយោបាយទាំងនោះមួយឬច្រើនយកមកសាកល្បងអភិវឌ្ឍ និងអនុវត្តដើម្បីគាំទ្រនិងទទួលស្គាល់ICCAs។ យើងជឿជាក់ថា អត្ថបទស្រាវជ្រាវនេះនឹងជួយអោយមានការយល់ដឹងកាន់តែប្រសើរឡើង និងធានាសន្តិសុខដល់រតនវត្តុដ៏វប្បធម៌សម្រាប់ប្រទេសកម្ពុជាជាពុំខានឡើយ។

Abstract

This paper reviews the cases of several important biodiversity areas in Cambodia that are and would benefit from remaining under the governance and care of the indigenous peoples and local communities customarily associated with them. Internationally referred as Indigenous Peoples' and Community Conserved Territories

CITATION: Borrini-Feyerabend, G. & Ironside, J. (2013) Communities and biodiversity in Cambodia—options for policies and action whose time has come. *Cambodian Journal of Natural History*, **2013,** 95–108.

and Areas (ICCAs), such community-conserved areas are highlighted by the Convention on Biological Diversity and the International Union for the Conservation of Nature, which call for their appropriate recognition and support. In Cambodia, however, no recognition has been forthcoming and, in place of support, threats to ICCAs abound. The indigenous peoples and local communities that have governed, managed and conserved their natural resources for centuries possess unique knowledge, skills, practices and institutions, and offer unique opportunities to contribute to the conservation objectives of any country. In Cambodia, the capacity of caretaker communities to protect their ICCAs in the face of unrelenting forces of change has shown mixed results, and their ongoing conservation and sustainable livelihoods role is precarious. In this paper we describe several ICCAs and their predicaments, contexts and needs for appropriate recognition and support. This offers a glimpse into a phenomenon that may be more widespread than imagined. To encourage ICCA recognition and support, we list a few policy options available under current legislation and rules, and others that require relatively minor legislative modifications. The Cambodian government, with or without the help of conservation and development partners, could choose one or more such options to be tested, developed and implemented to recognise and support ICCAs. We are confident this would help to better understand, and to secure, the bio-cultural jewels of the country.

Keywords

Biological diversity, Cambodia, collective stewardship, collective rights and responsibilities, commons, community-based conservation, cultural diversity, livelihoods, sacred natural sites, non-timber forest products.

Introduction

Over the past decade or more, international guidelines, resolutions and binding international agreements have brought to the fore the opportunity and commitment of the overwhelming majority of countries to recognise and provide appropriate support to the conservation initiatives of indigenous peoples and local communities (CBD, 2004, 2010; IUCN, 2012; Borrini-Feyerabend *et al.*, 2013). These initiatives are uniquely tailored to support bio-cultural diversity—the diversity of interrelated and often co-evolved biological, cultural, and linguistic manifestations of life on our planet (Maffi, 2012). Despite the pronouncements made by international policy, however, a rapid degradation of both cultural and biological diversity continues as the world's natural resources (land, forests, water bodies and their associated flora and fauna) are alienated from indigenous peoples and local communities and transferred to large state enterprises and private concessions (Sawyer & Gomez, 2012; Sibaud, 2012). Even governmental and non-governmental conservation initiatives add to the appropriation of community resources in ways collectively described as "green grabbing" (Fairhead *et al.*, 2012). As a result, traditional farmers, herders and fishermen lose out both economically and culturally, while the natural wealth of a country is transferred to elites and companies, often of foreign origin.

Cambodia—a signatory to both the Convention on Biological Diversity and the UN Declaration on the Rights of the Indigenous Peoples—is no exception to this worrying process. Until recently, Cambodia contained the largest proportion of forested land in the Mekong Region (Hirsch, 2000). From 1973 to 2013, however, forest cover fell from 72% to 46% of total territory (Worell, 2013). Since 2000, Cambodia has experienced the fifth fastest deforestation rate in the world, losing 7% of its total forest area during this time (Hansen *et al.*, 2013; Zsomsbor, 2013). The pace of deforestation has even accelerated in recent years due to uncontrolled logging and clearing for plantations (Zsomsbor, 2013). Along with overpowering commercial interests, insecure tenure has led to rapid land privatisation, which contributes to agricultural expansion and deforestation (Bottomley, 2000; Leuprecht, 2004; NGO Forum, 2006; Fox *et al.*, 2008; CHRAC, 2009; Ironside, 2013).

Despite all this, Cambodia still possesses important forest and freshwater resources (Ironside & Ken Serey, 2005). This paper describes a few examples of issues impacting community conserved areas in Cambodia and offers a number of policy options for strengthening their contribution to conserving the bio-cultural diversity patrimony of the country. We focus on community conserved areas in the upland forested regions that are, as discussed, actively coveted for conversion to plantations, mining operations, hydropower infrastructure, etc.

Conservation by indigenous peoples and local communities

The term 'ICCAs' is an abbreviation for 'Indigenous Peoples' and Community Conserved Territories and Areas', i.e., "*natural and modified ecosystems including significant biodiversity, ecological services and cultural values voluntarily conserved by indigenous peoples and local communities through customary laws or other effective means*" (Kothari *et al.*, 2012). Known by thousands of local names, this phenomenon is widespread throughout the world and identified by three essential characteristics (Borrini-Feyerabend *et al.*, 2010):

- The people or community possess a close and profound relation with a site (territory, area, habitat), which is embedded in local culture, sense of identity and/or dependency for livelihoods and well-being;
- The people or community have been the major player in the management of the site and a local institution has had *de facto*, and possibly also *de jure*, capacity to develop and enforce decisions;
- The people's or community's decisions and efforts have led to the conservation of habitats, species, genetic diversity, ecological functions, associated cultural values and other benefits (even when the conscious objective of management was not conservation alone or *per se*).

ICCAs are the oldest form of conservation on earth and protect an immense range of ecosystems, habitats and species, including sensitive ecological sites, while contributing to the livelihoods and cultural identity of millions of people (IUCN/WCPA, 2006). Often built on sophisticated ecological knowledge systems that have stood the test of time, ICCAs are governed by institutions that are "tailored to the context", skilled at adaptive management and capable of flexibly responding to change (Borrini-Feyerabend *et al.*, 2010).

Despite their values—which are many and amply recognised by their caretaker peoples and communities—many ICCAs, especially in the Global South, lack any form of formal recognition. This often leads to the appropriation of these areas from the caretaker people or community. Further major risks come from the increasingly fragile caretaker institutions that are under pressure from massive socio-economic and cultural changes (IUCN/CEESP, 2008; Milne, 2013). To understand how this change can undermine ICCAs, it is sufficient to draw on Ostrom's (1990) analysis of common property resources, in particular the important factors for effective governance over time. These factors include: well defined membership, clear boundaries of the resources, agreed and well defined rules of access and rights, and agreed monitoring and sanctions for misuse (Ostrom, 1990). In addition, homogeneity of interests among the group, legitimate leadership, equitable allocation of the resources, gradual change and adaptability to new opportunities, low cost adjudication of offences, and supportive state institutions and policy frameworks have also been identified as important and under increasing pressure (MacInnes, 2007). Links between local governance institutions and external organizations also appear to be increasingly important for assisting common property institutions to adapt to outside pressures (MacInnes, 2007; Sun, 2007).

Overall, ICCAs are sensitive socio-ecological phenomena, which can be severely damaged even in the process of trying to support them. This has led to extensive recommendations on "do's and don't's" in processes of formal recognition and support (Borrini-Feyerabend *et al.*, 2010; Kothari *et al.*, 2012).

ICCAs in Cambodia

Cambodia is blessed with a variety of ICCAs, encompassing sacred hills, lakes, forests and unique natural features such as caves and waterfalls. These "bio-cultural jewels" are often underpinned by a particular nature–culture relationship in which the world of humans is believed to be directly linked to powerful supernatural forces (Bourdier, 1995; Backstrom *et al.*, 2006; Brown *et al.*, 2006). Beliefs in the existence of earth spirits or "spirits of the land and water" are commonly held by the people of Cambodia, whether they are from towns or the countryside. Everywhere, the presence of such spirits is marked by a mixture of fear, respect and familiarity. Spirits can have different degrees of power and direct relationships with humans, but have a general tutelary role, 'watching over' and 'protecting' the land and people and ensuring prosperity and good health as long as customary rules are respected.

Characteristically, spirits reside in a feature of the landscape—a hill, a lake, a cave or even a rock—and maintain harmony, but also punish and torment people. In lowland parts of the country, they represent a spiritual hierarchy superimposed on human hierarchies, co-existing in a syncretic mix with Buddhist beliefs (Bonnefoy, 1991). In upland areas, inhabited by indigenous peoples, they are part of a dominant animist tradition which recognises lesser and more

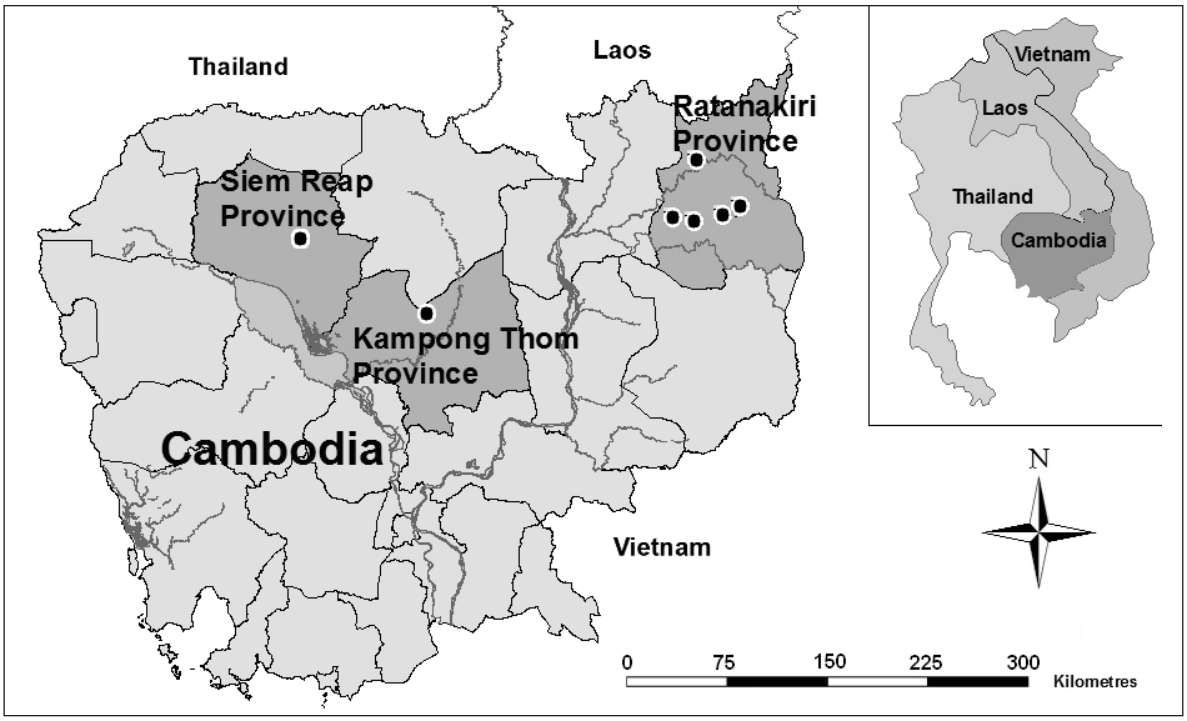


Fig. 1 The Indigenous Peoples' and Community Conserved Territories and Areas (ICCA) sites visited during the spot survey in 2009 (white circles).

powerful spirits living throughout the landscape (Colm *et al.*, 2000).

As a result of these belief systems, many areas believed to be imbued with particular spiritual power are set aside and protected from various kinds of uses. This often leads them to harbour unique biological diversity, closely connected and dependent upon the one or more communities that relate to them strongly in culturally-rich and spiritually-powerful ways (Brown *et al.*, 2006; Colm *et al.*, 2000). The spirits embody an energy force linking the people to the land and their ancestors. The presence of a spirit in a given area, such as a hill, does not impede people from utilising some of the natural resources found there, but disrespectful behaviours—such as indiscriminate tree cutting and killing of certain animals—are forbidden (Colm *et al.*, 2000; Brown *et al.*, 2006). These beliefs create a powerful stewardship relation between a given community and one or more areas where the relevant spirits reside.

Of course, intertwined with these sacred relationships between communities and their territories, there exist other more mundane, possibly less specifically documented but no less powerful, relationships to do with the satisfaction of livelihood needs, economic sustenance and development, health, historical and cultural ties, desire for political and economic autonomy and even the sense of personal identity and collective pride. In some cases the spiritual relationship with the territory may even be 're-created' and used instrumentally, for a variety of motives (Baird, 2013). Regardless of motives, it is the combination and variety of the ties linking specific peoples and communities to their specific territories—survival-related but also related to well-being and meaning—that makes the bond between an ICCA and its caretaker community particularly strong and 'umbilical' in nature.

A range of phenomena—from civil war to the Khmer Rouge regime, from widespread corruption to poor governance and an open access situation to natural resources, from aid-fuelled development and conservation initiatives (such as the establishment of protected areas) to international investors combing the country for oil, minerals, arable lands and energy (in particular hydropower projects)—have contributed to reshaping the relationships between Cambodia's communities and their territories and sacred areas. While in many cases the relationship has been affected but remains in place, in others the 'umbilical tie' linking specific peoples to specific territories has been severed altogether. Despite this, we started this study

with the hypothesis that ICCAs still exist, in particular for Cambodia's indigenous peoples.

Methods

In November 2009, a rapid spot-survey of ICCAs associated with seven different communities was carried out by the authors in the Cambodian provinces of Ratanakiri, Siem Reap and Kampong Thom (Fig. 1). The cases were chosen with a mix of considerations in mind, including accessibility and the potential to be information-rich. The sample is thus not necessarily representative of all communities.

In nearly all cases we had an opportunity to visit, albeit briefly, the territory of the ICCA, met with members of the 'caretaker communities' and held interviews with community leaders, government officials and others to discuss the current status, problems and needs of their ICCA. Case study sites chosen in Ratanakiri Province were those the second author has had a long association with (in some cases since 1996) and typify the multiple development pressures which such sites are now facing. The sites in Siem Reap and Kampong Thom provinces were chosen at least in part because they are within protected areas managed by the Ministry of Environment (MoE), and MoE officials were available to accompany us on the visits in these two provinces. The presence of these officials may have influenced villagers' responses, but given that the MoE has formally recognised these communities' conserved areas, discussions about the protection and management of these and other nearby areas were not considered controversial enough to inhibit open discussion.

The interviews with village leaders always started by asking permission to ask questions and visit their local territory and sacred sites—a fact that was not taken for granted. Focus group discussions were then conducted with key community leaders who have responsibility for managing the communities' natural resources. In some cases, such as Yeak Laom lake and Youl and Yetnang hills in Ratanakiri Province, we were also able to observe local community efforts to protect their ICCAs. Most participant observations, however, consisted of joining community meetings to understand how local people viewed their territories and sacred areas, and the strategies they use to protect them. At times, the community meetings included coordination efforts between neighbouring villages to discuss joint protection strategies (e.g., in the case of Youl hill). Our initial spot-survey of ICCAs in 2009 was followed up by subsequent visits to many of the same villages during 2010–2013, to gain an update on the challenges the ICCAs were facing and to understand how villagers were faring in protecting them.

In the sections that follow, we offer a qualitative summary of the issues discussed during our visits. Due to the limited space available for this article, only some of the visited communities and ICCAs will be described. The cases that we will not describe, but contribute to our analysis and to the development of recommendations include: the Sacred hill of Yetnang (Teun Commune) and Ndroo Hill (La'en Village, Teun Commune) in Ratanakiri Province; and Tonle Mriec lake (O Por Village) in Bung Per Wildlife Sanctuary, Kampong Thom Province. We conclude our discussion with recommendations for the consideration of national agencies and supporting organisations concerned with conservation, sustainable livelihoods and bio-cultural diversity in Cambodia.

Results

State-community conflicts over protected/ conserved and sacred areas—the spirit hills of Kavet communities in Kok Lak Commune, Ratanakiri Province.

One of the key issues found in our survey was the conflict between state and community visions over the management of areas considered sacred by local communities. The ethnic Kavet villages of La Meuay, Ndrak, Lalay and Rok (about 462 households, 2000 people, see Fig. 2), for example, formerly lived in what is now Virachey National Park, in Ratanakiri Province, covering 337,723 hectares close to the Laos/Cambodia border. Due to a number of factors including war, the government's desire for the people to be closer to populated areas, and the establishment of Virachey National Park, the villagers were relocated and now live in lowland areas south of the park. These communities, however, still maintain important sacred forest areas throughout Virachey National Park in the areas they formerly resided.

Community members reported that these areas have special characteristics, e.g. different sized bamboo, rocks, caves, waterfalls, grasslands and beautiful vistas. People still visit them for special ceremonies (which is difficult because some of these areas are in the core of the national park) and must observe special rules and rituals (e.g. only Kavet language can be spoken there). Going to these places means potentially being exposed to a variety of dangers and diseases. Village elders stressed that

Fig. 2 Kavet people in Kok Lak Commune, Ratanakiri Province (© G. Borrini-Feyerabend).

Fig. 3 Elders of Lalay Village discuss their spirit forest areas and their worries about the recent mining explorations there (© G. Borrini-Feyerabend).

respecting these places is very closely connected with the fate and livelihoods of the Kavet people. The communities have passionately defended these hill and watershed areas and other sensitive ecological areas.

As a result of the relocation, over a number of years these Kavet communities have adopted lowland rice farming, which has partially replaced the shifting agriculture they traditionally practiced in the bamboo groves along the banks of rivers and streams (Ironside & Baird, 2003). A lack of land in lowland areas, however, and the difficulty of finding suitable land for shifting agriculture means rice production is often insufficient for their needs and they often have to resort to eating yams and tubers from the forest. This, and the presence of other resources which are vital for livelihoods, such as bamboo, vines, mushrooms, forest vegetables and fruits, medicinal plants and even sharpening stones, explains why these communities still want access and user rights to forest areas inside and outside of Virachey National Park. Shifting agriculture in the vicinity of rivers is combined with strict conservation in the hills, where the spirits live and which abound with useful forest products.

Based on their traditional claims over areas inside Virachey National Park, the four villages were jointly assigned, some years ago, an area of approximately 10,000 ha as the O Tung Community Protected Area (CPA) inside Virachey National Park. CPAs are a mechanism for identifying areas within a national protected area for which a community is recognised as having some pre-existing customary rights. Some of the Kavet peoples' sacred areas are inside this CPA but others are located deeper inside Virachey National Park (see Baird, 2013). CPAs are supposed to be governed by a community committee, but gaining full control of this area has taken many years. Only recently, at the end of 2013, is the process nearing completion. In the years that followed the community's relocation, however, and despite its protected status, the government issued mining exploration permits over large areas of Virachey National Park in 2007–2008. Kavet elders believe that the unprecedented floods at the end of September 2009 were the direct consequence of exploratory drilling close to the sacred hills where the spirits live, which they said irritated the spirits (see Fig. 3).

In addition, in 2011 the Ministry of Environment awarded 50,000 hectares for economic land concessions inside Virachey National Park, along the border with Vietnam. Consequently the Kavet and the neighbouring Brao communities are now worried about their tenure security over their CPAs. Also as a result of allocating concessions, illegal logging of valuable timber species has escalated inside and adjacent to the Virachey National Park since 2012. Illegal loggers sell the logs to a company that has an exclusive license to buy all the logs from all the concession companies in Ratanakiri. Some Kok Lak community members have joined with the loggers, resulting in divisions within the community. Until there is an agreed management plan, and until the local Kok Lak governance institutions are able to implement it effectively, the long term governance of the O Tung CPA will remain unclear.

The indigenous territories which the Kavet people have long protected as sacred within and outside Virachey National Park are excellent examples of ICCAs. But the Kavet have been forced out and have lost much of their control. There is still an opportunity to ensure the conservation of these areas by allowing local communities some form of governance rights over them. But there are also plenty of open questions, in particular related to their present and future sources of livelihoods and to the subdivision of governance rights among the four communities associated with the O Tung CPA.

Opposing development and conservation visions—the sacred lake of Yeak Laom (Yeak Laom Commune, Ratanakiri Province) and the sacred hill of Youl, Aikapiep and Yeak Laom Communes (Ratanakiri Province).

The different visions of development and conservation that exist in Cambodia are also illustrated by the case of Yeak Loam Lake, also in Ratanakiri Province. This crater lake, only 5 km from the provincial capital, has been sacred to the local Tampuan people for many generations (see Fig. 4). In the past the lake was never disturbed. Because people were afraid of the spirits inhabiting it and the surrounding forests, only a few people went there for fishing, and while there they had to behave very respectfully and even refrain from making noise. As a result, the surrounding 240-ha crater and protected area has largely retained its original forest.

Following a history of government takeover, stretching back to the construction of a royal palace on the shores of the lake in the 1960s, in the 1990s the International Development Research Center (IDRC), a Canadian development agency, implanted a project to support the community management of the area. At the request of the Provincial Governor, IDRC promoted a community institution to re-take the governance of the lake and the surrounding forest. In this way, taking advantage of the presence of a progressive governor and of the technical and financial support of IDRC, in 1998 the Yeak Laom community obtained a 25-year management agreement over the lake from the Ratanakiri provincial authorities. IDRC and a follow-up UNDP project facilitated the setting up of a community-based lake management committee.

Currently, the lake is used by swimmers and handicraft shops flourish around the main access way to the lake. The lake is still a natural area, however, because no concrete buildings are allowed around it, the crater is well forested and the governance power is still in local hands. Based on their beliefs, the Yeak Laom community wishes to leave this area in its natural state for all to enjoy, for a modest entrance fee. The provincial level management agreement, however, is a limited and rather fragile form of tenure and powerful government officials and business interests would like to gain control of this lake for its income-earning potential by building a road around it to allow motorbikes and cars to enter, building up-market accommodation near the lake and on the crater summit above it, installing cable cars, etc. Provincial officials are reported to have said "This is the era of development not protection" to some members of the lake committee.

For the moment, however, the management agreement has been able to prevent outside tourism companies from appropriating the lake area. Despite its uncertain future, Yeak Laom lake is thus still an ICCA and, for the time being, the Yeak Laom community is able to retain its management rights and protect this area from significant transformation.

In contrast to this eco-cultural vision of tourism development, in 2009 Yeak Loam communities and neighbouring Pachon Village (Ncharr in Tampuan language) lost control of a nearby sacred hill known as Phnom Youl (Phnim Yun in Tampuan language), on the boundary between these communities. Phnom Youl is the most important sacred hill and spirit forest of the Pachon community. Community elders and authorities stressed that they protected the hill for a long time and as recently as 2007 they intervened to stop some logging activities there. Pachon and other communities collect bamboo and other non-timber forest products from this 218-ha hill area. Some 65 Yeak Laom communities also had upland fields in the valley areas of this hill complex. Despite this, the Minister of Agriculture allocated this sacred hill to the BVB Company for a 70-year tourism concession. The concession company wants to build a cable car, hotels (3 and 5 star) and a "recreation area", widely believed to be a casino.

To inform Yeak Laom communities of this expropriation, community members were summoned by the Provincial Governor to a distribution of rice and soy sauce, and were told the area would be given to a company. The neighbouring Aikapiep Commune communities were not notified. Receipt of a 'gift' of 20 kg of rice and a bottle of soy sauce for each family was expected to be acknowledged with a thumb-print. Fearing a community backlash, the Yeak Laom village chiefs refused to hand in these thumb-printed community lists, because they were worried they

Fig. 4 Yeak Laom crater lake, around 800 metres in diameter (© G. Borrini-Feyerabend).

Fig. 5 The new road bulldozed around Youl Hill by an 'eco-tourism' concession company (© G. Borrini-Feyerabend).

would be used as evidence of community acquiescence to this arrangement. People from Yeak Laom Commune maintain that they are against allowing the company to appropriate the hill, but it is very difficult to fight against them. Since taking over the sacred hill area, the concession company completed a road around it (Fig. 5), but as of late 2013, the company has done nothing with the area. The families with upland fields in the area, however, have been forced to vacate this area with inadequate compensation.

Despite the lack of consultation, the Aikapeap community is not opposed to tourism development in principle. It wishes, however, that the hill is respected and their rights to it as traditional caretakers are recognised. The villagers are afraid that the desecration of the hill will be interpreted by the spirits as a neglect of their responsibilities and the spirits will punish them with bad luck and disasters.

The potential of combining community conservation with sustainable livelihoods—*prey thom* areas and CPAs within Phnom Kulen National Park, Siem Reap Province.

The 35,000-hectare Phnom Kulen National Park, north of Siem Reap town and the Angkor Wat temple complex, was created in 1993, when the Ministry of Environment initiated the national protected area system. For several years, however, access to the national park was not possible. The steep hills and forested terrain made it a Khmer Rouge stronghold. Political reconciliation finally took place in 1997–1998, opening access to the region and to Phnom Kulen National Park. Recently, APSARA—the Cambodian government-appointed authority in charge of managing the Angkor Wat and surrounding temples—awarded a 7,000-ha eco-tourism concession in Phnom Kulen National Park. This caused a dispute between the Ministry of Environment and APSARA over the latter's authority to allocate the concession here.

Within Phnom Kulen National Park is a relatively new village, where the ex-Khmer Rouge families were relocated and now reside, and eight much older villages. These older villages have negotiated access to five Community Protected Areas (CPAs), totalling 1,088 ha (each ranging in size from 77 ha to 306 ha). The areas are under the direct governance/management and protection of the residents of the eight villages, who collect non-timber forest products from these areas according to their customary rules. The CPAs are essential for the livelihoods of the local communities because they are rich locations for harvesting wild lychees *Litchi chinensis*, the main forest product sold locally as a cash crop. Lychee trees are collectively protected, but the fruits are harvested and sold by each family (Fig. 6). Through some basic management practices, families are associated with specific areas and trees.

In the past, decisions about natural resources were taken by the elders, who were very concerned about the protection of the forest and water. The sustainable extraction of lychees and the protection of the forest were practiced for generations. Now, due to the long years of war and poaching, the tigers and other wildlife are gone and only birds, wild pigs and deer

Fig. 6 The lychee forest and Community Protected Area in Phnom Kulen National Park, where villagers harvest their fruits (© G. Borrini-Feyerabend).

remain. More and more people are coming into the area to collect traditional medicine, fruit, and natural resources in general, including fish and the little wildlife that is left, for the market. Consequently, the resources are suffering from over-exploitation. Internal population increase and limited land area also mean that periods for rotational shifting agriculture have declined from the ideal 15 years to 8–10 years. Some solutions have been attempted by the community, such as planting improved cultivated varieties of lychees and medicinal plants around their home gardens and agricultural areas.

Every village CPA committee consists of around seven members, which at the time of our visit included two women, elected democratically by general village assemblies. The committees are fully in charge of management (demarcation, rules of harvesting lychees, patrolling, establishing firebreaks, etc). The support or advice of national park rangers is called on only in case of need. The chief of the commune commented that people appreciate the CPAs because they have helped to control the anarchic exploitation of the forest, which was commonplace before their establishment.

The community members, however, are not only concerned about lychees and their CPAs. They deeply care also about other particular areas in the forest, where the spirits live. These areas—called *prey thom*, or "big forest" in Khmer—contain water sources or old temple sites. *Prey thom* areas remain well protected. Timber is not cut there for fear of the spirit's reprisal, but it is possible to collect rattan, vines, wild fruits and traditional medicines. The community is concerned that outsiders can come and try to extract timber from those areas, so they have been patrolling these areas, even if they are far from their CPAs. We saw in these communities that both economic and spiritual concerns are at play to make them careful and effective when governing (developing decisions) and managing (harvesting, patrolling) their local environments. It thus appears that both the CPAs and the *prey thom* areas qualify as ICCAs.

Community leaders were interested in obtaining a special status for their *prey thom*. The Commune Chief suggested a feasibility study should be carried out and some management procedures developed. In particular, community leaders said that they would like to officially extend their voluntary patrols to the *prey thom* areas. They said they are not afraid to patrol on their own, as their experience is that they do not need to get into fights with the people who do not respect the rules, they just need to talk to them. However, they also welcome the support of the park rangers to repress illegal activities in their ICCAs.

Discussion

As readily seen in the cases just described, the potential for conservation by indigenous peoples and local communities, including some form of formal governance of their ICCAs, is real. The process of recognising and supporting that governance, however, is fraught with difficulties related to policy, and problems related to implementation and practice.

Our observations confirm that ICCAs depend on the functioning of a community institution governing them (Ostrom, 1990). As noted by Murphree (1997), however, we also noticed that the bonds that link the caretaker communities and their territories must remain alive and congruent in terms of proximity and scale: a condition usually impacted by centralised decisions such as relocations, top-down attributions, etc. As an example of disrupting the bonds between social and natural units, the Kavet people have been forced out of their original territories in Virachey National Park. The O Tung CPA they have now been assigned is an area largely defined by park managers and governed by a community committee under the supervision of the park authorities. This results in an unnecessary layer of separation between the people and the natural resources. Equally importantly, the four communities of Kok Lak have complex roots in different ancestral areas inside the park (Ironside & Baird, 2003) and there is a need to answer questions

of which villages identify with which areas, and how they can divide up responsibilities for the CPA they have been assigned as "one management unit".

Our study has also found that companies, businesses and others are very adroit at dividing communities and playing off some members against others. Despite efforts by local communities to coordinate and defend their collective interests, the BVB company has so far been able to enclose and exclude families from both sides of Phnom Youl, namely the Yeak Laom and Pachon communities. This is a typical case of powerful outside forces managing to break down intra- and inter-community solidarity and managing to impede the development of a firm community position, which could allow them to negotiate more favourable outcomes (see Sawyers & Gomez, 2012). The losers are both the ICCAs and their communities.

The overall situation in Cambodia thus well fits a pattern that appears rather bleak for ICCAs and their caretaker communities all over the world. Our brief survey, however, also points to some reasons for hope and paths for action, and it is on these that we chose to focus. For instance, as seen from the case of the *prey thom* areas and the CPAs within Phnom Kulen National Park (and also the case of the O Tung CPA within Virachey National Park), there are opportunities to strengthen conservation in protected areas while allowing communities to gain their livelihoods through some form of governance rights to enough land of the appropriate types (for upland shifting cultivation and for lowland paddy rice cultivation, forest for wild products, hill areas protected for the village's spirits, etc.). As a matter of fact, the existing Cambodian legislation for forests, protected areas and fisheries explicitly calls for the active participation of indigenous peoples and local communities in conservation, and states that traditional rights need to be respected. There is, however, still a clear need to develop mechanisms to respond in practical ways to the existing legislation and to the obligations under the Convention on Biological Diversity (CBD), which Cambodia has ratified. Such mechanisms and a time of "learning by doing" in applying them, would both encourage respect of the legislation and demonstrate its benefits.

Recommendations for legal recognition and support to ICCAs in Cambodia

From the meetings and discussions held during our rapid ICCA survey, it seems that the engagement of indigenous peoples and local communities in conservation can be most effectively developed through security of collective land and resource tenure combined with respect for the existing customary institutions and, as necessary, some tailored forms of support, responding to the specificities of the context. This is consistent with the CBD technical study on recognition and support to ICCA, recently developed and launched at CBD COP 11 (Kothari *et al.*, 2012) and prior analyses (Borrini-Feyerabend *et al.*, 2010). Ongoing discussion is required to define how best to achieve this. To contribute to this discussion we offer the following recommended road map, which we hope could promote further reflection and action.

1. Conduct consultations with concerned communities about how best to secure and protect their ICCAs. These discussions could be then relayed to relevant government agencies in national level policy workshops focusing on recognising ICCAs as areas that provide crucial conservation and livelihood benefits. Lessons learned so far show that communities should be able to acquire security of tenure over their ICCAs without upsetting existing and customary institutions or regulations which have generally stood the test of time and can still contribute to present and future conservation and sustainable livelihoods strategies.
2. Identify the ICCAs that still exist in Cambodia. We recommend extreme care in this and in making sure that local community representatives, civil society organisations and networks, and supporting NGOs, possibly in association with international bodies such as the ICCA Consortium, discuss how to develop a national inventory of ICCAs in Cambodia. In Cambodia this step may even be best taken after Step 3 below.
3. Detailed analysis of existing policy and legal mechanisms that could be used to recognise and secure ICCAs and/or the development of proposals to modify existing legislation. Some existing options include:

- *Recognition of ICCAs within protected areas*. Protected area zoning could be revised to fully include ICCAs in CPAs and/or Community Zones. As part of this process, ICCA territories and resources should be kept under collective tenure and not subdivided or mismatched among communities. In cases where a protected area recognises ICCAs within it, an overall shared governance regime should be developed which involves ICCAs being represented in

the bodies governing the overall protected area (see the discussion by Stevens, in prep.).

- *ICCAs in areas administered by the Forestry Administration and Fisheries Administration*. Official recognition could involve both administrations, in collaboration with provincial and commune authorities, providing an extra layer of legal protection and security to the customary rules that community institutions would continue to enforce. This should be carried out following a request from, and in close consultation with, the concerned communities. Again, these areas should be recognised under collective tenure and not subdivided. The management plan for the ICCA would remain under the control of the community institution, with technical support from the Forestry Administration or Fisheries Administration as requested.
- *ICCAs in other areas*: Communities associated with an ICCA could also request their provincial or municipal governments to declare their ICCAs as a 'provincial/ municipal protected area or forest' and request governance/ management rights through long-term agreements.

4. In cases where the identification of ICCAs is not clear and/or there is a dispute over the land and natural resources between communities and private landowners or concession holders, a land dispute resolution process could be developed to allow communities to argue and substantiate their customary collective stewardship rights .
5. The concepts of 'Community Patrimony Forest' (CPF), 'Community Patrimony Land' (CPL) or 'Community Patrimony Water Body' (CPWB) could be explored further to understand how current legislation for CPAs, community forests and community fisheries could be amended to accommodate communities who wish to maintain governance and protection over areas they have long been associated with. A process for the competent government agency handing over authority to the concerned community (or communities) could involve a modified process of the existing CPA or Community Forestry and Fisheries regulations and involve a number of steps, such as:

- The community maps and demarcates its "collective patrimony" (spirit forest, sacred lake, sacred spring, etc.). The community clarifies and compiles and, if necessary, strengthens its regulations concerning the governance and management of the patrimony (CPF, CPL or CPWB), in particular with regard to protection of the area and wildlife. The map, rules and regulations and other eventual evidence demonstrating the community's long term association with the area and conservation results (e.g., presence of burial sites, cultural features, evidence of ceremonial practices, existence of names and stories related to the sites, presence there of wild species not found in surrounding areas, clear borders for the area, confirmed by community residents and neighbouring communities, etc.) are then submitted to the concerned ministries (Ministry of Agriculture, Forestry and Fisheries, Ministry of Environment, etc.) via an organisation willing and accustomed to provide liaison and technical support.
- An agreement is developed outlining the community's responsibilities to maintain the traditional governance institution and management system, e.g. regulations concerning tree-cutting and the commercial use of natural resources. As part of the negotiation process the community may be asked to accept some restriction on use or banning of specific practices, to strengthen the conservation of the area. The final agreement could entail the relevant ministries formally assigning to the community the right to govern/ manage its CPF, CPL or CPWB under a contract of, say, 30 years, automatically renewed if the community demonstrates its capacity to conserve the patrimony at stake (indicators would be specified as part of the agreement).

  The 'Patrimony Agreements' should be less directive, more flexible and more open than the community forestry agreements specified by the 2003 Sub-decree on Community Forestry Management. The concerned community would be responsible for organising governance structures and their own management plan. The government authorities would provide technical support upon request and carry out periodic monitoring and evaluation in collaboration with the communities. In other words, sensible latitude should be left to the indigenous and local communities to continue relating to their patrimony areas in their own customary ways. Only the agreed end goals of the Patrimony Agreement would be spelled out through specific indicators and these would be used to determine whether the agreement would be renewed or not.

6. In light of the above, we recommend that national agencies, NGOs and other supporting organisations collaborate to establish a set of parallel 'pilot initiatives' to implement different options for the

formal recognition of ICCAs in Cambodia. These experimental initiatives would provide concerned communities with a form of communal tenure to their ICCAs, with an emphasis on learning from the experience. As part of these pilot initiatives, some forms of technical support could be provided, upon request by the communities. Support could include legal advice, support in negotiations, support for networking and coordination among communities, impact studies or even assistance to establish agreements with private companies who have acquired concession rights over ICCAs, support to organise surveillance and security for the ICCA, etc. These pilot initiatives would constitute crucial 'learning sites' for future policy decisions for the country, helping to identify the pros and cons of different legal/policy choices, and would bring to light any eventual need for accompanying support.

7. Finally these pilot initiatives and discussions about recognition and support to ICCAs could be facilitated under a national learning network. For monitoring and evaluation of different options for recognition and support, ecological and socio-cultural indicators could be developed. Through such a learning network lessons could be drawn to feed the development of improved policy, legislation and practice in the country.

Conclusions

As shown by the cases briefly described above, the situation of ICCAs in Cambodia is various, complex and under pressure. One may be tempted to focus on the unique characteristics of each case and recommend tailored forms of recognition and support. This is unlikely to work, however, for obvious reasons of economic efficiency and political expediency. In addition, experience accumulated all over the world points at a number of desirable characteristics for officially recognised ICCAs. These characteristics, confirmed by both the above mini-case studies and the abundant literature available on common property resources, are listed in Box 1.

Box 1. Desirable characteristics of an officially recognised ICCA (adapted from Borrini-Feyerabend *et al.*, 2010)

- An ICCA should be a territorial unit, governed and managed as a unit by a well-defined community. This does not exclude multiple or complex territorial units, or territorial units whose borders may shift seasonally or under climatic conditions—all these cases are worth exploring.
- The concerned community should be—as far as possible—naturally constituted and relatively small (e.g. a village rather than a "rural commune" or municipality"). This does not exclude joint governance by two or several communities.
- The ICCA should be governed by the concerned community under a form of communal tenure. Common property by the concerned community is best, but government property under community long-term access and use agreement can also be explored.
- The ICCA regime should be such that the land and resources cannot be sold, in totality or in part, nor otherwise subdivided and appropriated for private benefits.
- The ICCA should be maintained under the governance of the traditional institutions that established it and ruled over it under customary law, supported—as necessary—by others of their choice (e.g. literate local youth to interact with government authorities in written form; technical staff with specific competences).
- The ICCA should not be externally regulated or evaluated in terms of process and structures (e.g. rules to set up a management committee, management plans), but in terms of outputs and impacts for both conservation and livelihoods for the concerned communities.
- As necessary, the ICCA could be jointly monitored and evaluated by the concerned communities and government administrations, with a view to problem-solving and constructive support.

From the above-mentioned pilot initiatives and national learning network, we believe, it will be possible to develop well-grounded advice and policy recommendations for the Cambodian government, well suited for the Cambodian context. As mentioned, this would allow for the implementation of existing legislation and respond to the directives of the CBD Programme of Work on Protected Areas, the CBD Biodiversity Targets for 2020 and obligations under the UN Declaration on the Rights of Indigenous Peoples, of which Cambodia is a signatory country.

Concrete avenues and mechanisms for ICCA recognition and support need to be tested, assessed, adopted and implemented to secure Cambodia's bio-cultural jewels. This is a challenge we hope the government will take upon itself, with or without

the help of conservation and development partners. Indeed, this is policy and action whose time has come!

Acknowledgements

Our warmest thanks to the villagers and protected area staff who welcomed us in the three Cambodian provinces visited. With them, the authors would sincerely like to acknowledge the great help and advice of the people who made this study possible, in particular Mr Ken Serey Rotha of the Ministry of Environment, Mr Ken Serey Rona of the CBNRM Learning Institute, Ms Hou Kalyan of RECOFTC and Mr Van Son in Ratanakiri Province. Warm thanks also to Ashish Kothari, who read and commented on an earlier version of this paper. Dr Borrini-Feyerabend received partial travel and accommodation support during her visit from the IUCN Commission on Environmental, Economic and Social Policy (CEESP). The map was prepared by Jeremy Ironside and all of the photos are by Grazia Borrini-Feyerabend.

References

Backstrom, M., Ironside, J., Paterson, G., Padwe, J. & Baird I.G. (2006) *Case Study of Indigenous Traditional Legal Systems in Ratanakiri and Mondulkiri Provinces*. UNDP/Ministry of Justice, Phnom Penh, Cambodia.

Baird, I.G. (2013) Shifting contexts and performances: the Brao-Kavet and their sacred mountains in Northeast Cambodia. *Asian Highlands Perspectives*, **28,** 1-23.

Bonnefoy, Y. (1991) *Asian Mythologies*. University of Chicago Press, Chicago, USA.

Borrini-Feyerabend, G., Lassen, B., Stevens, S., Martin, G., Riascos de la Peña, J.C., Ráez-Luna, E.F. & Fa, M.T. (2010) *Bio-cultural Diversity Conserved by Indigenous Peoples & Local Communities: Examples & Analysis*. IUCN Commission on Environmental, Economic and Social Policy (CEESP) and the Centre for Sustainable Development (CENESTA), Tehran, Iran. [Reprinted 2012].

Borrini-Feyerabend, G., Dudley, N., Jaeger, T., Lassen, B., Pathak Broome, N., Phillips, A. & Sandwith, T. (2013) *Governance of Protected Areas: From Understanding to Action*. IUCN Best Practice Protected Area Guidelines Series No. 20, Gland, Switzerland.

Bourdier, F. (1995) *Knowledge and Practices of Traditional Management of Nature in a Remote Province: Report of a Research Mission on the Theme of Environment in Cambodia, Under the Sponsorship of AUPEL/UREF (October 1994 - July 1995)*. East West Center, Honolulu, Hawaii, USA. (*Unofficial English translation by Dr Carol Mortland*).

Bottomley, R. (2000) *Structural Analysis of Deforestation in Cambodia (With a Focus on Ratanakiri Province, North-east Cambodia)*. Non-Timber Forest Products Project for Mekong Watch and Institute for Global Environmental Strategies of Japan, Ban Lung, Ratanakiri, Cambodia.

Brown, G., Ironside, J., Poffenberger, M. & Stephens, A. (2006) *Formalizing Community Forestry in Ratanakiri Province, Cambodia: Linking Indigenous Resource Systems to Government Policies and Programs*. Community Forestry International, Phnom Penh, Cambodia.

CBD—Convention on Biological Diversity (2004) Programme of Work on Protected Areas: CBD Decision VII.28. *Proceedings of the Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, 9–20 February 2004, Kuala Lumpur, Malaysia*.

CBD—Convention on Biological Diversity (2010) Decision X/31 on protected areas. *Proceedings of the Seventh Meeting of the Conference of the Parties to the Convention on Biological Diversity, 18–29 October 2010, Nagoya, Japan*.

CHRAC—Cambodian Human Rights Action Committee (2009) *Losing Ground: Forced Evictions and Intimidation in Cambodia*. Cambodian Human Rights Action Committee, Phnom Penh, Cambodia.

Colm, S., Srey M. & Hou K. (2000) *Cultural Resources Study: Impacts of the Hero Taiwan Company Concession on Sites of Religious and Cultural Significance in O Chum District, Ratanakiri*. Report to Ratanakiri Provincial Rural Development Department, Ratanakiri Provincial Environment Department, Ratanakiri Provincial Culture Department, CIDSE, UNDP-CARERE, NTFP, ADHOC and Virachey National Park, Ban Lung, Cambodia.

Fairhead, J., Leach, M. & Scoones, I. (2012) Green grabbing: a new appropriation of nature? *The Journal of Peasant Studies*, **39,** 237–261.

Fox, J., McMahon, D., Poffenberger, M. & Vogler, J. (2008) *Land for My Grandchildren: Land Use and Tenure Change in Ratanakiri, 1989–2006*. Community Forestry International, Phnom Penh, Cambodia, and the East West Center, Honolulu, Hawaii, USA.

Hansen, M.C., Potapov, P.V., Moore, R., Hancher, M., Turubanova, S.A., Tyukavina, A., Thau, D., Stehman, S.V., Goetz, S.J., Loveland, T.R., Kommareddy, A., Egorov, A., Chini, L., Justice, C.O. & Townshend, J.R.G. (2013) High-resolution global maps of 21st-Century forest cover change. *Science*, **342,** 850–853.

Hirsch, P. (2000) Underlying causes of deforestation in the Mekong Region. *Paper presented to the IGES-NUOL Workshop on Forest Conservation, 2–3 August 2000, National University of Laos, Vientiane, Lao PDR*.

Ironside, J. (2013) *Thinking outside the fence: exploring culture/land relationships, a case study of Ratanakiri Province, Cambodia*. PhD thesis: University of Otago, Dunedin, New Zealand.

Ironside, J. & Ken Serey R. (2005) *An Overview of the Status of Indigenous People and Protected Areas in Cambodia*. Forest Peoples Programme, Asia Indigenous Peoples Pact (AIPP), Chiang Mai, Thailand.

Ironside, J. & Baird, I.G. (2003) *Wilderness or Cultural Landscape: Settlement, Agriculture, and Land and Resource Tenure in Virachey National Park, Northeast Cambodia*. Biodiversity and Protected Areas Management Project, Ministry of Environment, Ban Lung, Ratanakiri, Cambodia.

IUCN—International Union for the Conservation of Nature (2012) Resolution no. 94 on respecting, recognizing and supporting Indigenous Peoples' and Community Conserved Territories and Areas. *Proceedings of the IUCN World Conservation Congress, 6–15 September 2012, Jeju, Republic of Korea*.

IUCN/CEESP—Commission on Environmental, Economic and Social Policy (2008) *Recognising and Supporting Indigenous & Community Conservation: Ideas & Experiences From the Grassroots*. Briefing note no. 9, . Http://cmsdata.iucn.org/downloads/ceesp_briefing_note_9_iccas.pdf

IUCN/WCPA—World Commission on Protected Areas (2006) Community Conserved Areas. *Parks*, **16,** 1–79.

Kothari, A., Corrigan, C., Jonas, H., Neumann, A. & Shrumm, H. (eds.) (2012) *Recognising and Supporting Territories and Areas Conserved by Indigenous Peoples And Local Communities: Global Overview and National Case Studies.* CBD Technical Series no. 64, Secretariat of the Convention on Biological Diversity, Montreal, Canada.

Leuprecht, P. (2004) *Land Concessions for Economic Purposes in Cambodia: A Human Rights Perspective*. United Nations Cambodia Office of the High Commissioner for Human Rights, Phnom Penh, Cambodia.

MacInnes, M. (2007) *Bunong use of anthropogenic fire as a natural resource management tool in Mondulkiri province, Northeast Cambodia*. MSc thesis, University of East Anglia, Norwich, UK.

Maffi, L. (ed.) (2012) *Biocultural Diversity Conservation: A Global Sourcebook*. Earthscan, London, UK.

Milne, S. (2013) Under the leopard's skin: land commodification and the dilemmas of indigenous communal title in upland Cambodia. *Asia Pacific Viewpoint*, **54,** 323–339.

Murphree, M. (1997) Synergizing conservation incentives: sociological and anthropological dimension of sustainable use. *Paper presented to the Scientific and Technical Advisory Panel (STAP) Expert Workshop on the Sustainable Use of Biodiversity, 24-26 November 1997, Kuala Lumpur, Malaysia.*

NGO Forum on Cambodia (2006) *Land Alienation in Indigenous Minority Communities: Ratanakiri Province.* NGO Forun on Cambodia, Phnom Penh, Cambodia.

Ostrom, E. (1990) *Governing the Commons: The Evolution of Institutions for Collective Action.* Cambridge University Press, Cambridge, UK.

RGC—Royal Government of Cambodia (2003) *Sub-decree #79 on Community Forestry Management.* Royal Government of Cambodia, Phnom Penh, Cambodia.

RGC—Royal Government of Cambodia (2008) *Protected Area Law*. Royal Government of Cambodia, Phnom Penh, Cambodia.

Sawyer, S. & Gomez, E.T. (2012) *The Politics of Resource Extraction*. United Nations Research Institute for Social Development (UNRISD), Geneva, Switzerland.

Sibaud, P. (2012) *Opening Pandora's Box*. Gaia Foundation, London, UK.

Stevens, S. Appropriate recognition and respect for Indigenous Peoples' and Community Conserved Territories and Areas which overlap protected areas: policy brief. *In prep.*

Sun Q. (2007) *Rebuilding common property management: a case study of community-based natural resource management in rural Guizhou, China*. PhD thesis, Wageningen University, Netherlands.

Worell, S. (2013) Can't see the forest… *Phnom Penh Post, 12 December 2013*. Http://www.phnompenhpost.com/national/can%E2%80%99t-see-forest-%E2%80%A6

Zsomsbor, P. (2013) Loss of forest in Cambodia among worst in the world. *The Cambodia Daily 19 November 2013*. Http://www.cambodiadaily.com/news/loss-of-forest-in-cambodia-among-worst-in-the-world-47259/

About the Authors

GRAZIA BORRINI-FEYERABEND has been associated with the International Union for the Conservation of Nature (IUCN) for 20 years. Among her various capacities with IUCN she has been Head of its Social Policy Programme, Vice-chair of its Commission on Environmental, Economic and Social Policy (CEESP) and Vice-chair of the World Commission on Protected Areas (WCPA). She is currently Global Coordinator of the ICCA Consortium, President of the Paul K. Feyerabend Foundation, and member of governing and advisory bodies dealing with natural resources in various countries. Dr Borrini-Feyerabend has worked in 60 countries; authored, co-authored or edited more than 20 volumes of "collective thinking" and organised many more international gatherings that fostered innovative and progressive steps in the policy and practice of conservation.

JEREMY IRONSIDE has lived and worked on and off in Cambodia since 1994, advising and consulting on community livelihoods, sustainable agriculture, community resource management, and land and tenure issues for indigenous communities in Ratanakiri Province and in the Cardamom Mountains area. His PhD studies explored communal land ownership in Ratanakiri Province, Cambodia. Dr Ironside presently works as a consultant for the McKnight Foundation, which supports indigenous and local communities in Cambodia, Laos and Vietnam, to secure and protect their land and natural resources. He has been a Honorary member of the ICCA Consortium since its inception.

Recent Master's Theses

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

Human influences on the dynamics of wild edible plants in the Samras Sub-group, Kam Village, Ratanakiri Province, Cambodia

CHHUON Socheata

មូលន័យសង្ខេប

បន្លែព្រៃជាសមាសភាគសំខាន់នៃរបបអាហារប្រចាំថ្ងៃក៏ដូចជាឱសថសម្រាប់ប្រជាជនកម្ពុជា។ ប៉ុន្តែ ចំណេះដឹងពីប្រភេទបន្លែព្រៃទាំងនោះនៅតិចតួចនៅឡើយ និងនិរន្តរភាពរយៈពេលវែងនៃបន្លែព្រៃទាំងនោះកំពុងរងការគម្រាមកំហែងពីសកម្មភាពមនុស្ស។ ការស្រាវជ្រាវនេះមានគោលបំណងស្វែងយល់ពីឥទ្ធិពលរបស់សកម្មភាពមនុស្សទៅលើបន្លែព្រៃ ដែលប្រជាជនគ្រឹងនៅភូមិកាំ ខេត្តរតនគិរី អាស្រ័យលើ។ ដំណើរសិក្សាពីរលើកត្រូវបានដំណើរការ គឺនៅរដូវប្រាំងមួយលើក និងរដូវវស្សាមួយលើក ដោយប្រើប្រាស់វិធីសាស្ត្រសម្ភាសន៍ប្រជាជន ការដើរសង្កេតព្រៃដោយផ្ទាល់ និងការប្រមូលសំណាករុក្ខជាតិ។ ការកើតមាននិងបរិបទសង្គមនៃឥទ្ធិពលមនុស្សលើរុក្ខជាតិអាហារព្រៃត្រូវបានសិក្សា។ ប្រជាជន២១គ្រួសារត្រូវបានសម្ភាសន៍ ហើយការសង្កេតផ្ទាល់ត្រូវបានដំណើរការដោយការដើរសង្កេតព្រៃ។ កត្តាធំៗបីបានត្រូវរកឃើញថាមានឥទ្ធិពលទៅលើរុក្ខជាតិបន្លែព្រៃ។ ទីមួយ តំហាយគុណភាពដីដោយសារសម្បទានដីសេដ្ឋកិច្ច (ដែលទាក់ទងជាសំខាន់នឹងការកែប្រែដីជាចំការកៅស៊ូ) និងការកើនឡើងនៃការដាំដំណាំកសិកម្មវិលជុំគ្មាននិរន្តរភាព ដែលធ្វើឲ្យបាត់បង់កន្លែងសម្រាប់រុក្ខជាតិបន្លែព្រៃ។ ទីពីរគឺការកើនឡើងនៃចំនួនប្រជាជនក្នុងតំបន់ រួមជាមួយនឹងលទ្ធភាពកំណត់ក្នុងការប្រមូលផលបន្លែព្រៃដែលពីមុនមកធ្លាប់តែអាចរកទទួលទានបាន និងការបាត់បង់នូវការប្រមូលផលតាមទម្លាប់របស់ប្រជាជនក្នុងភូមិ ដែលនាំអោយមានការប្រមូលផលហួសកំរិត។ ទីបី គឺសមត្ថភាពទន់ខ្សោយរបស់សហគមន៍ជនជាតិភាគតិចក្រឹងក្នុងការគ្រប់គ្រងធនធាន ដោយសារកង្វះការចូលរួមពីអ្នកភូមិខ្លួនឯងផ្ទាល់ និងការខ្វះខាតចំណេះដឹងលើសិទ្ធិកម្មសិទ្ធិដីធ្លីរបស់គាត់។ ការផ្តល់ដីសម្បទានសេដ្ឋកិច្ច ការប្រមូលផលហួសកំរិត និងការដាំដំណាំវិលជុំគ្មាននិរន្តរភាពមានឥទ្ធិពលលើការប្រែប្រួលនៃរុក្ខជាតិអាហារព្រៃនៅតំបន់សិក្សានេះ។ ជាអនុសាសន៍ គួរលើកកម្ពស់និងពង្រឹងការអនុវត្តការវាយតម្លៃផលប៉ះពាល់បរិស្ថាន គួរកសាងសមត្ថភាពគ្រប់គ្រងធនធានធម្មជាតិនៅកំរិតមូលដ្ឋាន និងលើកទឹកចិត្តអ្នកភូមិឲ្យចូលរួមក្នុងការគ្រប់គ្រង និងធ្វើការស្រាវជ្រាវបន្តលើរុក្ខជាតិអាហារព្រៃនិងអនុផលព្រៃឈើផ្សេងទៀត។

Abstract

Wild vegetables are an important component of the diets of many Cambodians as well as being used medicinally. However, very little knowledge exists about these wild species and whether their long term sustainability is threatened by human activities. This research aimed to determine the human influence on the dynamics of the wild plants that are depended upon by the Kreung indigenous people of Kam Village in Ratanakiri Province.

CITATION: Chhuon S. (2013) Human influences on the dynamics of wild edible plants in the Samras Sub-group, Kam Village, Ratanakiri Province, Cambodia. *Cambodian Journal of Natural History*, **2013,** 109–110.

Two field trips were conducted during the dry and rainy seasons, and data on wild vegetables were obtained using semi-structured interviews, forest walks and botanical specimen collection. The incidence and social context of human influence on wild food plants was studied with an ethnobotanical survey. Twenty-one households were interviewed and direct observations were undertaken by conducting forest walks.

Three main factors were found to affect the dynamics of wild edible plants. First, land degradation resulting from Economic Land Concessions—mainly relating to the conversion of land to rubber plantations—and increasingly unsustainable shifting agricultural practices are causing the loss of the wild food plants' habitat. Second, human population growth in this region, coupled with restricted access to wild food plants in previously available foraging areas and a breakdown of the traditional harvesting practices of villagers, has led to over-harvesting. Third, the weakness in the ability of the Kreung indigenous community to manage resources due to a lack of participation from the villagers themselves and their lack of knowledge of their land ownership rights.

Economic Land Concessions, overharvesting, and unsustainable shifting cultivation significantly influence the dynamics of wild food plants in the study site. I recommend enhancing and strengthening Environmental Impact Assessment practices, building natural resource management capacity at the local level, encouraging villagers to participate in management, and conducting further research on wild edible plants and other non-timber forest products.

Major economic activities from the consumption of fuel-wood sourced from Chumriey Mountain, Kampong Chhnang Province

HONG Lina

មូលន័យសង្ខេប

ការសិក្សានេះស្វែងយល់ពីការប្រើឈើជាអុសដុតដោយក្រុមអ្នកប្រើប្រាស់ខុសៗគ្នា ដែលរួមមានអ្នកផលិតស្ករត្នោត អ្នកផលិតធ្យូង អ្នករកអុស និងអ្នកកាប់កូនឈើធ្វើបង្គោល។ សក្តានុពលសេដ្ឋកិច្ចនិងចំណូលចិត្តប្រើប្រភេទឈើត្រូវបានសិក្សាស្រាវជ្រាវ ដែលជាកត្តាអាចរួមចំណែកលើកស្ទួយជីវភាពរស់នៅរបស់ប្រជាជនក្នុងឃុំត្បែងខ្ពស់ ឃុំក្រាំងល្វា និងឃុំពាម នៅក្នុងស្រុកសាមគ្គីមានជ័យ ខេត្តកំពង់ឆ្នាំង។ ការសម្ភាសន៍ជាប្រព័ន្ធ ដែលរួមមានការសួរសំណួរស្ទង់មតិនិងវិធីវាយតម្លៃភ្លាមៗដោយមានការចូលរួម ដែលរួមមានការធ្វើដែនទីធនធានសង្គម ត្រូវបានប្រើប្រាស់ ដើម្បីទទួលបានទិន្នន័យ។ ក្រុមគ្រួសារដែលបានចូលរួមក្នុងការសិក្សានេះភាគច្រើនរស់នៅដោយអាស្រ័យលើការកាប់កូនឈើនិងអុសសម្រាប់ផលិតស្ករត្នោត ធ្វើធ្យូង និងសម្រាប់លក់។ ក្រុមគ្រួសារដែលទទួលបានចំណូលប្រចាំខែពីការផលិតស្ករត្នោត គឺអាស្រ័យលើចំនួនដើមត្នោត ចំនួនកញ្ចុំផ្កាត្នោត និងតំលៃស្ករត្នោតនៅទីផ្សារ។ ប្រាក់ចំណូលបានពីការដុតធ្យូងប្រែប្រួលជាសំខាន់ទៅតាមទំហំផលិតកម្ម ចំនួនឡធ្យូង និងគុណភាពធ្យូង។ អ្នកកាប់អុសនិងកូនឈើទទួលបានប្រាក់ចំណូលប្រែប្រួលទៅតាមសមត្ថភាពនៃការដឹកជញ្ជូន រួមជាមួយនឹងទំហំ ប្រវែង និងភាពត្រង់នៃបង្គោល។ ក្នុងចំណោមដើមឈើ៥៦ប្រភេទក្នុងតំបន់នេះ ដើមឈើ២៥ប្រភេទត្រូវបានគេចូលចិត្តប្រើ។ ធ្នឹក(*Shorea obtusa*)ជាប្រភេទដើមឈើត្រូវបានប្រើប្រាស់ជាងគេបំផុតបន្ទាប់មកសុក្រម(*Xylia xylocarpa*)កកោះ(*Sindora siamensis*) និងត្បែង(*Dipterocarpus obtusifolius*)។

CITATION: Hong L. (2013) Major economic activities from the consumption of fuel-wood sourced from Chumriey Mountain, Kampong Chhnang Province. *Cambodian Journal of Natural History*, **2013,** 110–111.

ការអភិរក្សប្រភេទឈើធ្វើអុសដុតអាចត្រូវបានធ្វើឲ្យប្រសើរឡើងទាំងការផ្គត់ផ្គង់និងតម្រូវការ។ចំពោះការផ្គត់ផ្គង់ការគ្រប់គ្រងព្រៃឈើអាចត្រូវបានធ្វើឲ្យប្រសើរឡើង តាមរយៈការភិរក្សព្រៃឈើ ដោយការផ្លាស់ប្តូររបៀបប្រមូលផលព្រៃឈើ ដើម្បីកាត់បន្ថយការបំផ្លាញ (ការកាប់ឆ្ការជ្រើសរើស) ដោយការអភិវឌ្ឍនិងការទ្រទ្រង់កម្មវិធីរុក្ខាវប្បកម្មសហគមន៍ និងការបង្កើតអចលនទ្រព្យព្រៃឈើ។ ចំពោះតម្រូវការ ការប្រើប្រាស់ឈើជាអុសដុតអាចត្រូវបានកាត់បន្ថយ ដោយការប្រើប្រព័ន្ធដុតមានប្រសិទ្ធភាពជាង និងការជំរុញការប្រើប្រាស់ថាមពលផ្សេងជំនួសវិញ។

Abstract

This study explored fuel wood consumption by different user groups including palm sugar producers, charcoal producers, fuel wood collectors and pole collectors. Economic potential and species preferences were investigated, as were the enabling factors contributing to the improvement of local livelihoods in Tbeng Khpos, Krang Lvea and Peam communes, Sameakki Mean Chey District, Kampong Chhnang Province, Cambodia.

Data were obtained from structured interviews, involving a questionnaire, and a participatory rapid assessment, comprising social resource mapping. Most of the sampled households depended on trading poles and fuel wood for producing palm sugar, charcoal and for sale. Households with a monthly income from palm sugar production were influenced by the number of sugar palm trees, number of inflorescences and the market price of palm sugar. The revenue generated from charcoal production varied significantly due to production capacity (size of the kilns), number of the kilns and quality of charcoal (iron or soft charcoal). Fuel wood and pole collectors varied in income according to their capacity for transportation and the size, length and straightness of poles. Among 46 tree species in the area, 24 species were preferred by respondents. Ptchoek *Shorea obtusa* was the favourite tree species, followed by sok kram *Xylia xylocarpa*, kor kosh *Sindora siamensis* and tbaeng *Dipterocarpus obtusifolius*.

Conservation of fuel wood species may be improved on both the supply and demand side. On the supply side, forest management can be improved through forest conservation, changing wood collection patterns to reduce destruction (selective cuttings, pruning), development and support of community forestry programmes, and establishing forest estates. On the demand side, fuel wood consumption may be reduced by using more efficient burning systems and promoting energy substitution.

Ecology of flying foxes (*Pteropus* species) and assessment of the risk of emergence of Nipah virus in Battambang and Kandal provinces, Cambodia

HUL Vibol

មូលន័យសង្ខេប

មានការយល់ដឹងតិចតួចណាស់ពីអាកប្បកិរិយាសត្វជ្រៀងនៅកម្ពុជា ដែលជាប្រភេទមានសក្តានុពលក្នុងការចម្លងជំងឺបង្កដោយវីរុស Nipah virus (NiV)។ការសិក្សានេះបានកំណត់រយៈពេលហានិភ័យខ្ពស់នៃការបង្កជំងឺដោយវីរុសនេះ និងបានវាយតំលៃហានិភ័យនៃការកើតមាន NiV នៅក្នុងទីជម្រកសត្វជ្រៀងពីរកន្លែងក្នុងខេត្តកណ្តាល និងខេត្តបាត់ដំបង។ ការសិក្សាក៏បានគិតគូរកំណត់ថាតើ

CITATION: Hul V. (2013) Ecology of flying foxes (*Pteropus* species) and assessment of the risk of emergence of Nipah virus in Battambang and Kandal provinces, Cambodia. *Cambodian Journal of Natural History*, **2013,** 111–112.

មានទំនាក់ទំនងរវាងវដ្តបន្តពូជនិងវីរុស NiV ដែរឬទេ។ ដើម្បីវាយតម្លៃហានិភ័យនៃការបង្កជំងឺដោយវីរុសនេះ ដំណើរសិក្សាជ្រាំបួនលើកត្រូវបានដំណើរការពីខែមីនាដល់ខែកក្កដា ឆ្នាំ២០១៣។ ការជំរឿននិងការសង្កេតអាកប្បកិរិយាជ្រុងត្រូវបានធ្វើ ការវិភាគរកវីរុសក្នុងសំណាកទឹកនោមត្រូវបានដំណើរការ និងការសម្ភាសន៍ពីរោគរាតត្បាត ដែលពាក់ព័ន្ធនឹងការប្រើប្រាស់ទឹកត្នោត វត្តមានជ្រូក និងវត្តមានជ្រុងនៅក្បែរទីជម្រកត្រូវបានធ្វើឡើង។ សំណាកទឹកនោមនិងលាមកជ្រុង សរុបចំនួន១០១០ បានត្រូវប្រមូលនៅពេលព្រឹកព្រលឹម(ជ្រុងត្រឡប់ពីរកអាហារ) និងពេលយប់(មុននិងក្រោយពេលជ្រុងទៅរកអាហារ)។ អ្នកភូមិ១១០នាក់ត្រូវបានសម្ភាសន៍។ ការសង្កេតក្នុងរយៈពេលប្រាំខែបានបង្ហាញថា ចំនួនជ្រុងកើនឡើងនៅខែមេសានិងឧសភា គឺនៅពេលដែលកូនជ្រុងកើនឡើងត្រូវបានកត់ត្រា។ វដ្តជីវិតរបស់ប៉ូពុយឡាស្សុងសត្វជ្រុងត្រូវគ្នាជាមួយនឹងករណីសង្ស័យនៃវីរុសNiVដែលមានកំរិតខ្ពស់នៅខែឧសភា។ មានកត្តាពីរដែលត្រូវបានវាយតម្លៃថាជាហានិភ័យនៃការបង្កជំងឺដោយវីរុស NiV គឺទាក់ទងទៅនឹងវត្តមានសត្វជ្រូកនិងការទទួលទានទឹកត្នោត ដែលជាមូលហេតុនៃការផ្ទុះឡើងនៃ NiVនៅប្រទេសម៉ាឡេស៊ីនៅឆ្នាំ១៩៩៨ និងនៅប្រទេសបង់ក្លាដែស នៅឆ្នាំ២០០១។ តាមរយៈបទសំភាសន៍ មានគ្រួសារជាង២0%ចិញ្ចឹមជ្រូក និងជាង៥0%ទទួលទានទឹកត្នោត។ ប៉ុន្តែការសិក្សាបង្ហាញថាគេមិននិយមទទួលទានទឹកត្នោតស្រស់ទេ ភាគច្រើននិយមទទួលទានទឹកត្នោតជូរគាមទំលាប់ជាងទទួលទានទឹកត្នោតស្រស់។ ប៉ូពុយឡាស្សុងសត្វជ្រូកទាប(តិចជាង១00) បើប្រៀបធៀបជាមួយកន្លែងដែលមានជម្ងឺនេះនៅប្រទេសម៉ាឡេស៊ី។ ជ្រុងចូលចិត្តដើមស្វាយក្នុងចំណោមដើមឈើហូបផ្លែនៅកន្លែងសិក្សាទាំងពីរ។ ជាអនុសាសន៍ ប្រជាជនដែលរស់នៅក្បែរជម្រកជ្រុងគួរចៀសវាងកុំប៉ះពាល់សត្វជ្រុងពីខែមេសាដល់ខែមិថុនា ដែលជាពេលវេលានៃការរាតត្បាតកម្រិតខ្ពស់បំផុត និងគួរចៀសវាងការបង្កជំងឺកូនជ្រុងនិងការពារកូនជ្រុងពីការរំខាន នៅពេលដែលវាងាយរងគ្រោះ។

Abstract

Little is known about the behaviour of flying foxes in Cambodia, which have the potential to transmit diseases such as the Nipah virus (NiV). This study identified the high risk period of infection of this virus, and assessed the risk of NiV emergence in two roosts in Kandal and Battambang provinces. The study also sought to determine whether there is a relationship between flying fox reproductive phenology and NiV prevalence.

To assess the risk of NiV infection, nine field trips were undertaken from March to July, 2013. On each trip, a census and behavioural observations were made on the flying foxes, urine samples were collected, and epidemiology interviews were carried out regarding palm juice consumption, pig presence, and the occurrence of flying foxes around the roost sites. A total of 1,010 urine and faeces samples from flying foxes were collected during the early morning (upon return from foraging) and night (before and after foraging). In total, 110 households were interviewed.

Five months of observations showed the number of flying foxes increased in April and May, when more juveniles were recorded. This phenology of flying fox populations coincided with a high number of suspected NiV cases in May. Two factors that were assessed for the risk of infection of NiV relate to the presence of pigs and human consumption of palm sap juice, which caused NiV outbreaks in Malaysia in 1998 and Bangladesh in 2001. More than 20% of households keep pigs, and more than 50% drink palm sap, but surveys revealed that the juice was not drunk fresh, and in most cases, traditional palm wine was more popular than palm juice. The pig population was low (<100 individuals) in comparison to the outbreak site in Malaysia. Mango trees were the favourite fruit trees of flying foxes in both sites.

It is recommended that people living near roosts avoid contact with flying foxes from April to June, when NiV prevalence is highest, to avoid infection and to protect juveniles from disturbance while they are vulnerable.

Assessment of fishing practices in marine fisheries management areas around Koh Rong and Koh Rong Sanleom, Cambodia

LENG Phalla

មូលន័យសង្ខេប

តំបន់គ្រប់គ្រងនេសាទសមុទ្រ (MFMA) ដែលត្រូវបានស្នើឡើងដំបូងគេនៅកម្ពុជា នឹងត្រូវបានអនុវត្តនៅជុំវិញកោះរុង និងកោះរុងសន្លឹម ខេត្តព្រះសីហនុ។ ដែនទឹកទំហំ៣៤០គម២នឹងត្រូវបានបង្កើតឡើងដើម្បីការពារជីវៈចម្រុះ និងអភិវឌ្ឍអេកូទេសចរណ៍សមុទ្រ និងធានានិរន្តរភាពនៃការនេសាទ។ សហគមន៍នេសាទ (CFis) គ្រប់គ្រង ការពារ និងអភិរក្សធនធានសមុទ្រ ព្រមទាំងលើកកម្ពស់សិទ្ធិប្រើប្រាស់របស់ប្រជាជនថ្នាក់ភូមិ។ភូមិ៣ក្នុងចំណោមភូមិ៥ក្នុងតំបន់MFMAត្រូវបានទទួលស្គាល់ជាសហគមន៍នេសាទ។ ការសិក្សានេះមានគោលបំណងស្វែងយល់ពីរបៀបនេសាទរបស់សហគមន៍ក្នុងតំបន់MFMAដែលត្រូវបានស្នើឡើង កំណត់ចំណុចខ្លាំងនិងចំណុចខ្សោយនៃរមជ្ឈការរបស់សហគមន៍នេសាទ និងធ្វើអនុសាសន៍សម្រាប់ការរីកចំរើនរបស់សហគមន៍នេសាទ។ ប្រជានេសាទត្រូវបានសម្ភាសន៍ជាលក្ខណៈបុគ្គលនិងជាក្រុមពិភាក្សា ហើយការសង្កេតផ្ទាល់ក៏ត្រូវបានធ្វើឡើងផងដែរ។ កន្លងមក ប្រភេទនៃផលនេសាទបានមិនផ្លាស់ប្តូរទេ ប៉ុន្តែទិន្នផលសរុបថយចុះ។ ទោះបីប្រាក់ចំណូលរបស់អ្នកនេសាទថយចុះក្នុងពេលកន្លងមកក៏ដោយ ក៏ការនេសាទនៅតែជាប្រភពចំណូលសំខាន់ជាងការងារផ្សេងទៀតរបស់អ្នកភូមិ។ ទីតាំងនេសាទនិងប្រភេទផលនេសាទគឺអាស្រ័យលើឧបករណ៍ដែលគេប្រើ។ ចំនួនថ្ងៃនេសាទនិងប្រភេទគោលដៅគឺអាស្រ័យលើរដូវ។ សន្ទូចមឹកជាឧបករណ៍នេសាទដែលប្រើប្រាស់ជាទូទៅ ហើយមឹកជាប្រភេទសត្វសមុទ្រ ដែលគេចូលចិត្តនេសាទ។ ជារបាយការណ៍ អ្នកនេសាទមិនដែលបានប្រើប្រាស់ឧបករណ៍នេសាទខុសច្បាប់ និងនេសាទប្រភេទសត្វសមុទ្រដែលកំពុងរងគ្រោះថ្នាក់ទេ។ ប៉ុន្តែការនេសាទខុសច្បាប់នៅតែកើតឡើងនៅក្នុងតំបន់MFMAដែលតាមរបាយការណ៍ច្រើនតែពេលយប់ពីសំណាក់អ្នកនេសាទមកពីប្រទេសវៀតណាមនិងប្រទេសថៃ។ អ្នកនេសាទដែលត្រូវបានសម្ភាសន៍ភាគច្រើនបានយល់ដឹងនិងគាំទ្រសហគមន៍នេសាទ។ អនុសាសន៍របស់ខ្ញុំគឺអ្នកនេសាទនិងអាជ្ញាធរពាក់ពន្ធ័គួរតែធ្វើការជាមួយគ្នា ដើម្បីការពារធនធានសមុទ្រ ជាមួយនឹងការនេសាទប្រកបដោយនិរន្តរភាព និងបង្កើនជីវភាពរបស់អ្នកនេសាទ។ សហគមន៍នេសាទគួរបន្ថែមការល្បាតនៅពេលយប់ដើម្បីឈ្លាំមើលការនេសាទខុសច្បាប់។ គួរធ្វើការអប់រំផ្សព្វផ្សាយអំពីការអភិរក្សសមុទ្រក្នុងចំណោមអ្នកនេសាទទាំងក្នុងនិងក្រៅដែនសហគមន៍នេសាទ ដើម្បីឲ្យពួកគាត់យល់កាន់តែច្បាស់ និងគោរពច្បាប់សហគមន៍នេសាទ។ គួរបង្កើតតំបន់គ្រប់គ្រងនេសាទសមុទ្រឲ្យបានឆាប់តាមដែលអាចធ្វើបាន ដើម្បីពង្រឹងគោលបំណងសរោគមន៍នេសាទ។

Abstract

Cambodia's first proposed Marine Fisheries Management Area will be established around Koh Rong and Koh Rong Sanleom Islands, Preah Sihanouk Province. Encompassing 340 km^2, it will be created to protect biodiversity and develop marine eco-tourism, and ensure the sustainability of fisheries. Community Fisheries manage, protect and conserve marine resources, and enhance the rights of local users at the village level. Three of the five villages in the proposed Marine Fisheries Management Area are recognised as Community Fisheries.

This study aimed to understand community fishing practices within the proposed Marine Fisheries Management Area, identify the strengths and weaknesses of the more decentralised Community Fisheries, and make recommendations for their improvement. Fishermen were interviewed individually and in group discussions and direct observations were also made.

CITATION: Leng P. (2013) Assessment of fishing practices in marine fisheries management areas around Koh Rong and Koh Rong Sanleom, Cambodia. *Cambodian Journal of Natural History*, **2013,** 113–114.

According to the respondents, the species caught have not changed over time, but total harvest has decreased. Although the fishers' income has decreased, fishing remains a better source of income than other jobs for villagers. Fishing location, and the species caught, depended on the fishing gear used. The number of days spent fishing and species targeted were seasonally dependent. Squid hooks were the most commonly used fishing gear, with squid the preferred species. Fishermen reportedly did not fish illegally, nor did they catch endangered species. However, illegal fishing still occurs in the proposed Marine Fisheries Management Area; reportedly mostly at night and by boats from Vietnam and Thailand. Most of the fishers interviewed understand and support Community Fisheries.

I recommend that fishers and relevant authorities work together to protect the marine resources through sustainable fishing practices and to support improved livelihoods for local fishers. Community Fisheries should undertake more night patrols to detect illegal fishing. Awareness of marine conservation should be raised among fishers both in and outside of the Community Fisheries boundaries to ensure they understand and abide by Community Fisheries regulations. I also recommend establishing the Marine Fisheries Management Area as soon as possible to strengthen the aims of the Community Fisheries.

Comparison of the effects of ecotourism between two villages in Ang Trapeang Thmor Sarus Crane Reserve Conservation and Management Area, Northwest Cambodia

NGIN Kamsan

មូលន័យសង្ខេប

ដោយសារលក្ខណៈធម្មជាតិ វប្បធម៌ និងប្រវត្តិសាស្ត្រនៃប្រទេសកម្ពុជា វិស័យទេសចរណ៍ត្រូវបានចាត់ទុកថាជាវិស័យមួយដ៏សំខាន់សំរាប់អភិវឌ្ឍសេដ្ឋកិច្ចជាតិ។ អេកូទេសចរណ៍គឺជាការធ្វើដំណើរទៅកាន់តំបន់ធម្មជាតិដែលអភិរក្សបរិស្ថាន និងធ្វើអោយប្រសើរឡើងនូវសុខុមាលភាពរបស់ប្រជាជនមូលដ្ឋាន។ ផ្ទៃដីទំហំ១២,៥០០ហិចតានៃដែនបម្រុងសត្វក្រៀលអាងត្រពាំងថ្ម(ATTSCR) ក្នុងខេត្តបន្ទាយមានជ័យមានបក្សីចំនួន១៩៨ប្រភេទរស់នៅ ដែលភាគច្រើនជាប្រភេទមានសារៈសំខាន់ចំពោះការអភិរក្សជាសាកល និងតំបន់ និងមានសត្វមាំង(*Cervus eldii*)ដែលជាប្រភេទកំពុងរងគ្រោះថ្នាក់ជាសកល។ នៅរដូវប្រាំង គេអាចឃើញហ្វូងសត្វក្រៀល (*Grus antigone*)ជាច្រើន ដែលមករកចំណីនៅតាមវាលស្រែ និងវាលស្មៅ។ ការសិក្សានេះបានវាយតម្លៃឥទ្ធិពលនៃអេកូទេសចរណ៍លើជីវភាពរស់នៅនិងអាកប្បកិរិយារបស់ប្រជាជន ចំពោះការអភិរក្សដែនបម្រុងសត្វក្រៀលអាងត្រពាំងថ្ម។ ការស្រាវជ្រាវបានត្រូវដំណើរការពីខែកុម្ភៈដល់ខែឧសភា ឆ្នាំ២០១៣ ក្នុងភូមិសំបួរនិងភូមិពង្រ ដែលស្ថិតនៅជិតតំបន់អភិរក្ស។ ភូមិសំបួរជាភូមិកំពុងចូលរួមអភិវឌ្ឍសហគមន៍អេកូទេសចរណ៍តាមរយៈសកម្មភាពបង្កើតប្រាក់ចំណូល ដូចជាការធ្វើជាមគ្គុទេសក៍ទេសចរណ៍ជាដើម ចំណែកភូមិពង្រមិនទាន់ចូលរួមក្នុងគម្រោងអេកូទេសចរណ៍នៅឡើយនាពេលបច្ចុប្បន្ន។ ប្រជាជន២០គ្រួសារដែលមកពីភូមិនីមួយៗត្រូវបានសម្ភាសន៍ និងបែងចែកជាក្រុមពិភាក្សាជា៣ក្រុម។ សំណួរដែលសួរប្រជាជនទាំងពីរភូមិទាក់ទងទៅនឹងស្ថានភាពមុននិងក្រោយពេលបង្កើតគំរោងអេកូទេសចរណ៍។ គ្មានភាពខុសគ្នាសំខាន់ៗពីជីវភាពរស់នៅបានត្រូវរកឃើញរវាងភូមិទាំងពីរដែលត្រូវបានផ្តល់ដោយគំរោងអេកូទេសចរណ៍ទេ។ ទោះយ៉ាងណាក្តី ឥទ្ធិពលអេកូទេសចរណ៍លើអាកប្បកិរិយាប្រជាជននៃភូមិទាំងពីរចំពោះការអភិរក្សមាន

CITATION: Nhin K. (2013) Comparison of the effects of ecotourism between two villages in Ang Trapeang Thmor Sarus Crane Reserve Conservation and Management Area, Northwest Cambodia. *Cambodian Journal of Natural History*, **2013,** 114–115.

ភាពខុសគ្នា។ អ្នកភូមិសំបួរ ដែលបានចូលរួមគម្រោងអេកូទេសចរណ៍ គាំទ្រការអភិរក្សយ៉ាងខ្លាំងក្លា ទោះបីការរកប្រាក់ចំណូលពីការធ្វើមគ្គុទេសក៍ទេសចរណ៍បានតិចតួចក្តី។ ជាលទ្ធផលនៃការអភិវឌ្ឍគំរោងនេះ អ្នកភូមិពង្រាជាច្រើននាក់ឥឡូវនេះពិចារណាមកចូលរួមក្នុងគម្រោងអេកូទេសចរណ៍នេះ។ ជាអនុសាសន៍ ការសិក្សាគួរតែត្រូវធ្វើម្តងទៀតនាពេលអនាគត ដើម្បីរកអោយឃើញថា តើជីវភាពរស់នៅមានការផ្លាស់ប្តូរ ដោយសារឥទ្ធិពលរបស់អេកូទេសចរណ៍ក្នុងរយៈពេលវែងដែរឬទេ។ ការធ្វើអោយប្រសើរឡើង និងការបង្កើនសេវាកម្មអេកូទេសចរណ៍ ដូចជាមគ្គុទេសក៍ទេសចរណ៍ ការចំអិនអាហារ ផ្ទះស្នាក់នៅ និងសេវាកម្មផ្សេងៗទៀតនៅក្នុងភូមិក៏គួរត្រូវបានគិតគូរដែរ។

Abstract

In Cambodia, tourism is considered an important sector for national economic development as the country has significant historical, cultural and natural features. Ecotourism is “responsible travel to natural areas that conserve the environment and improves the well-being of local people”. The 12,500 hectare protected Ang Trapeang Thmor Sarus Crane Reserve Conservation and Management Area in Banteay Meanchey Province supports 198 bird species, many of which are of global or regional conservation importance, and the globally Endangered Eld’s deer *Cervus eldii*. During the dry season, many flocks of sarus crane *Grus antigone* can be seen congregating in rice fields and grasslands, feeding and interacting.

This study evaluated the effects of ecotourism on livelihoods and local attitudes toward conservation in the Sarus Crane Reserve. The research was carried out from February to May 2013 in Sambour and Pongror villages, which are located close to the conservation area. Sambour Village is developing community participation in ecotourism through income generating activities such as guiding visitors, whilst Pongror Village is currently not involved in ecotourism activities. Twenty households from each village were interviewed and three group discussions were held. Questions were asked in both villages relating to the situation before and after the ecotourism project was established. No significant differences were found in livelihoods between the villages that could be attributed to the ecotourism project. However, the effect of ecotourism on attitudes towards conservation between the villages was significant: villagers in Sambour, which had introduced ecotourism, strongly supported conservation and had experienced development, even though little income had been generated from guiding visitors. As a result of this development, many Pongror villagers are now considering becoming involved in ecotourism.

It is recommended that this study be repeated in the future to see whether livelihoods change significantly due to the effects of ecotourism projects over a longer period. Improving and increasing ecotourism services, including guiding, cooking, home stay and other services, in local villages is also recommended.

A systematic review of the fruit bat fauna (Pteropodidae) of Cambodia

POEUV Narith

មូលន័យសង្ខេប

ក្នុងចំណោមប្រចៀវ១២៥៩ប្រភេទដែលត្រូវបានស្គាល់នៅលើពិភពលោក មានប្រចៀវ១៨៦ប្រភេទជាប្រភេទប្រចៀវក្នុងអំបូរជ្រឹង (Pteropodidae)។ នៅប្រទេសកម្ពុជា ប្រចៀវចំនួន១១ប្រភេទក្នុងចំណោមប្រចៀវទាំងអស់៦៦ប្រភេទ ត្រូវបានកត់ត្រានៅក្នុងអំបូរជ្រឹង។ ទោះបីការសិក្សាពីប្រចៀវមានការកើនឡើងនៅប្រទេសកម្ពុជា ក្នុងឆ្នាំកន្លងទៅថ្មីៗនេះក៏ដោយ ក៏ការសិក្សាពីប្រព័ន្ធចំណែកថ្នាក់ប្រចៀវក្នុងអំបូរជ្រឹងនៅតិចតួចនៅឡើយ។ ការសិក្សានេះមានវត្ថុបំណងបី គឺ(១)សិក្សាឡើងវិញនិងបញ្ជាក់ពីប្រភេទប្រចៀវទាំងអស់ក្នុងអំបូរជ្រឹងនៅក្នុងប្រទេសកម្ពុជា និងកំណត់លក្ខណៈសម្គាល់សម្រាប់ប្រភេទនីមួយៗ (២)បង្កើតការពិពណ៌នាលម្អិតនៃប្រភេទ និងគន្លឹះកំណត់ប្រភេទ និង(៣)កំណត់លក្ខណៈរូបសាស្ត្រខុសគ្នារវាងភេទនៃប្រចៀវក្នុងអំបូរជ្រឹងនៅប្រទេសកម្ពុជា ដែលត្រូវបានជ្រើសរើសមកសិក្សា។ ក្នុងការសិក្សានេះ សំណាកប្រចៀវចំនួន៥៧ (រួមទាំងឆ្អឹងលលាដ៍ក្បាលផង) ត្រូវបានសិក្សាឡើងវិញនិងធ្វើការវាស់វែង។ លក្ខណៈសម្គាល់ប្រភេទត្រូវបានកំណត់ និងលក្ខណៈរូបសាស្ត្រខុសគ្នារវាងភេទនិងប្រភេទស្រដៀងគ្នាខ្លាំងត្រូវបានវិភាគ។ ការពិពណ៌នាប្រភេទថ្មីនិងគន្លឹះកំណត់ប្រភេទប្រចៀវក្នុងអំបូរជ្រឹងត្រូវបានបង្កើតឡើង។ ការវិភាគលក្ខណៈរូបសាស្ត្រខុសគ្នារវាងភេទបង្ហាញថា ប្រភេទ*C. brachyotis* មានលក្ខណៈខុសគ្នារវាងភេទពីប្រវែងឆ្អឹងស្មងជើង(TIB) ប្រភេទ*C. horsfieldii* មានលក្ខណៈខុសគ្នារវាងភេទពីទំហំថ្គាមលើទីបី(M^3W)ប្រភេទ*C. sphinx* មានលក្ខណៈខុសគ្នារវាងភេទពីឆ្អឹងថ្នាំងដៃទីមួយនៃម្រាមទីប្រាំ (1P5D)។ប្រភេទ*Eonycteris spelaea* មានលក្ខណៈខុសគ្នារវាងភេទពីឆ្អឹងថ្នាំងដៃទីពីរនៃម្រាមទីបី ទីបួននិងទីប្រាំ ប្រវែងជួរធ្មេញលើទំហំឆ្អឹងក្រអូបមាត់ខាងមុខ ទំហំច្របូញមាត់ និងទំហំបាតចង្កូម (2P3D, 2P4D, 2P5D, ZW, IOW, CM3, M3M3និង C1BW)។ ចំពោះប្រភេទ*C. brachyotis*និងប្រភេទ*E. spelaea*ឈ្មោលធំជាងញីចំណែកប្រភេទ*C. horsfieldii*និងប្រភេទ*C. sphinx*ឈ្មោលតូចជាងញី។សម្រាប់ប្រភេទមានលក្ខណៈរូបរាងខាងក្រៅស្រដៀងគ្នានៃប្រភេទ*C. brachyotis*, *C. horsfieldii* និង *C. sphinx* ការវិភាគជាគូបង្ហាញថាមានភាពខុសគ្នាអន្តរយថាប្រភេទខ្លាំងស្ទើរគ្រប់លក្ខណៈ។ រវាងប្រភេទ*C. brachyotis* និង*C. horsfieldii* ខុសគ្នា២១លក្ខណៈ ប្រភេទ*C. brachyotis*និង*C. sphinx* ខុសគ្នា១៦លក្ខណៈនិងរវាងប្រភេទ*C. horsfieldii*និង*C. sphinx*ខុសគ្នា៣លក្ខណៈ។ នេះជាការសិក្សាប្រព័ន្ធចំណែកថ្នាក់ដំបូង ដែលពិពណ៌នាលម្អិតពីប្រភេទ និងបង្កើតគន្លឹះកំណត់ប្រភេទ សម្រាប់ប្រចៀវក្នុងអំបូរជ្រឹងនៅកម្ពុជា។

Abstract

Of the 1,259 bat species recognized worldwide, 186 are pteropodid bats. In Cambodia, 11 of the 66 recorded bat species belong to the family Pteropodidae. Although there has been an increase in bat studies in this country in recent years, little is known about pteropodid bat taxonomy.

This study had three objectives: (i) to review and confirm the pteropodid fauna of Cambodia and identify diagnostic characters for each species, (ii) to create detailed species accounts and a species identification key, and (iii) to determine whether sexual dimorphism occurs in selected Cambodian pteropodids. Fifty-seven voucher specimens (including skulls) were reviewed and measured. Diagnostic characters were found, and sexual dimorphism and closely similar species were analysed.

CITATION: Poeuv N. (2013) A systematic review of the fruit bat fauna (Pteropodidae) of Cambodia. *Cambodian Journal of Natural History*, **2013,** 116–117.

A new species account and an identification key for Cambodian pteropodid bats was created. The sexual dimorphism analysis showed *Cynopterus brachyotis* displays sexual dimorphism in tibia length, *C. horsfieldii* shows sexual dimorphism in upper third molar width, *C. sphinx* shows sexual dimorphism in the first phalanx of the fifth digit, and *Eonycteris spelaea* shows sexual dimorphism in the second phalanx of the third, fourth and fifth digits, zygomatic width, interorbital width, upper toothrow length, anterior palatal width, rostral width, and canine tooth basal width. *Cynopterus brachyotis* and *E. spelaea* males were larger than females in most characters, whereas *C. horsfieldii* and *C. sphinx* males were usually smaller.

For the morphologically similar species *C. brachyotis, C. horsfieldii* and *C. sphinx*, pair-wise analysis showed significant interspecific differences in almost all characters: in 21 characters between *C. brachyotis* and *C. horsfieldii*, in 16 characters between *C. brachyotis* and *C. sphinx* and in three characters between *C. horsfieldii* and *C. sphinx*. This is the first taxonomic study to organise species accounts and create an identification key for Cambodian pteropodid bats. Further research on the taxonomy and population status of Cambodian pteropodids is recommended to assist conservation of these species.

Factors affecting trapaeng use by dry forest waterbirds and the impact of rice cultivation on trapaeng ecology in Western Siem Pang Proposed Protected Forest, Northeast Cambodia

SUM Phearun

មូលន័យសង្ខេប

បក្សីទឹកជាសមាសភាគសំខាន់មួយនៃជីវៈចម្រុះពិភពលោក។ ការសិក្សានេះពិនិត្យមើលត្រពាំង (វាលស្មៅលិចទឹក) និងវាយតម្លៃពីលក្ខណៈទូទៅរបស់វា រួមមាននានាភាពនៃទីជម្រកនីមួយៗ ចម្ងាយទៅត្រពាំងផ្សេងៗ ចម្ងាយទៅភូមិឋាននិងផ្លូវដើរ និងជម្រកព្រៃឈើនៅជុំវិញ ដែលមានឥទ្ធិពលលើបរិមាណនិងភាពសម្បូរបែបនៃប្រភេទបក្សីទឹក នៅតំបន់ព្រៃស្នើការពារភាគខាងលិចសៀមប៉ាង ខេត្តស្ទឹងត្រែង ប្រទេសកម្ពុជា។ លើសពីនេះ ផលប៉ះពាល់នៃកសិកម្មលើបរិមាណនិងភាពសម្បូរបែបនៃប្រភេទបក្សីទឹកក៏ត្រូវបានសិក្សាស្រាវជ្រាវផងដែរ។ ត្រពាំងធម្មជាតិនិងត្រពាំងដាំដុះស្រូវត្រូវបានប្រៀបធៀប ដើម្បីរកភាពខុសគ្នានៃបរិមាណនិងភាពសម្បូរបែបនៃប្រភេទបក្សីទឹក។ ដង់ស៊ីតេបក្សីទឹកខ្ពស់ជាងត្រូវបានកត់ត្រានៅក្នុងត្រពាំងចម្ងាយពី០ទៅ៤គីឡូម៉ែត្រពីភូមិឋាន។ ទំហំត្រពាំង បរិមាណប្រភេទបក្សីទឹក និងភាពសម្បូរបែបនៃប្រភេទបក្សីទឹកមានទំនាក់ទំនងគ្នាជាវិជ្ជមាន។ ត្រពាំងធំៗ ដែលមានព្រៃឈើនៅជុំវិញ ប្រមាណ០.០៥ដើម/ម^{2} និងកម្ពស់មធ្យម៧.៥ម ត្រូវបានចាត់ទុកជាជម្រកល្អបំផុតសម្រាប់បក្សីទឹក។ ក្របីបង្កើតបានជាកន្លែងរកចំណីអាហារសំរាប់បក្សីទឹក ដោយសារសកម្មភាពស៊ីស្មៅ ការជញ្ជ្រុំដីភក់ និងការដេកត្រាំក្នុងត្រពាំងរបស់វា។ ត្រពាំងធម្មជាតិមានសារៈសំខាន់ចំពោះបក្សីទឹកខ្លាំងជាងត្រពាំងដាំដុះដំណាំ។ ដង់ស៊ីតេបក្សីទឹកខ្ពស់ជាងត្រូវបានសង្កេតឃើញនៅតាមត្រពាំងធម្មជាតិដែលទាក់ទងទៅនឹងលក្ខណៈដោយឡែក ដែលត្រពាំងដាំដុះដំណាំគ្មាន ដូចជាមានរុក្ខជាតិចម្រុះគ្នាច្រើនប្រភេទជាដើម។ បក្សីចូលចិត្តត្រពាំងដែលមានទឹកជាអចិន្ត្រៃយ៍ ហើយក៏ជាកន្លែងងាយស្រួលពិនិត្យតាមដាននិងអភិរក្សផងដែរ។ ការប្រែក្លាយតំបន់ត្រពាំងអោយទៅជាដីកសិកម្មហាក់ដូចជាការគំរាមកំហែងចម្បងដល់បក្សីទឹក ដែលជាហានិភ័យនៃការបាត់បង់កន្លែងរកចំណីអាហារនានារបស់វា។ ការគ្រប់គ្រងត្រពាំងធម្មជាតិនៅក្នុងតំបន់ភាគខាងលិចសៀមប៉ាងដោយប្រសិទ្ធភាពមានសារសំខាន់ខ្លាំងចំពោះការអភិរក្ស

CITATION: Sum P. (2013) Factors affecting trapaeng use by dry forest waterbirds and the impact of rice cultivation on trapaeng ecology in Western Siem Pang Proposed Protected Forest, Northeast Cambodia. *Cambodian Journal of Natural History*, **2013,** 117–118.

ប្រភេទបក្សីទឹកដែលកម្រ។ អនុសាសន៍របស់ខ្ញុំគឺ ត្រពាំងគួរតែត្រូវបានគ្រប់គ្រងសម្រាប់បក្សីទឹកច្រើនប្រភេទ និងគួរយកចិត្តទុកដាក់ពង្រឹងសមត្ថភាពក្នុងការពិនិត្យតាមដាន ថែរក្សា និងធ្វើឲ្យប្រសើរឡើងនូវទីជម្រកបក្សីទឹក។

Abstract

Waterbirds are a vital component of the world's biodiversity. This study examines trapaengs (flooded grasslands) and evaluates how their characteristics—including microhabitat diversity, distance to other trapaengs, distance to settlements and trails, and surrounding forest habitats—influence the abundance and species richness of waterbirds in Western Siem Pang Proposed Protected Forest, Stung Treng Province, Cambodia. Furthermore, the impact of agriculture on waterbird abundance and species richness was also investigated.

Forest trapaengs were compared to cultivated trapaengs to determine any differences in waterbird species richness and abundance. Higher densities of waterbirds were recorded in trapaengs 0–4 km from settlements. There was a positive relationship between trapaeng size and the number of waterbird species and their abundance. Larger trapaengs, with approximately 0.05 trees/m² and tree heights of 7.5 m, were found to represent the best habitat for waterbirds. Water buffalo create accessible foraging habitats for birds in trapaengs by grazing, tramping and wallowing. Forest trapaengs were significantly more important for waterbirds than cultivated trapaengs. The higher waterbird density observed in forest trapaengs was linked to specific characteristics that did not exist in the cultivated trapaengs, including more heterogeneous vegetation.

Birds preferred trapaengs with permanent water, and such areas are easier to monitor and conserve. Conversion of trapaengs to cultivated areas is likely to be the main threat to waterbirds, which risk losing their diverse foraging habitat. Effectively managing natural trapaengs in Western Siem Pang is vital to conserve rare waterbird species. I recommend that trapaengs are managed for multiple waterbird species and that efforts are made to strengthen capacity to monitor, maintain and improve waterbird habitats.

Designing agroforestry systems for community livelihood improvement and rehabilitation of degraded forestlands: implications for community needs and ecological sustainability

THI Sothearen

មូលន័យសង្ខេប

នៅពេលដែលកំណើនប្រជាជនបានជះឥទ្ធិពលអវិជ្ជមានលើគំរបព្រៃឈើនិងជីវៈចម្រុះក្នុងប្រទេសកម្ពុជា កសិរុក្ខកម្មផ្តល់នូវដំណោះស្រាយដ៏មានសក្តានុពលចំពោះបញ្ហានេះ។ ជាឧទាហរណ៍ កំណើនប្រជាជនក្នុងភូមិគល់ទទឹង ក្នុងខេត្តពោធិ៍សាត់ពឹងផ្អែកលើប្រាក់ចំណូលបានពីប្រភពធនធានព្រៃឈើ។ គោលបំណងនៃការសិក្សានេះ គឺសិក្សាស្វែងយល់ពីការអនុវត្តកសិរុក្ខកម្មសំរាប់ការអភិរក្សអេកូឡូស៊ី ការអភិវឌ្ឍចំណេះដឹង និងការធានាសន្តិសុខស្បៀងអាហារនៃអ្នកភូមិគល់ទទឹង ដែលអាចនាំអោយជីវភាពរស់នៅមាននិរន្តរភាព និងជីវៈចម្រុះមានស្ថិរភាពយូរអង្វែង។ ខ្ញុំបានសិក្សាជាដំបូងទៅលើដំណាំដាំដុះនៅក្នុងភូមិ និងប្រភពទ្រទ្រង់ជីវភាពរស់

CITATION: Thi S. (2013) Designing agroforestry systems for community livelihood improvement and rehabilitation of degraded forestlands: implications for community needs and ecological sustainability. *Cambodian Journal of Natural History*, **2013,** 118–119.

នៅផ្សេងទៀត ដើម្បីរកអោយឃើញថាតើចំណូលចំបងរបស់អ្នកភូមិជាអ្វី និងប្រជាជនចំនួនប៉ុន្មាននាក់ដែលរស់នៅដោយអាស្រ័យលើធនធានព្រៃឈើ។ បន្ទាប់មកខ្ញុំបានរៀបចំប្រព័ន្ធកសិរុក្ខកម្មសំរាប់សហគមន៍នៅក្នុងភូមិនេះ។ ការរៀបចំប្រព័ន្ធកសិរុក្ខកម្មផ្អែកទៅលើការស្ទង់មតិរបស់ប្រជាជនអំពីប្រភេទដំណាំដែលពួកគាត់ចង់ដាំ និងប្រភេទរុក្ខជាតិដែលណែនាំដោយឯកសារកសិរុក្ខកម្ម។ ការសាកស្បងពិសោធន៍ត្រូវបានដំណើរការដើម្បីស្វែងយល់ឥទ្ធិពលនៃជីសំយោគNPK និងជីលាមកប្រចៀវសម្រាប់រុក្ខជាតិ៥ប្រភេទដែលរួមមានដើមឈើ ដំណាំហូបផ្លែ និងបន្លែ។ ទោះបីស្រូវជាដំណាំចំបងក្នុងភូមិក៏ដោយ ក៏វាមិនមែនជាប្រភពចំណូលសំខាន់សំរាប់ប្រជាជនក្នុងភូមិនោះទេ។ ក្រុមគ្រួសារដែលត្រូវបានសិក្សាភាគច្រើនរស់នៅពឹងផ្អែកលើប្រាក់ចំណូលបានពីធនធានព្រៃឈើ ដោយការប្រមូលនិងកាប់យកឈើធ្វើអុសលក់។ ដំណាំ៦ប្រភេទ ដើមឈើ និងប្រភេទរុក្ខជាតិតូចៗនៃកសិរុក្ខកម្ម ត្រូវបានណែនាំឲ្យដាំក្នុងប្រព័ន្ធកសិរុក្ខកម្ម ជាមួយបន្លែ៤ប្រភេទលាយជាមួយដំណាំសំខាន់ៗ។ ការពិសោធន៍បានបង្ហាញថា ជាទូទៅជីលាមកប្រចៀវជាជីល្អប្រសើរជាងជីសំយោគNPK។រុក្ខជាតិ៣ប្រភេទក្នុងពិសោធន៍នេះលូតលាស់ល្អជាងជាមួយជីលាមកប្រចៀវ ចំណែករុក្ខជាតិ២ប្រភេទទៀតលូតលាស់ល្អជាមួយជីNPK។ ជីលាមកប្រចៀវត្រូវបានណែនាំឲ្យប្រើទាំងក្នុងដំណាំកសិកម្មនិងកសិរុក្ខកម្ម។ កសិរុក្ខកម្មគួរតែត្រូវបានពង្រីកទៅតំបន់ដែលព្រៃរងការគំរាមកំហែងដោយសកម្មភាពមនុស្ស និងនៅកន្លែងដែលទាមទារអោយមានសន្តិសុខស្បៀងអាហារ ឬការធ្វើអោយជីវភាពរស់នៅប្រសើរឡើង។

Abstract

Whilst population growth has a negative influence on forest cover and biodiversity in Cambodia, agroforestry provides a potential solution to this conflict. For example, the growing population of Kol Toteung Village in Pursat Province relies on income generated from forest resources. The aim of this study was to investigate agroforestry practices for food security, ecological conservation and awareness development in Kol Toteung, and how these affect sustainable livelihoods and biodiversity.

I firstly studied the crops cultivated in the village and other sources of livelihood support to examine what the main household income was, and how many people depend on forest resources. Secondly, I designed an agroforestry system for the village based on a survey of which agroforestry species the community wanted to grow, and species recommended from the literature. Experimental trials were conducted to test the performance of a synthetic NPK (nitrogen, phosphorous and potassium) fertiliser and bat guano for five plant species which included trees, fruits and vegetables.

Although rice was the main crop cultivated in the village, it did not provide the main income source. The majority of surveyed households depended on income gained from collecting and cutting wood for sale. Six crop, tree and shrub species were recommended for agroforestry, with four species of vegetables mixed in with the main crops. Overall, bat guano was found to be a better fertiliser than the synthetic NPK fertiliser: three plant species in the experimental trials grew better with bat guano, while two grew better with NPK fertiliser. Bat guano is recommended for use in both agricultural crops and agroforestry. Agroforestry should be expanded to areas where forests are threatened by the activities of people, and to places that require greater food security or livelihood improvement.

A comparative study of marine fish and invertebrates inhabiting coral reefs surrounding Koh Rong Island, Cambodia

THAUNG Ret

មូលន័យសង្ខេប

ចំណេះដឹងអំពីស្ថានភាពតំបន់ថ្មប៉ប្រះទឹក និងប្រភេទសត្វសមុទ្រ ដែលរស់នៅតំបន់ផ្កាថ្មប៉ប្រះទឹក មានអត្ថប្រយោជន៍ដល់ការសម្រេចចិត្តនៃការគ្រប់គ្រងទៅតាមពតិមានជាក់ស្តែង។ ចំណេះដឹងនេះគឺជាសេចក្តីត្រូវការសម្រាប់ការគ្រប់គ្រងកោះរុងប្រកបដោយនិរន្តរភាព ដែលស្ថិតនៅក្នុងតំបន់សមុទ្រស្នើការពារជាលើកដំបូងនៅកម្ពុជា។ ពពួកត្រីនិងសត្វឥតឆ្អឹងកងដែលរស់នៅតំបន់ថ្មប៉ប្រះទឹកជុំវិញកោះត្រូវបានសិក្សា ដើម្បីកំណត់ភាពដូចគ្នានិងភាពខុសគ្នារវាងតំបន់ឆ្នេរខាងលិចនិងខាងកើត និងរវាងខាងក្នុងនិងខាងក្រៅតំបន់កោះដែលគ្រប់គ្រងដោយសហគមន៍នេសាទ។ ទិន្នន័យពីឆ្នាំ២០១០ដល់២០១២ត្រូវបានវិភាគដើម្បីកំណត់លក្ខណៈខុសគ្នារវាងបរិមាណត្រីនិងសត្វឥតឆ្អឹងកងរស់នៅតំបន់ថ្មប៉ប្រះទឹក និងរចនាសម្ព័ន្ធសហគមន៍រវាងតំបន់ឆ្នេរទាំងសងខាងនៃកោះ ក៏ដូចជាខាងក្នុងនិងខាងក្រៅតំបន់សហគមន៍នេសាទផងដែរ។ ទំនាក់ទំនងរវាងប្រភេទ ស៊ុបស្រ្តា និងសហគមន៍ត្រីនិងសត្វឥតឆ្អឹងកងក៏ត្រូវបានសិក្សាផងដែរ។ ជាលទ្ធផល គ្មានភាពខុសគ្នាខ្លាំងជាស្ថិតិពីបរិមាណត្រីនិងសត្វឥតឆ្អឹងកងរស់នៅតំបន់ថ្មប៉ប្រះទឹក រវាងខាងក្នុងនិងខាងក្រៅតំបន់សហគមន៍នេសាទ ត្រូវបានរកឃើញឡើយ។ នានាភាពនៃត្រីរស់នៅតំបន់ផ្កាថ្មប៉ប្រះទឹកក្នុងឆ្នេរខាងលិចខ្ពស់ជាងត្រីរស់នៅក្នុងឆ្នេរខាងកើត។ ប៉ុន្តែ នានាភាពសត្វឥតឆ្អឹងនៅឆ្នេរខាងលិចមិនខុសគ្នាពីសត្វឥតឆ្អឹងកងនៅឆ្នេរខាងកើតទេ។ ជាអនុសាសន៍ គួរបន្តការសិក្សាស្រាវជ្រាវនិងការពិនិត្យតាមដានលើផលប៉ះពាល់នៃការប្រើប្រាស់ធនធានក្នុងមជ្ឈដ្ឋានជុំវិញ ជាពិសេសក្នុងតំបន់អភិរក្សសមុទ្រ។ ហើយការយកចិត្តទុកដាក់លើការអនុវត្តជាក់ស្តែងនៃការគ្រប់គ្រងក៏ត្រូវការផ្តល់ជូនផងដែរ ដើម្បីកាត់បន្ថយការគំរាមកំហែងពីកង្វក់។

Abstract

Knowledge of reef health and the marine species that inhabit coral reefs are useful for informing management decisions. This knowledge is required for the sustainable management of Koh Rong Island, which is encompassed by the first proposed marine protected area in Cambodia. The reef fish and invertebrate assemblages surrounding the island were examined to determine any similarities and differences between sites on the East and West coast, as well as inside and outside of the island's managed Community Fishery area.

Data from 2010–2012 were analysed to characterise differences in reef fish and invertebrate abundance and community structure (diversity and evenness) between the two sides of the island, as well as within and outside the Community Fishery area. The relationship between substrate type and fish and invertebrate communities was also examined.

No statistically significant differences in reef fish or invertebrate abundance and composition were found between the inside and outside of the Community Fishery area. Reef fish on the West coast were significantly more diverse than those on the East coast, but there was no difference in invertebrate diversity between the two coasts.

Further surveys and monitoring of the impacts of resource use on surrounding environments are recommended, particularly in marine conservation areas, and consideration needs to be given to management practices to mitigate threats from pollution.

CITATION: Thaung R. (2013) A comparative study of marine fish and invertebrates inhabiting coral reefs surrounding Koh Rong Island, Cambodia . *Cambodian Journal of Natural History*, **2013,** 120.

Key factors potentially influencing the occurrence of the Critically Endangered giant ibis *Thaumatibis gigantea* during the breeding season (April to June) in Western Siem Pang Proposed Protected Forest, Northeast Cambodia

TY Srun

មូលន័យសង្ខេប

ដើមឡើយត្រយងយក្ស (*Thaumatibis gigantea*) មានរបាយទូទាំងអាស៊ីអាគ្នេយ៍តែបច្ចុប្បន្នវាជាប្រភេទរងគ្រោះខ្លាំង និងមានតែក្នុងព្រៃស្ងួតភាគឥសាននៃប្រទេសកម្ពុជាប៉ុណ្ណោះ។ ការសិក្សាមុនៗបង្ហាញថាត្រយងយក្សពឹងផ្អែកលើត្រពាំងសំរាប់ការរកចំណីនៅរដូវប្រាំង។ ប៉ុន្តែកត្តាផ្សេងៗដែលអាចមានឥទ្ធិពលលើវត្តមានត្រយងយក្សនៅរដូវនេះមិនទាន់ត្រូវបានដឹងនៅឡើយ។ ស៊ុបស្ត្រាតនៃជម្រកទំរង់រុក្ខជាតិ ចំងាយពីភូមិ ចំងាយពីត្រពាំងផ្សេងនិងពីស្ទឹងទន្លេ សកម្មភាពមនុស្ស និងប្រេកង់នៃការបញ្ចេញសម្លេងនៃត្រយងយក្សត្រូវបានកត់ត្រានិងវិភាគពីត្រពាំង១២(ប៉ុស្ត៍ស្ពាប់) ស្ថិតក្នុងតំបន់បក្សីសំខាន់ភាគខាងលិចសៀមប៉ាង (Western Siem Pang Important Bird Area)ភាគឥសាននៃប្រទេសកម្ពុជា។ទីតាំងសិក្សា៤កន្លែងដែលមានប្រភេទរុក្ខជាតិផ្សេងគ្នាត្រូវបានជ្រើសរើសដោយការកំណត់ចម្ងាយពីភូមិដែលចែកចេញជា៣ថ្នាក់ គឺចម្ងាយជិត(៤-៥ គម) ចម្ងាយឆ្ងាយ(៨-៩ គម) និងចម្ងាយឆ្ងាយខ្លាំង(១២-១៣ គម)។ ប៉ុស្ត៍ស្ពាប់ត្រូវបានប្រើនៅគ្រប់កន្លែងសិក្សាទាំងអស់ដើម្បីកំណត់ចំនួនត្រយងយក្ស។ ជាលទ្ធផល ត្រយងយក្សចំនួន៣៩ក្បាលត្រូវបានកត់ត្រាពីទីតាំងសិក្សាទាំង១២កន្លែង។ ទោះបីមិនមានសារសំខាន់ជាស្ថិតិក៏ដោយ ក៏កម្រិតនៃការរំខានមានទំនាក់ទំនងអវិជ្ជមានជាមួយចម្ងាយពីភូមិ។ វត្តមានត្រយងយក្សមានទំនាក់ទំនងជាវិជ្ជមានជាមួយនឹងចម្ងាយពីភូមិ តែមិនសូវខ្លាំងទេ ដោយត្រយងយក្សមានវត្តមានច្រើនបំផុតនៅកន្លែងដែលមានចម្ងាយមធ្យមពីភូមិ។ ចំងាយពីត្រពាំងនិងស្ទឹងទន្លេមានទំនាក់ទំនងអវិជ្ជមានជាមួយនឹងវត្តមានសត្វត្រយងយក្ស។ ទំនាក់ទំនងអវិជ្ជមានតិចតួចរវាងរុក្ខជាតិនិងវត្តមានត្រយងយក្សត្រូវបានរកឃើញ។ ត្រពាំងដែលមានប្រេកង់ត្រយងយក្សខ្ពស់បំផុតគឺនៅជម្រកព្រៃចំហ ដែលត្រយងយក្សចំនួន១៥ក្បាលត្រូវបានកត់ត្រា បើប្រៀបធៀបជម្រកដទៃទៀត គឺ១០ក្បាលពីជម្រកព្រៃជ្រុះស្លឹកប្រចាំឆ្នាំ ៩ក្បាលពីជម្រកព្រៃជ្រុះស្លឹកប្រចាំឆ្នាំលាយនឹងព្រៃចំហ និង៥ក្បាលពីជម្រកព្រៃពាក់កណ្តាលបៃតង។ ត្រយងយក្សបញ្ចេញសម្លេងនៅពេលព្រឹកញាប់ជាងនៅពេលរសៀល ញឹកញាប់បំផុតពីម៉ោង៥ទៅម៉ោង៥:៣០នាទីព្រឹក។ ទោះបីគ្មានស្ថិតិបង្ហាញពីទំនាក់ទំនងខ្លាំងរវាងចម្ងាយពីភូមិនិងចំនួនត្រយងយក្សក៏ដោយ ក៏ការសង្កេតបានបង្ហាញថាចម្ងាយកាន់តែឆ្ងាយពីភូមិគឺមានការរំខានកាន់តែតិច និងមានវត្តមានត្រយងយក្សកាន់តែខ្ពស់។ ដោយសារត្រយងយក្សច្រើនមានវត្តមានក្នុងព្រៃចំហ នៅតាមបណ្តោយស្ទឹងទន្លេនិងត្រពាំង ដូច្នេះការអភិរក្សគួរផ្តោតការយកចិត្តទុកដាក់ទៅលើតំបន់ទាំងនោះ។ សំឡេងត្រយងយក្សគួរត្រូវបានប្រើជាជំនួយក្នុងការកំណត់ទីតាំងសំបុករបស់វា។

Abstract

Once widespread throughout Southeast Asia, the Critically Endangered giant ibis *Thaumatibis gigantea* is now restricted to the dry forests of northeastern Cambodia. Previous studies have shown that giant ibises rely on trapaengs (flooded grasslands) during the dry season for feeding, but the factors that may affect giant ibis occurrence at this time of year are not fully understood. Habitat substrate, vegetation structure, distance from villages, distance from other trapaengs and rivers, human activities and the frequency of giant ibis calls were recorded and analysed from 12 trapaengs in Western Siem Pang Important Bird Area, northeastern Cambodia. Four sites with

CITATION: Ty P. (2013) Key factors potentially influencing the occurrence of the Critically Endangered giant ibis *Thaumatibis gigantea* during the breeding season (April to June) in Western Siem Pang Proposed Protected Forest, Northeast Cambodia. *Cambodian Journal of Natural History*, **2013,** 121–122.

different vegetation types were selected from each of three distance classes: near (4–5 km) villages, far (8–9 km) from villages, and very far (12–13 km) from villages. Listening posts were used at all sample sites to determine giant ibis abundance.

A total of 39 individuals were recorded from the 12 sites. Although not statistically significant, levels of disturbance were negatively correlated with distance from village. Giant ibis occurrence was positively correlated with distance from villages, and negatively correlated with distance from other trapaengs and rivers, although these trends were not statistically significant. The trapaengs with the highest frequency of giant ibises were in open forest habitats, with 15 giant ibises recorded in this habitat, compared to 10, 9 and 5 individuals from deciduous, mixed deciduous-open and semi-evergreen forest habitats, respectively. Giant ibises called more frequently in the morning than in the evening, with the highest frequency observed from 0500–0530 h.

Although not statistically significant, numbers of giant ibises tended to increase with distance from villages, in areas with less disturbance. Because giant ibises most often occurred within open forest habitats, along rivers and near trapaengs, future conservation efforts should focus on these areas. Ibis calls should be used to assist in locating nests.

Food selection and disturbance events for sarus cranes *Grus antigone* and other birds in Anlung Pring Management and Conservation Area in Kampong Trach District, Kampot Province

YAV Net

មូលន័យសង្ខេប

ប្រភពអាហារនិងសុវត្ថិភាពមានឥទ្ធិពលទៅលើការជ្រើសរើសទីជម្រករបស់បក្សី។ ដែនបម្រុងសត្វក្រៀលអន្លង់ព្រីង(SCR) គឺជាដែនបម្រុងមួយក្នុងចំណោមដែនបម្រុងបី ដែលទ្រទ្រង់សត្វក្រៀល (*Grus antigone*) នៅរដូវមិនបន្តពូជក្នុងប្រទេសកម្ពុជា។ ដែនបម្រុងនេះភាគច្រើនគ្របដណ្តប់ដោយប្រភេទផ្លុង ដែលត្រូវបានគេជឿថាវាជាអាហារចម្បង និងមានទំនាក់ទំនងជាមួយនឹងវត្តមានសត្វក្រៀលក្នុងរដូវមិនបន្តពូជ។ ការសិក្សានេះបានត្រូវដំណើរការដើម្បីកំណត់ថា តើផ្លុងជាប្រភេទអាហារដែលសត្វក្រៀលចូលចិត្ត និងតើវត្តមានសត្វក្រៀលនិងវត្តមានផ្លុងមានទំនាក់ទំនងគ្នាដែរឬទេ។ ចំនួននិងប្រភេទស្មៅទាបខ្ពស់ត្រូវបានកំណត់បរិមាណដោយការប្រើក្រឡាបន្ទាត់៦០០ក្រឡាក្នុងដែនបំរុងនោះ ទាំងកន្លែងដែលមានអាំងតង់ស៊ីតេសត្វក្រៀលខ្ពស់និងទាប ឬគ្មានសត្វក្រៀល។ ក្នុងចំណោមផ្លុងបីប្រភេទក្នុងដែនបម្រុងនេះ ផ្លុងពីរប្រភេទ(*E.spiralis* និង *E.dulcis*)មានមើម ចំណែកផ្លុងមួយប្រភេទទៀត (*E.philippinensis)*គ្មានមើមទេ។ សត្វក្រៀលចូលចិត្តរកស៊ីនៅកន្លែងដែលមានប្រភេទផ្លុងមានមើមពីរប្រភេទដុះច្រើន តែមិនសូវឃើញវានៅកន្លែងដែលមានប្រភេទ*E.philippinensis* ដុះច្រើនឡើយ។ សកម្មភាពមនុស្សក្នុងឬក្បែរកន្លែងសត្វក្រៀលរកស៊ីមានឥទ្ធិពលលើការជ្រើសរើសជម្រករបស់សត្វក្រៀលផងដែរ។ សកម្មភាពរបស់ប្រជាជនក្នុងសហគមន៍ដែលរំខានបំផុតដល់សត្វក្រៀលរួមមានការដើរ

CITATION: Yav N. (2013) Food selection and disturbance events for sarus cranes Grus antigone and other birds in Anlung Pring Management and Conservation Area in Kampong Trach District, Kampot Province. *Cambodian Journal of Natural History*, **2013,** 122–123.

កាត់ ការនេសាទ និងការដាក់លបបង្គា។ កសិដ្ឋានចិញ្ចឹមបង្គា និងកន្លែងមានព្រៃគុម្ពោតនៅក្បែរទ្រនំរបស់សត្វក្រៀល ដែលត្រូវបានបំលែងជាផ្ទៃដីកសិកម្ម ជាកត្តាគំរាមកំហែងខ្លាំងចំពោះដែនបម្រុងនេះ។ ការខ្វះខាតទឹកសាបសម្រាប់សត្វក្រៀលផឹកក៏ជាកត្តាគំរាមកំហែងនៅដែនបម្រុងផងដែរ។ ដែនបម្រុងសត្វក្រៀលអន្លង់ព្រីង (SCR) គឺជាតំបន់សំខាន់មួយសម្រាប់ផ្តល់ទីជម្រក និងការរកចំណីរបស់សត្វក្រៀលក្នុងរដូវមិនបន្តពូជ ពីព្រោះតំបន់នេះមានប្រភេទផ្លុងមានមើមយ៉ាងច្រើន ដែលជាប្រភពអាហារសំខាន់សម្រាប់សត្វក្រៀល។ ដើម្បីធ្វើឱ្យការអភិរក្សកាន់តែប្រសើរឡើង គេគួរតែគ្រប់គ្រងកន្លែងរកចំណីនិងទ្រនំរបស់សត្វក្រៀល តាមរយៈការបង្កើនលទ្ធភាពរកចំណីរបស់វា និងលើកកំពស់ការយល់ដឹងអំពីការអភិរក្សរបស់ប្រជាជនមូលដ្ឋាន។

Abstract

Food sources and safety influence habitat selection by birds. Anlung Pring Management and Conservation Area is one of three important bird areas that support sarus cranes *Grus antigone* during the non-breeding period in Cambodia. This reserve is mostly covered by *Elecoharis* species that are hypothesized to be the primary food of, and correlate with the presence of, sarus cranes during the non-breeding season. This study was conducted to determine whether *Eleocharis* species are indeed the preferred food of sarus cranes, and whether sarus crane occurrence and *Eleocharis* species presence are correlated.

The amount and type of grass and sedge species present were quantified using 600 quadrats in both high-intensity and low- or zero-intensity habitats of sarus cranes in the reserve. Of the three *Eleocharis* species in this reserve, two produce tubers (*E. spiralis* and *E. dulcis*) and one (*E. philippinensis*) does not. Sarus cranes were found to prefer foraging in areas dominated by the two tuber-producing species, and were less likely to be found in areas dominated by *E. philippinensis*.

Human activities inside, or close to, the foraging areas affected habitat selection by sarus cranes. Activities that caused greatest disturbance to sarus cranes included fishing, walking across the habitat and shrimp trapping by the local community. Shrimp farms and shrublands close to roosting habitats being converted for agriculture are the main threats to the reserve. A shortage of fresh water for the birds to drink also poses a threat.

Anlung Pring Management and Conservation Area is an important area for sarus cranes during the non-breeding season because of the high abundance of tuber-producing *Eleocharis* species, the cranes' primary food source. To improve conservation, the reserve should manage the feeding and roosting habitat of sarus cranes through improving the availability of their food and raising the awareness among local people.

Recent literature from Cambodia

This section summarises 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. Authors are usually willing to provide free reprints or electronic copies of their papers on request and their email addresses, where known, are included in the summaries below.

If you or your organisation have recently published a technical paper or report that you would like to be listed in the next issue, please send an electronic copy, summary or Internet link to Editor.CJNH@gmail.com

New species and taxonomic reviews

Averyanov, L.V., Tanaka, N. & Luu H.T. (2013) New species of *Ophiopogon* and *Peliosanthes* (Asparagaceae) from Cambodia and Vietnam. *Taiwania,* **58,** 233–241.

Two new species in the genus *Ophiopogon* are described from Vietnam and one species, *Peliosanthes cambodiana* sp. nov., is described from Cambodia. The latter was discovered around the Kbal Chhay Waterfall near Sihanoukville, Kampong Saom Province. All three new plant species are probably local endemics with a restricted distribution range. This paper contains information on their ecology, phenology and distribution, as well as taxonomic descriptions and illustrations. Online: http://tai2.ntu.edu.tw/Taiwania/pdf/tai.2013.58.4.233.pdf

Chan, K.O., Blackburn, D.C., Murphy, R.W., Stuart, B.L., Emmett, D.A., Ho T.C. & Brown, R.M. (2013) A new species of narrow-mouthed frog of the genus *Kaloula* from eastern Indochina. *Herpetologica*, **69,** 329–341.

A new species of microhylid frog, *Kaloula indochinensis* sp. nov., is described from Vietnam, Laos and eastern Cambodia. The new species was previously confused with *K. baleata*. In Cambodia, it is known only from a photograph by Phan Channa in Phnom Prich Wildlife Sanctuary, Mondulkiri Province. Author: chanko@ku.edu

Chaowasku, T. & Keßler, P.J.A. (2014) *Miliusa cambodgensis* sp. nov. (Annonaceae) from Cambodia and *M. astiana*, *M. ninhbinhensis* spp. nov. from Vietnam. *Nordic Journal of Botany*. Article first published online 2 January 2014, doi: 10.1111/j.1756-1051.2013.00219.x.

Cambodia and Vietnam each have six species of *Miliusa* (flowering plants in the custard-apple family Annonaceae). This paper describes three new species, including one from Cambodia—*Miliusa cambodgensis* sp. nov.—and provides identification keys and taxonomic information for all known *Miliusa* species in Cambodia and Vietnam. Author: cyathostemma@yahoo.com

Choi, H. & Lee, S. (2013) New species of the genus *Schoutedenia* (Hemiptera: Greenideinae) from Cambodia. *Korean Society of Applied Entomology*, **2013,** 279. [*Abstract only, in Korean*].

Article not seen. Author: seung@snu.ac.kr

Dubatalov, V.V. & Bucsek, K. (2013) New species of lichen-moths from South-East Asia (Lepidoptera, Noctuoidea, Lithosiini). *Tinea*, **22,** 279–291.

Fourteen new species are described, including five from Cambodia: *Cernyia kosterini* sp. nov. and *Lyclene kosterini* sp. nov. from Bokor National Park, *Lyclene kepica* sp. nov. from Kep Province, *Eugoa nata* sp. nov. from Tatai, Koh Kong Province, and *Cyclomilta cambodiaca* sp. nov. from Southwest Cambodia and Southeast Thailand. Holotype specimens have been deposited in the Institute of Systematics and Ecology of Animals in Novosibirsk, Russia. Author: vvdubat@mail.ru

Ermilov, S.G. & Niedbała, W. (2013) Contribution to the knowledge of the oribatid mite fauna of Bolivia, Zambia, Cambodia and Vietnam, with descriptions of two new species (Acari, Oribatida). *Spixiana*, **36,** 9–19.

An annotated checklist of identified oribatid mites from Bolivia, Zambia, Cambodia and Vietnam is presented, and 37 species are recorded for the first time in Cambodia. Prior to this study, no species of oribatid mites had been recorded in this country. All of the Cambodian specimens were collected from forest leaf litter around the Angkor temple complex. Author: ermilovacari@yandex.ru; Online: http://www.pfeil-verlag.de/04biol/pdf/spix36_1_02.pdf

Kim, C.-J., Olmi, M., Lee, S., Lim, J., Choi, G.-W. & Lee, J.-W. (2013) A checklist of Dryinidae (Hymenoptera: Chrysidoidea) from Cambodia, with new records. *Journal of Asia-Pacific Entomology,* **16,** 485–488.

A checklist and key to the parasitic wasps of the family Dryinidae of Cambodia. This paper contains 14 species, of which 12 are new records for Cambodia. Their distribution ranges are described, together with the known hosts of their larvae. Author: jwlee1@ynu.ac.kr

Takeda, M., Habe, S. & Kubota, M. (2011) Records of some freshwater crabs from Laos and Cambodia. *Journal of Teikyo Heisei University,* **22,** 205–226. [*In Japanese*].

Esanthelphusa sp., *Heterothelphusa beauvoisi*, *Sayamia germaini*, *S. melanodactylus* and *Somanniathelphusa lacuvita* are recorded from Cambodia. These large freshwater crabs are used as a food, but if poorly cooked, carry a high risk

of transmitting the parasitic lung fluke *Paragonimus* sp. Author: takeda-m@thu.ac.jp

Lim, J. & Lee, S. (2012) Taxonomy of the family Bethylidae (Hymenoptera: Chrysidoidea) from Cambodia and adjacent countries: I, genus *Odontepyris* Kieffer (Bethylidae: Bethylinae) with four new species and two new records. *Journal of Natural History*, **47,** 2017–2038.

Four new species of wasps are described: *Odontepyris acutus* sp. nov., *O. cardamomensis* sp. nov. and *O. concavus* sp. nov. from Cambodia, and *O. prolatus* sp. nov. from Cambodia and Thailand. *Odontepyris muesebecki* and *O. formosicola* are also confirmed as new records for this country. This paper contains a key to the Cambodian wasps of the genus *Odontepyris* and their distributional records. Author: seung@snu.ac.kr

Park, K.-T., Bae, Y.-S. & Kim S. (2013) Three new species of *Thubana* Walker, 1864 from Cambodia and Malaysian Borneo (Lepidoptera: Lecithoceridae). *SHILAP Revista de Lepidopterologia*, **41,** 311–316.

Three new species of moths are described, including two from Cambodia: *Thubana seimaensis* sp. nov. and *T. eremophila* sp. nov. Author: ktpark02@gmail.com

Park, K.-T., Bae, Y.-S. Kim S. & Heppner, J.B. (2013) Genus *Torodora* Meyrick in Cambodia (Lepidoptera: Lecithoceridae: Torodorinae), with descriptions of three new species. *Journal of Natural History*, **47,** 2289–2304.

A review of the long-horned moth genus *Torodora* (Lepidoptera: Lecithoceridae) in Cambodia, using material collected by the authors in 2009–2011. Eight species are recognised, including three new species: *T. osamensis* sp. nov., *T. occidentalis* sp. nov. and *T. cambodiana* sp. nov. In addition, five species in this genus—*T. parotidosa*, *T. nabiella*, *T. aritai*, *T. sagmaria* and *T. pentagona*—are reported in Cambodia for the first time. Author: ktpark02@gmail.com

Qi, M.-J., László, G.M., Ronkay, G., Bae, Y.-S. & Han, H.-L. (2013) Description of a new genus *Purenola* Qi, László, Ronkay, Bae & Han, gen. n. and a new species of the tribe Nolini from Cambodia (Lepidoptera: Nolidae, Nolinae). *SHILAP Revista de Lepidopterologia*, **41,** 371–376.

A new moth genus and its type species, *Purenola fibigeri* sp. nov., are described from Cambodia. Author: baeys@incheon.ac.kr

Biodiversity inventories and monitoring

Chanthy P., Martin, R.J., Gunning, R.Y. & Andrew, N.R. (2013) Arthropod survey on soybean crops in Cambodia: a comparison of the sweep netting and beat sheeting collection methods for estimating arthropod diversity and species richness. *Australian Journal of Entomology*, **52,** 299–308.

Sweep netting and beat-sheeting collection methods were used in the first assessment of insects on soybean crops in Cambodia. The two methods produced substantially different results: sweep netting caught significantly higher numbers of most insect orders, but beat-sheeting caught more Acari and *Nezara viridula*, a major invertebrate pest of soybean. The use of different sampling methods to assess pests, predators and parasitoids in crops is useful for assessing Integrated Pest Management strategies. Author: nigel.andrew@une.edu.au

Goes, F. (2012) *Cambodia Recent Bird Reports, January–March 2013*. Http://www.samveasna.org/userfiles/recent_bird_reports_2013a.pdf

Quarterly round-up of unusual and important bird sightings in Cambodia. Includes the first confirmed national records of northern boobock *Ninox japonica* (in Phnom Penh), dunlins *Calidris alpina* (near Kampot) and jack snipe *Lymnocryptes minimus* (in the Anlong Pring Sarus Crane Conservation Area). Author: fredbaksey@yahoo.com

Roos, C., Boonratana, R., Supriatna, J., Fellowes, J.R., Rylands, A.B. & Mittermeier, R.A. (2013) An updated taxonomy of primates in Vietnam, Laos, Cambodia and China. *Vietnamese Journal of Primatology,* **2,** 13–26.

The four countries contain 41 species, of which 13 are known in Cambodia: *Nycticebus bengalensis, N. pygmaeus, Macaca leonina, M. arctoides, M. fascicularis, Trachypithecus germaini, T. margarita, Pygathrix cinerea, P. nemaeus, P. nigripes, Hylobates pileatus, Nomascus annamensis* and *N. gabriellae*. None of the species in Cambodia are endemic, but many are globally threatened. Author: croos@dpz.eu; Online: http://zgf.de/download/1899/Vietnamese%2BJournal%2Bof%2BPrimatology%2Bvol.%2B2(2).pdf

Species ecology and status

Gilbert, M., Bickford, D., Clark, L., Johnson, A., Joyner, P.H., Ogg Keats, L., Khammavong, K., Nguyen Van L., Newton, A., Seow, T.P.W., Roberton, S., Silithammavong, S., Singhalath, S., Yang, A. & Seimon, T.A. (2013) Amphibian pathogens in Southeast Asian frog trade. *EcoHealth,* **9,** 386–398.

This study assessed the health of amphibians traded for food or as pets. Samples from 2,389 individuals in 51 sites in Laos, Cambodia, Vietnam and Singapore were tested for the parasitic fungus *Batrachochytrium dendrobatidis*, and 74 individuals in Cambodia and Vietnam were tested for ranavirus. *Batrachochytrium dendrobatidis* was found on only one frog in Cambodia (n = 347) and 13 individuals in Singapore, but none in Laos or Vietnam. No ranavirus was found in Cambodia (n = 70) or Vietnam. Skin lesions caused by mycobacteria were observed in every East

Asian bullfrog *Hoplobatrachus rugolosus* sampled on farms in Vietnam. These results confirm that *B. dendrobatidis* is still fairly rare among traded amphibians in Southeast Asia, but the presence of bacterial disease in farmed *H. rugolosus* may have public health implications. This study indicates the need for improved biosecurity in amphibian farming and trade. Author: rokrok@nus.edu.sg

Handschuh, M. & Hassanin, A. (2013) Pure banteng *Bos javanicus* persist in southern Preah Vihear Province, Central Cambodia, despite apparent hybridisation with domestic cattle. *Natural History Bulletin of the Siam Society*, **59,** 57–60.

Previous research has found evidence of hybridisation among Cambodian banteng *Bos javanicus*, kouprey *B. sauveli* and domestic cattle *B. primigenius*. Reports from hunters suggest as many as half of the banteng in southern Preah Vihear Province have colouring indicative of domestic cattle ancestry. However, a single calf captured in southern Preah Vihear Province was genetically tested and confirmed to be a purebred banteng. Author: markus.handschuh@gmx.de; Online: http://www.researchgate.net/publication/256353550_Pure_Banteng_Bos_javanicus_Persist_in_Southern_Preah_Vihear_Province_Central_Cambodia_Despite_Apparent_Hybridisation_with_Domestic_Cattle

McDougall, S., Watson, A., Stodart, B., Kelly, G., Troldahl, D. & Tesoriero, L. (2013) *Tomato, Capsicum, Chilli and Eggplant: a Field Guide for the Identification of Insect Pests, Beneficials, Diseases and Disorders in Australia and Cambodia.* ACIAR Monograph Series, No. 157, Australian Centre for International Agricultural Research, Bruce, ACT, Australia.

Designed for Cambodian and Australian farmers who are interested in integrated pest management, this field guide identifies insect pests, the likely natural enemies of these pests ('beneficials'), crop diseases and nutritional disorders. It includes information on the biology of important insect pests, how they are spread and the factors that may limit or control their populations. Author: sandra.mcdougall@dpi.nsw.gov.au

Rowley, J.J.L., Hoang H.D., Le D.T.T., Dau V.Q., Neang T. & Cao T.T. (2013) Low prevalence or apparent absence of *Batrachochytrium dendrobatidis* infection in amphibians from sites in Vietnam and Cambodia. *Herpetological Review*, **44,** 466–469.

Batrachochytrium dendrobatidis, the parasitic fungus that causes the amphibian disease chytridiomycosis, is now widely but patchily distributed throughout Asia. Amphibians in Vietnam and Cambodia were sampled for *B. dendrobatidis*, including 100 frogs (approximately 16 species) in Seima Protection Forest in 2009. None of the Seima frogs were infected, but other recent surveys in Southwest Cambodia and other lowland sites have detected high incidences of chytridiomycosis. Author: jodi.rowley@austmus.gov.au

Songsawatkiat, S., Baimai, V., Saeung, A., Thongsahuan, S., Otsuka, Y., Srisuka, W. & Choochote, W. (2013) Cytogenetic, hybridization and molecular evidence of four cytological forms of *Anopheles nigerrimus* (*Hyrcanus* Group) in Thailand and Cambodia. *Journal of Vector Ecology*, **38,** 266–276.

Thirteen isoline colonies of the mosquito *Anopheles nigerrimus* were established from wild-caught females in Thailand and Cambodia (Ratanakiri Province). Three types of X chromosome and four types of Y chromosomes were recognised by their differing amounts of extra heterochromatin, and four karyotypic forms were identified by their unique combination of these X and Y chromosomes. One form is common in both Thailand and Cambodia, two forms were detected only in Thailand, and one form was found only in Cambodia. The four genetic strains readily interbred in captivity, suggesting they belong to the same species. Author: wchoocho@mail.med.cmu.ac.th

Wright, H.L., Collar, N.J., Lake, I.R. & Dolman, P.M. (2013) Amphibian concentrations in desiccating mud may determine the breeding season of the white-shouldered ibis (*Pseudibis davisoni*). *The Auk*, **130,** 774–783.

White-shouldered ibises rarely forage in water, but use all exposed substrates to hunt amphibians and small invertebrates. Amphibians were found to be the most abundant prey in waterholes and accounted for 81% of biomass consumed by these birds. Both intake rates and density of amphibians were higher on dry substrates than on moist or saturated ones. The ibises' use of dry waterholes to exploit seasonally concentrated prey is unusual among large waterbirds, and their breeding season may be timed to coincide with low water levels. Over the nesting period, a breeding pair of ibises requires the equivalent of nearly two-thirds of the available amphibians in a large waterhole. Every pair may therefore require multiple waterholes to breed successfully, which could explain why white-shouldered ibises do not breed in colonies. Author: hughlewiswright@gmail.com

Coasts, wetlands and aquatic resources

Burnett, W.C., Wattayakorn, G., Kum V. & Sioudom, K. (2012) Nutrient sources to Tonle Sap Lake, Cambodia. *APN Science Bulletin*, **3,** 108–111.

The Great Lake hosts one of the most productive inland fisheries in the world, accounting for >75% of Cambodia's inland fish catch and about 60% of the country's protein needs. This report describes a new study of the relationships between the Mekong River's hydrology, dissolved and particulate phosphorus cycle, and aquatic productivity. As fieldwork in Cambodia has not been completed yet, the findings in this report are merely preliminary. Author: wburnett@fsu.edu; Online: http://www.researchgate.net/

publication/258848473_Nutrient_Sources_to_Tonle_Sap_Lake_Cambodia/file/e0b495297d8ce98291.pdf

Hap N., Un S., Tray B. & Pomeroy, R.S. (2013) Value chain analysis of freshwater small-sized fish in Cambodia. In *Technical Reports: Investigations 2013–2015* (eds H. Egna, K. Goetting & C. Price), pp. 225–292. AquaFish Innovation Lab, Oregon State University, Corvallis, Oregon, USA.

Cambodia's total fish production was 515,000 tonnes in 2009, more than three-quarters of which came from inland fisheries. There is growing demand for, and trade in, small wild freshwater fish for human consumption, and animal feed (including aquaculture and crocodile farms). This study interviewed fishermen, fish farmers, traders, exporters, processors and end consumers in Kandal, Kampong Chhnang, Battambang and Siem Reap provinces, and in Phnom Penh city. The report provides detailed statistics on the species, origin, volume and prices of fish traded and consumed, and outlines recommendations to upgrade this industry. A notable constraint is that the preferred species are effectively available for only a few days each year, while migrating. Online: http://aquafish-crsp.oregonstate.edu/Documents/Uploads/FileManager/Technical_Report_2014.pdf

Kim, K.-W. & Phan K. (2014) Arsenic contamination in groundwater and human health risks in the Mekong River Basin of Cambodia. *From Sources to Solution*, **2014,** 531-535.

To investigate the human health impacts of arsenic in well water, groundwater and biological samples were collected from three provinces in the Mekong River Basin. Significant positive correlations were found between groundwater arsenic concentrations and levels of arsenic detected in hair, fingernails and toenails, suggesting the latter could be used as biomarkers of chronic arsenic exposure from consuming polluted groundwater. Non-cancer effects from arsenic were detected among 98.7%, 13.5% and 0% of respondents from the Kandal, Kratie and Kampong Cham provinces respectively, and risks of cancer were as high as 33.7% in Kratie Province. Author: kwkim@gist.ac.kr

Kim S.S. (2013) *Territoriality and state power in Cambodia: the case of demarcation in Tonle Sap*. PhD thesis, University of Sydney, Sydney, Australia.

The author suggests that the Cambodian state exploits international interests in environmental protection and modern resource governance to legitimise its interventions. However, corrupt officials often disregard rational resource governance in pursuit of personal interests. The study concludes that state power, as expressed through resource governance, is largely based on personal power exercised in an outwardly rational framework of conservation, natural resource regulation and state modernisation. Online: http://ses.library.usyd.edu.au//bitstream/2123/9522/1/kim_ss_thesis.pdf

Murphy, T., Guo, J., Irvine, K., Slotton, D., Wilson, K., Lean, D. & Lim S. (2013) Emerging problems with mercury in Cambodia. *Global Health Perspectives,* **1,** 113–134.

Mercury is used by artisanal miners in Cambodia to extract gold. Downstream from the gold mines, levels of mercury in the hair of people in the Srepok River Basin are three to five times higher than recommended by USEPA (1 μg/g), a level associated with attention-deficit hyperactivity disorder and reduced male fertility. Fishes in the Srepok River contain levels of mercury that exceed human consumption guidelines by 4–11 times. This problem could worsen with the completion of new hydroelectric dams, which typically increase levels of mercury in fish by fivefold. In addition, consumer goods, including Chinese traditional medicines, children's toys and skin whitening creams, contain dangerously high levels of mercury. Further field mercury monitoring of water, fish, consumer goods and people is needed because the risk of toxicity is high. Author: tompatmurphy@gmail.com

Nao T., Ing T. & Jensen, K.R. (2013) Relevant international and regional instruments for sustainable development of small-scale marine fisheries: significance to Cambodia. *Fish for the People,* **11,** 24–31.

To support the decentralization and deconcentration of Cambodia's fisheries, the Fisheries Administration has compiled a handbook for stakeholders at academic, scientific and management levels to summarise the conventions, protocols, agreements, action plans, memoranda of understanding, and other instruments applicable to the conservation and management of aquatic resources. The country's marine fisheries have significantly grown in recent years, especially in terms of the number of fishers and fishing boats. Author: naothuok.fia@maff.gov.kh); Online: http://www.seafdec.org/download/fish-for-the-people-vol-11-no-2/

Nen P., So N., Oem R. & Pomeroy, R.S. (2013) Experimental pond unit assessment in Cambodia. In *Technical Reports: Investigations 2013–2015* (eds H. Egna, K. Goetting & C. Price), pp 69–92. AquaFish Innovation Lab, Oregon State University, Corvallis, Oregon, USA.

Fish provide more than 75% of the animal protein eaten by Cambodians, with an average of 23-31 kg of fish consumed per person per year. As the human population has grown, wild fish catches have plummeted, driving pressure to develop aquaculture to meet the demand. This study tested water quality and the growth rates of non-native gift tilapia *Oreochromis niloticus* in artificial ponds under different husbandry regimes. Production and food conversion by tilapia were significantly higher in ponds where both commercial pellet food and chemical fertilisers (urea and di-ammonium phosphate) were added than when food or fertiliser alone were provided. Online: http://aquafishcrsp.oregonstate.edu/Documents/Uploads/FileManager/Technical_Report_2014.pdf

Okazumi, T., Tanaka, S., Kwak, Y., Shrestha, B.B. & Sugiura, A. (2013) Flood vulnerability assessment in the light of rice cultivation characteristics in Mekong River flood plain in Cambodia. *Paddy and Water Environment.* First published online 26 November 2013, doi: 10.1007/s10333-013-0403-1

Rice is cultivated on more than two million hectares of the lower Mekong River floodplain, from southern Cambodia to the border with Vietnam. This geographical information system (GIS) study developed flood inundation maps by combining a satellite-based digital elevation model with river water level data, overlaid with rice crop vulnerability data. This simple, inexpensive methodology was found to be useful for understanding flood risks to farmers in the Cambodian floodplain. Author: okazumi@pwri.go.jp

Phan K., Phan S., Heng S., Huoy, L. & Kim K.-W. (2014) Assessing arsenic intake from groundwater and rice by residents in Prey Veng Province, Cambodia. *Environmental Pollution*, **185,** 84–89.

Groundwater, rice and fingernail samples were randomly collected from residents in Prey Veng Province and analysed for arsenic (As) using inductively coupled plasma mass spectrometry. Daily intake of inorganic arsenic was found to be at a level associated with increased incidence of lung cancer. Author: kongkeaphan@gmail.com

Ruangsivakul, S., Sornkliang, J. & Suasi, T. (2013) Revealing the socio-economic features of small-scale fisheries in Southeast Asia. *Fish for the People,* **11,** 2–15.

A very detailed report on the findings from a 2011–2012 socio-economic survey in seven countries, including Cambodia (specifically Sihanoukville Province). In some 40 coastal fishing villages, about one million Cambodians are employed in fishing and fish processing. Cambodia's fishers tend to be younger than their counterparts from other countries and less educated, with 35% having had no schooling at all. Nearly four-fifths have other occupations in addition to fishing, notably farming, and they believe further diversification is necessary. Their earnings tend to be below the regional average, with more than half of Cambodia's fishers earning less than US$ 150 per month. This country has the highest percentage of fishers with loans (72%), and many identified the need for micro-credit schemes and government subsidies. More than one fifth have no boat at all. None of the small Cambodian fishing boats in this survey were licensed. Most Cambodian fishers fish all year, often changing their gears to match the seasonal availability of fish and other aquatic resources. The greatest problems reported by Cambodian fishers were the impacts of climate change, illegal fishing and the falling quality and abundance of fisheries resources. Four-fifths also expressed lack of confidence in their safety at sea. Author: sumitra@seafdec.org; Online: http://www.seafdec.org/download/fish-for-the-people-vol-11-no-2/

Shaheed, A., Orgill, J., Ratana C., Montgomery, M.A., Jeuland, M.A. & Brown, J. (2013) Water quality risks of 'improved' water sources: evidence from Cambodia. *Tropical Medicine & International Health*. Article first published online 20 November 2013, doi: 10.1111/tmi.12229

This study investigated the quality of on-plot piped water and rainwater at the point of consumption in Kandal Province. Rainwater was the most commonly used source of drinking water, but households mixed different water sources in storage containers, including 'improved' with 'unimproved' sources. Piped water from taps deteriorated during storage, with *Escherichia coli* (faecal bacteria) rising from 520 to 1,100 cfu/100 ml. Stored non-piped water had an even higher mean *E. coli* count of 1,500 cfu/100 ml. Microbial contamination of stored water was associated with poor storage and handling practices. Thus, the quality of 'improved' water sources is not maintained at the point of consumption, posing risks of diarrhoeal diseases. Author: joe.brown@lshtm.ac.uk

Thol D. & Sato, J. (2013) *State–Society Relations in Natural Resources: A Case Study on Fishery Politics in Cambodia*. University of Tokyo, Tokyo, Japan.

While many governments enclose natural resources for economic development, Cambodia appears to have taken the opposite course. In 2001, the government reformed the management of its fisheries by reducing the size and number of fishing lots in the Tonle Sap Great Lake, and turned 56% of private fishing sites into open access areas. In 2011–2012, the government again intervened by closing all fishing lots in the lake, and allocating more than 70% of the areas to communal use. The government indicated its main purpose was to reduce conflict and conserve the lake's resources, but there may be other reasons, including appeasing voters. The authors argue that the outcome may be poorer governance of the lake's ecology as well as the economy. Author: tholdinajp@gmail.com

Tsujimoto, K. & Koike, T. (2013) Land-lake breezes at low latitudes: the case of Tonle Sap Lake in Cambodia. *Journal of Geophysical Research: Atmospheres*, **118,** 6970–6980.

After the monsoon season, a small linear cloud system has been observed over the Tonle Sap Lake in the early morning, while the sky above the surrounding land is clear. Simulations show a linear updraft system forms along the southwest lake shore around 2200 h and moves northeast to the middle of the lake. Heavier air from the land meets the extraordinarily warm and humid air mass that forms over this relatively shallow lake, triggering updrafts. This unique feature generates a distinct nocturnal land breeze circulation over the lake, in spite of its low latitude. Author: tsujimoto@hydra.t.u-tokyo.ac.jp

Forests and forest resources

Baird, I.G. (2013) 'Indigenous peoples' and land: comparing communal land titling and its implications in Cambodia

and Laos. *Asia Pacific Viewpoint,* **54,** 269–281.

The 2001 Land Law recognised, for the first time, a new legal category of people: 'indigenous peoples' or *chuncheat daoem pheak tech*. It also introduced the legal concept of communal land rights. The 2002 Forestry Law followed suite by formally recognising indigenous peoples. When compared with the mechanism for developing communal land rights in Laos, the author asks whether it is advantageous to adopt indigenous identities, and examines the types of communal land and community forestry rights that are presently possible in Cambodia. Author: ibaird@wisc.edu

Baird, I.G. (2013) Shifting contexts and performances: the Brao-Kavet and their sacred mountains in Northeast Cambodia. *Asian Highlands Perspectives,* **28,** 1–23.

The Brao-Kavet are an indigenous ethnic group in northeastern Cambodia and southern Laos. Many members have livelihood and spiritual links to forested mountainous areas, such as the Haling-Halang, a pair of high mountains in Virachey National Park. The Brao-Kavet do not hunt wildlife on these mountains or fell trees, but may collect a thin bamboo for drinking beer after making offerings to the mountain spirits. The author argues in favour of indigenous-supported biodiversity conservation and for recognising the Brao-Kavet indigenous rights to land and other resources in Virachey National Park. Author: ibaird@wisc.edu; Online: http://plateauculture.org/sites/plateauculture.org/files/writing/shifting-contexts-and-performances-brao-kavet-and-their-sacred-mountains-northeast-cambod

Chan S., Sasaki, N. & Kobayashi, S. (2013) Reducing deforestation and forest degradation in Phnom Tbeng forests. *International Journal of Environmental and Rural Development*, **4,** 19–24.

Tropical deforestation is responsible for up to 25% of global carbon emissions. Phnom Tbeng, in Preah Vihear Province has 41,530 hectares of evergreen forest, semi-evergreen forest, deciduous forest and other forest types. This study suggests that a carbon project in this site could reduce carbon emissions by about 3.7 million tonnes of CO_2 over a 30-year project. Depending on carbon prices, revenue could be US$ 600,000 per year for a 30-year REDD+ project cycle. In addition to carbon revenue, well-protected forests bring other ecosystem benefits to local people. Success, however, would depend on appropriate policies and measures to reduce the drivers of deforestation and forest degradation, underpinned with law enforcement. Online: http://iserd.net/ijerd41/41019.pdf

Charoenpol, K., Kheoruenromne, I., Suddhiprakarn, A. & Charuppat, T. (2013) Assessment on land use of Phanom Dong Rak Mountain Range. *Thai Journal of Agricultural Science,* **46,** 1–10.

Land use in the Phanom Dong Rak mountain range has been affected by the conflict between Thailand and Cambodia over ownership of Phra Viharn Temple. Analysis of satellite images in 2001, 2006 and 2011 found a net increase in dry evergreen forest cover in Thailand's Phanom Dong Rak Wildlife Sanctuary, outside of the disputed territory, except in a few parts cleared by villagers. In Cambodia the natural forest cover decreased, and new roads, military posts and villages were established. The authors conclude that land use in Cambodia has changed in response to political forces, while the changes in Thailand reflect socio-economic factors and the government's policy on forest protection. Author: agrrbk@ku.ac.th

Estoria, E. (2013) *Improving the implementation of CBNRM in indigenous communities in Ratanakiri Province, Cambodia.* PhD thesis, University of Queensland, Brisbane, Australia.

This study focused on a Community Based Natural Resources Management (CBNRM) project involving indigenous communities in Ratanakiri Province to address their loss of access and control of their traditional territories. This thesis concludes that there are opportunities for participatory CBNRM, even within the prevailing top-down governance systemsm and essential components include gaining the support of key decision makers and building local capacity. To enable indigenous peoples to become equal partners in implementing CBNRM, they should be granted tenure of their traditional territories, backed up with policies to legitimize their rights. Author: Estela.Estoria@toowoombaRC.qld.gov.au

Halperin, J.J. & Turner, R.L. (2013) *Forest Degradation in Cambodia: an Assessment of Monitoring Options in the Central Cardamom Protected Forest*. United States Forest Service, Pacific Southwest Research Station, Washington DC, USA.

The Central Cardamom Protection Forest (401,313 ha) was established in 2002 in Koh Kong, Pursat and Kampong Speu provinces in Southwest Cambodia. Only 1,600 people live inside this area. This study devised and tested three steps for monitoring forest degradation: defining biomass references for monitoring in each forest strata of interest, assessing the scale and intensity of the drivers of forest degradation, and identifying and assessing monitoring approaches based on defined biomass change thresholds. The recommended approaches entail a combination of ground-based field measurements—many of which could be implemented by Forestry Administration rangers— remotely sensed imagery, and predictive modelling. Author: rlturner@fs.fed.us; Online: pdf.usaid.gov/pdf_docs/pnaec275.pdf

Hendrickson, M., Hua Q. & Pryce, T.O. (2013) Using in-slag charcoal as an indicator of 'terminal' iron production within the Angkorian period (10th to 13th C. CE) centre of Preah Khan of Kompong Svay, Cambodia. *Radiocarbon*, **55,** 1–17.

Evidence is presented of a major iron production industry near Phnom Dek ("Iron Mountain"), the richest known source of iron oxide in Cambodia. Carbon dating of charcoal from surface slag cakes indicate that metallurgy was practiced at various locations within Preah Khan during the mid-13th to late 17th centuries, with three distinct clusters between the late 13th and late 15th centuries. The Kuay, or Kuay Dek ("Iron People") are believed to have continued smelting iron using the bloomery process until the mid-20th century. Many of the surface slag piles are enormous. Production of iron on this industrial scale would have consumed vast quantities of charcoal, produced from the surrounding forests. The authors were unable to identify the species of trees used. Online: http://www.academia.edu/4034636/Using_in-slag_charcoals_as_an_indicator_of_terminal_iron_production_within_the_Angkorian_period_10th_to_13th_c._CE_centre_of_Preah_Khan_of_Kompong_Svay_Cambodia

Ichikawa, K. (2013) Understanding socio-ecological production landscapes in the context of Cambodia. *International Journal of Environmental and Rural Development*, **4,** 57–62.

Many Cambodians depend on agriculture, forestry and fisheries, but their livelihoods are threatened by the deteriorating condition of the natural environment. This study found parallels between the multiple-use landscapes in Cambodia and the mixed agricultural and forestry landscapes in Japan, which have been shaped by people working with nature to achieve sustainable production. The landscapes of Cambodia's hill areas, for example, are often a mosaic of evergreen forests, semi-evergreen forests, deciduous forests, shrubs and grasslands, chamkar areas, home gardens, cash crop fields, and settlements. Online: http://iserd.net/ijerd41/41057.pdf

Ironside, J. (2013) *Thinking outside the fence: exploring culture/land relationships, a case study of Ratanakiri Province, Cambodia*. PhD thesis, University of Otago, Dunedin, New Zealand.

Ratanakiri Province has been undergoing rapid land use change for more than a decade. This thesis explores this process, in particular, the privatization of communally owned landscapes of forest fallows and swidden agriculture fields for cash cropping (cashews, soybeans, cassava and more recently rubber) by outside farmers and companies, versus the attempts to secure the lands of Ratanakiri's indigenous communities through communal land titling. Online: http://otago.ourarchive.ac.nz/bitstream/handle/10523/4364/IronsideJeremy2013PhD.pdf?sequence=1

Keating, N.B. (2013) Kuy alterities: the struggle to conceptualise and claim indigenous land rights in neoliberal Cambodia. *Asia Pacific Viewpoint,* **54,** 309–322.

Based primarily on fieldwork with Kuy people in Rovieng District, Preah Vihear Province, this article examines the effects of land concessions such as the Delcom mining concession. Although the 2001 Land Law enables indigenous peoples to gain communal land tenure, it has largely failed to protect their rights due to persistent discrimination against indigenous minorities and the state's use of land concessions for economic development. The Kuy peoples' classification as ethnic minorities is recent, and in the past they played more active roles in Cambodian state-building projects. Author: nkeating@brockport.edu

Milne, S. (2013) Under the leopard's skin: land commodification and the dilemmas of indigenous communal title in upland Cambodia. *Asia Pacific Viewpoint,* **54,** 323–339.

Two opposing land tenure policies are taking place in Cambodia's uplands: indigenous communal title—the product of a decade of advocacy for indigenous rights—and Order 01 to provide private individual titles to farmers on state public land. This has caused confusion among indigenous villagers, who must weigh up the risks and constraints of communal versus individual tenure. One mixed Bunong-Khmer village in Mondulkiri has experienced rapid deforestation and market integration since 2005. When individual titling commenced in 2012, communal land claim was abandoned by one quarter of its constituents. Author: sarah.milne@anu.edu.au

Ou R. & Terauchi, M. (2013) Using choice experiment to estimate the value of sustainable rattan resource management in Cambodia. *International Journal of Environmental and Rural Development*, **4,** 88–94.

Rattan generates approximately US$ 1.5 million of revenue per year in Cambodia. Prek Thnot community, Kampot Province, was selected for a sustainable rattan management programme comprising nursery management, enrichment planting and a harvesting plan. Interviews with 324 families revealed 93% were willing to pay a tax fee through a revolving fund to manage their natural resources. Even though they did not expect benefits from REDD+, they were willing to pay more to increase populations of endangered species and restore their rattan resources through conservation and enrichment planting in degraded and over-harvested areas. Author: ratanak.ou@gmail.com; Online: http://iserd.net/ijerd41/41088.pdf

Ra K. & Sasaki, N. (2013) Assessment of local livelihood of forest-dependent communities in Cambodia. *International Journal of Environmental and Rural Development*, **4,** 63–68.

Cambodia's forest subsector contributed 8.4% to agricultural GDP between 1999 and 2008. To assess the contribution of forest goods and services at the local level, 600 households were interviewed in Takaen, Sangke Satob, and Tumring communes in Kampot, Kampong Spoeu and Kampong Thom provinces, respectively. Income from forest products was found to contribute an average of 76,892 riels or 13% of household income in the first quarter of the year, rising to 142,645 riels (24%), 146,422 riels (33%)

and 122,512 riels (31%) in the second, third and fourth quarters, respectively. The importance of such resources should be incorporated into development planning with the active participation of local people to ensure there can be sustainable development while also conserving the forests. Online: http://iserd.net/ijerd41/41063.pdf

Sasaki, N., Abe, I., Khun N., Chan S., Ninomiya, H. & Chheng K. (2013) Reducing carbon emissions through improved forest management in Cambodia. *Low Carbon Economy*, **4,** 55–67.

Carbon emissions from selectively logged forests in the tropics are heavily affected by logging practices. This report calculates carbon stocks, timber supply and carbon emission reductions under conventional logging, reduced-impact logging (RIL), and reduced-impact logging with special silvicultural treatments (RIL+) across 3.4 million ha of concession forests in Cambodia. Carbon emissions under conventional logging were estimated to be 12.4 Tg CO_2 per year. The currently accepted 25-year cycle is too short, and a 45-year selective cutting cycle is required to maintain commercial timber supply and reduce carbon emissions. If RIL or RIL+ are used, carbon credits from selective logging in Cambodia would be 6.2–7.9 Tg CO_2 or about $31.0–39.5 million annually. The authors conclude that RIL or RIL+ should be adopted for the "sustainable management of forests" element of the REDD+ scheme. Author: nopsasaki@gmail.com; Online: http://www.google.co.uk/url?sa=t&rct=j&q=&esrc=s&source=web&cd=2&ved=0CDgQFjAB&url=http%3A%2F%2Fwww.scirp.org%2Fjournal%2FPaperDownload.aspx%3FpaperID%3D40374&ei=7QfeUsSJGsas0QX26IDYBg&usg=AFQjCNHHLs-PjoQoobQSIcG-X5pTDTYBUA&bvm=bv.59568121,d.d2k&cad=rja

Seak S., Phat C. & San V. (2013) Importance of forest ecosystem services for the livelihoods of a rural community in O'Som Commune, Pursat Province, Cambodia. *Research Papers*, **1,** 5–22.

This paper examines the value of forest resources to the livelihoods of O'Som Commune, Pursat Province. This commune, situated in the Cardamom Mountains, consists of four villages. Many residents collect both forest products and non-timber forest products for domestic consumption (including medicines) and sale (e.g. wild cardamoms). Sales of NTFPs alone amount to an average of 11,426,661 riels per household per year. Residents identified the main causes of forest degradation are illegal logging by new migrants and, linked to this, the construction of a new hydropower dam on the nearby Atay River. Whereas the new migrants tend to cut and clear the forest in response to market demands without thinking about the longer-term health of the environment or the commune's future dependency on forest resources, the indigenous residents are proactive in reporting illegal activities and protecting important forest areas, leading to tensions between the two groups. Online: http://www.researchgate.net/publication/256980238_Importance_of_Forest_Ecosystem_Services_for_the_Livelihoods_of_a_Rural_Community_in_O%27_Som_Commune_Pursat_Province_Cambodia

Singh, R., Phan C., Prum S., Pin C., Ryan, G. & Wright, M. (2013) The Serengeti of Asia: conservation in two major protected areas of the Eastern Plains Landscape Protected Area Complex, Cambodia. *Parks*, **19,** 23–32.

The Eastern Plains landscape of Cambodia still has good forest cover over a large area but wildlife populations remain low after many years of civil unrest and hunting pressure. The Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary have seen modest successes in curbing illegal activities. Conservation efforts include regular monitoring of biodiversity, law enforcement and gaining community support for forest protection through awareness and livelihood interventions. Conservation needs long-term investment, and policy, social and economic factors must be addressed to ensure sustainability. Author: rsingh@wwf.org.my; Online: https://cmsdata.iucn.org/downloads/parks_19_2_singh.pdf

Tong K., Lun P. & Sry B. (2013) *Levels and Sources of Household Income in Rural Cambodia 2012*. Working Paper Series No. 83. Cambodia Development Resource Institute (CDRI), Phnom Penh, Cambodia.

In rural areas, mean annual income was 1,850,000 riels per capita in 2004: 1.9 lower than in Phnom Penh. Rural incomes rose to 2,665,000 riels in 2011, narrowing the gap to only 1.5 times less than in Phnom Penh. The incomes of rural Cambodians come from salaries and wages (37%), "non-farm self employment" (21%), crops (especially rice, 13%), livestock (3%), "forestry and hunting" (3%) and fishing (only 2%). The proportional contribution from fishing, forestry and hunting appears to have halved since 2004. Online: http://www.cdri.org.kh/webdata/download/wp/wp83e.pdf

Turner, R., Halperin, J., Manley, P. & Mortenson, L. (2013) Forest degradation sub-national assessments: monitoring options for Cambodia, Lao PDR, and Vietnam. In *Proceedings of the International Workshop on Monitoring Forest Degradation in Southeast Asia* (eds L.A. Mortenson, J.J. Halperin, P.N. Manley & R.L. Turner). p. 39. General Technical Report PSW-GTR-246, Department of Agriculture, Forest Service, Pacific Southwest Research Station, Albany, CA, USA.

Unlike monitoring of carbon stocks, techniques for monitoring forest degradation are relatively untested in developing countries. This study tested three steps for monitoring forest degradation, including monitoring the drivers of forest destruction. The recommended approaches entail a combination of ground-based field measurements, remotely sensed imagery, and predictive modelling. The study areas included the Central

Cardamom Protection Forest in Southwest Cambodia. Author: rlturner@fs.fed.us

Payments for conservation services, including carbon

Avtar, R., Suzuki, R., Takeuchi, W. & Sawada, H. (2013) PALSAR 50 m mosaic data based national level biomass estimation in Cambodia for implementation of REDD+ mechanism. *PLOS ONE*, **8** (10): e74807

Information about forest biomass is needed to implement climate change mitigation mechanisms related to Reducing Emissions from Deforestation and forest Degradation (REDD+). This study tested the use of Phased Array-type L-band Synthetic Aperture Radar Fine Beam Dual (PALSAR FBD) 50 m mosaic data in Cambodia. PALSAR estimates of above-ground biomass showed good results in deciduous forests, but were less reliable in dense evergreen forests. An above-ground biomass map of Cambodian forests could benefit REDD+ assessment and implementation. Author: ram.envjnu@gmail.com

Chhinh N. & Kong S. (2013) A feasibility study on payment for forest environmental services in Cambodia. *International Journal of Environmental and Rural Development*, **4,** 39–44.

This study combined quantitative and qualitative data sources, including literature reviews, interviews and focus groups discussion. Results showed that Payments for Environmental Services (PES) schemes require well defined ecosystem services, transaction costs that do not exceed the potential benefits, and the flexibility to adapt to changing conditions. Past failures to apply PES systems in Cambodia can be attributed to inequities in benefit-sharing, a lack of management capacity to monitor participants and carry out punitive measures, and poor communication. Factors contributing to successes included low administrative costs, transparency of benefit-sharing to service-providers, and active participation from villagers in complying with the regulations. Payments for forest environmental services could be integrated into REDD mechanisms. Online: http://iserd.net/ijerd41/41039.pdf

Climate change

Chhinh N. & Cheb H. (2013) Climate change vulnerability: household assessment levels in Kampong Speu Province, Cambodia. *International Journal of Environmental and Rural Development*, **4,** 31–38.

Cambodia is highly vulnerable to climate change and has a lower adaptive capacity than other countries in Southeast Asia. Floods and drought are the greatest threats to rural farmers. This study assessed climate change vulnerability at the household level in the drought-prone Kampong Speu Province using a framework developed by the Inter-governmental Panel on Climate Change. Results indicate that drought is the most severe climate hazard, and irregular rainfall often results in crop damage or loss. Adaptations to drought by the farmers include water storage, use of drought-tolerant crop varieties, and developing alternative sources of income. Online: http://iserd.net/ijerd41/41031.pdf

Ek, G. (2013) *Cambodia Environmental and Climate Change Policy Brief*. Sida's Helpdesk for Environment and Climate Change, Göteborg, Sweden.

Cambodia's diverse ecosystems have contributed to economic growth and rising living standards, but the rural poor face increasing challenges due to the rapid decline in natural resources. The country's deforestation rate is among the highest in the world, causing biodiversity loss and many other problems. The loss of ecosystem services and environmental degradation suggests that Cambodia's actual economic growth is significantly lower than its GDP growth rate indicates. Climate change is forecast to create additional pressures, including rising sea levels, salinization of surface and groundwater, increased rainfall and flooding, and fewer fish. Better governance is key for more sustainable development. Author: goran.ek@slu.se

Martin, R.J. & Van T. (2013) Pilot case studies of climate risk-coping strategies of small-scale farmers in Cambodia. *International Journal of Environmental and Rural Development*, **4,** 106–111.

Cambodia is predicted to experienced increased temperature and rainfall, with a wetter monsoon but less rainfall in the dry season. Climate change mitigation planning has focused on technical interventions and disaster relief rather than adaptive responses. This paper examines risk-coping strategies currently employed by small rice farmers in Trapeang Ruessei Commune in Kampong Thom Province and Snam Krapeu Commune in Kampong Speu Province. Even today, these households cannot survive on farm income alone, especially during droughts, and rely on other jobs when they need extra money. Researchers and policy makers must avoid a narrow mind-set on agricultural solutions to understand how small farmers can diversify their livelihoods to cope with climate change. Online: http://iserd.net/ijerd41/41106.pdf

Human History

Padwe, J. (2013) Highlands of history: indigenous identity and its antecedents in Cambodia. *Asia Pacific Viewpoint*, **54,** 282–295.

The notion that highland people may claim a distinct 'indigenous' identity has emerged only recently in Cambodia. Among the problems faced by advocates for indigenous rights are problems of definition and

translation. This paper explores our understanding of who highlanders are. The use of the Khmer word *daeum* ('original') for indigenous and other ethnic groups points to historical beliefs about highlanders being the living ancestors of modern Khmers. Author: padwe@hawaii.edu

Swift, P. (2013) Changing ethnic identities among the Kuy in Cambodia: assimilation, reassertion and the making of Indigenous identity. *Asia Pacific Viewpoint*, **54,** 296–308.

The Kuy are one of the largest indigenous groups in Cambodia. Though similar to the Khmer in physical appearance and material culture, a significant distinction between the two groups has been maintained. Recently, some people have reasserted their Kuy identity, driven by awareness of the benefits of being recognised as indigenous peoples and by a lessening of the prejudice against Kuy identity. Author: pswift@wisc.edu

Forestier, H., Heng S., Puaud, S., Mourer, R., Billault, L., Philippe, M. & Zeitoun, V. (2013) New evidence of old stone tools from the Mekong terraces, Cambodia. *Comptes Rendus Palevol.* First available online 24 November 2013.

Prehistoric stone tools collected several decades ago on the Mekong Terraces in central Cambodia were originally dated to the start of the Middle Pleistocene. This paper presents further analysis of these and other, more recently discovered prehistoric tools to understand early human occupation of Asia. Author: hubforestier@gmail.com

Regional Reviews

Das, I. & van Dijk, P.P. (2013) Species richness and endemicity of the herpetofauna of South and Southeast Asia. *Raffles Bulletin of Zoology*, **Supplement No. 29,** 269–277.

South and Southeast Asia have a highly diverse array of reptiles and amphibians. Rainforests at lower elevations are the richest habitats in terms of number of species, and different rainforest ecoregions share relatively few species. Knowledge of the region's herpetofauna remains poor, but sufficient to indicate regions of high conservation value. Cambodia contains part or all of several recognised ecoregions, principally the Tonle Sap Freshwater Swamp Forests, Cardamom Mountains Rain Forests and parts of the more extensive Central Indochina Dry Forests and Southeastern Indochina Dry Evergreen Forests. Author: idas@ibec.unimas.my; Online: http://rmbr.nus.edu.sg/rbz/biblio/s29/s29rbz269-277.pdf

Miscellaneous

Durnez, L., Mao S., Denis, L., Roelants, P., Tho S. & Coosemans, M. (2013) Outdoor malaria transmission in forested villages of Cambodia. *Malaria Journal*, **2013,** 12:329.

Large-scale control of mosquitoes that carry malaria currently comprises the free distribution of long-lasting insecticidal nets that target indoor- and late-biting species. Mosquitoes were sampled in 12 villages and nearby forest plots in East and West Cambodia. Test results showed 29% of infectious bites occurred before people go to bed, and 65% while they were in the forest. While deforestation might reduce densities of the primary vectors, secondary vectors tend to invade deforested areas, resulting in more infections. Additional control measures should be developed to target outdoor-biting and early-biting mosquitoes. Author: ldurnez@itg.be; Online: http://www.malariajournal.com/content/pdf/1475-2875-12-329.pdf

Ellis, K., Keane, J., Lemma, A. & Lonn P. (2013) *Low Carbon Competitiveness in Cambodia.* Overseas Development Institute, London, UK.

Climate change, international mitigation policies, and decreasing natural resources will transform global trade patterns over the next decade, creating both opportunities and threats. Investment in hydropower and an improved electricity supply may improve Cambodia's competitiveness, but hydropower is seasonal and vulnerable to climate change. Other renewable energy sources are required to improve energy security and competitiveness in the long term. Further growth of the tourism industry could also yield significant economic and environmental benefits, but must be well managed to ensure it is sustainable and to strengthen Cambodia's brand as a "green tourism" destination. Online: http://www.odi.org.uk/sites/odi.org.uk/files/odi-assets/publications-opinion-files/8592.pdf

Sour S., Chin S. & Wildblood, R. (2013) Municipal solid waste management in Cambodia. In *Municipal Solid Waste Management in Asia and the Pacific Islands* (eds A. Pariatamby & M. Tanaka), pp. 77–94. Springer Singapore, Singapore.

Cambodia's fast-growing and increasingly urbanized population generates approximately 6.8 million tonnes of waste per year, or 0.487 kg per person per day. This is comprised of 60–80% organic waste and about 15% plastics. Waste management is contracted to private companies who focus more on profits than environmental and public health concerns. Existing dump sites are poorly designed, creating environmental and social problems. There is a need to enforce existing waste management legislation and raise awareness of its existence. Author: ssethy@yahoo.com

The Recent Literature section was compiled by JENNY C. DALTRY, with additional contributions from Oleg Kosterin, Berry Mulligan, Chan Kin Onn, Frédéric Goes and Nicholas Souter. All Internet addresses were correct at the time of publication. Please send contributions (published or grey literature, including project technical reports and conference abstracts not more than 18 months old) by email to: Editor.CJNH@gmail.com

Instructions for Authors

Purpose and Scope

The *Cambodian Journal of Natural History* is a free journal that is 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. Authors are, however, 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, the Journal is freely available online at: http://www.fauna-flora.org/publications/cambodian-journal-of-natural-history/

Papers and Short Communications

Full Papers (2,000–7,000 words) and Short Communications (300–2,000 words) are invited 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.
- Research on the sustainable use of wild species.
- Abstracts of student theses (Short Communications only).

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.

How to Submit a Manuscript

Manuscripts should be submitted by email to the Editors at **Editor.CJNH@gmail.com** In the covering email, the Lead (Corresponding) Author must 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.

If you have any questions before or after submitting a manuscript, you are welcome to contact the Editors at any time.

Review and Editing

All contributors are strongly advised to ensure that their spelling and grammar is checked by a native English speaker before the manuscript is submitted to the Journal. The Editorial Team reserves the right to reject manuscripts that need extensive editing for spelling and grammar.

All manuscripts will be subject to rigorous peer review by a minimum of two qualified reviewers. Authors are welcome to suggest appropriate reviewers.

Proofs will be sent to authors as a portable document format (PDF) file attached to an email note. Acrobat Reader can be downloaded free of

charge from <www.adobe.com> to view the PDF files. Corrected proofs should be returned to the Editor within three working days of receipt. Minor corrections can be communicated by email.

The Editorial Team welcomes contributions to the journal, as follows:

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.

Preparation of Manuscripts

Authors should consult examples in this issue for general style. First-time authors are also advised to read the Editorial in the *Cambodian Journal of Natural History*, volume 2012, issue 2, entitled "How to write a winning paper" (freely available from http://www.fauna-flora.org/publications/cambodian-journal-of-natural-history/).

Contributions should be in English, with 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', 'rtf' or 'wpd' format, preferably as a single file attached to one covering email. The order of the sections of the manuscript should be: cover page, main text, references, short biography of each author, tables, figures and plates (photographs).

The cover page should contain the title and full mailing address and email address of the Lead Author and the addresses of all co-authors. All pages should be numbered consecutively.

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. There is no need to repeat words that are already in the title.

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 are written in full.

The following are examples of house style:

Papers:

Amano, A. & Kazama, S. (2012) Relationship between discharge and nutrient concentration in inundation areas in Cambodia. *Journal of Water and Environment Technology,* **10,** 165–175.

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.

Miles, L., Newton, A.C., Defries R.S., Ravilious, I. May I., Blyth, S., Kapos, V. & Gordon, J.E. (2006) A global overview of the conservation status of tropical dry forests. *Journal of Biogeography,* **33,** 491–505.

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.

Koh, L.P., Kettle, C.J., Sheil, D., Lee, L.T., Giam, X., Gibson, L. & Clements, G.R. (2013) Biodiversity State and Trends in Southeast Asia. In *Encyclopedia of Biodiversity, Volume 1* (ed. S.A. Levin), 509–527. Elsevier Academic Press, Amsterdam, The Netherlands.

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 every author (<150 words each), apart from what is obvious from the subject of the manuscript and the authors' affiliations.

Tables, figures and plates: These should be self-explanatory, each on a separate page and with an appropriate caption. 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.

Publisher: Centre for Biodiversity Conservation, Room 415, Main Campus, Faculty of Science, Royal University of Phnom Penh, Confederation of Russian Boulevard, Phnom Penh, Cambodia.

The journal online. All issues of this journal can be freely downloaded from:

http://www.fauna-flora.org/publications/cambodian-journal-of-natural-history/

Authors are permitted to post their papers on their personal and institutional webpages on condition that access is free and no changes are made to the content.

Cambodian Journal of Natural History

The preparation and printing of this volume was generously supported by:

Royal University of Phnom Penh—Centre for Biodiversity Conservation

RUPP is Cambodia's oldest university, with over 9,000 students and over 400 teachers. The Department of Biology founded the Centre for Biodiversity Conservation to provide training and support for national scientists. The Centre delivers a Masters of Science curriculum in Biodiversity Conservation and has established a library, classrooms, herbarium and zoological reference collection for use by students and scholars of Cambodian natural science.

Website: http://www.rupp.edu.kh/master/biodiversity/?page=cbc

Fauna & Flora International

FFI protects threatened species and ecosystems worldwide, choosing solutions that are sustainable, are based on sound science and take account of human needs. Operating in more than 40 developing countries worldwide, FFI saves species from extinction and habitats from destruction, while improving the livelihoods of local people. Founded in 1903, FFI is the world's longest established international conservation body. FFI has been active in Cambodia since 1996.

Website: www.fauna-flora.org

The present issue was also supported by a major foundation that chooses to remain anonymous.

The Cambodian Journal of Natural History does not charge subscription fees. The journal depends upon the generosity of its partner organisations and sponsors to be published and distributed free of charge to readers throughout Cambodia and worldwide.

If you or your organisation are interested in supporting the Cambodian Journal of Natural History or the Centre for Biodiversity Conservation, kindly contact the editors (Editor.CJNH@gmail.com) or the staff of the Centre for Biodiversity Conservation (mbiodiversity.info@rupp.edu.kh). The names and logos of all supporters will be published in the journal unless they wish to be anonymous.

The Editors are grateful to Chheang Sarak, Lonnie McCaskill, Neang Thy, Phauk Sophany and Roger Ingle for their kind assistance with the production of this issue.

Cambodian Journal of Natural History

Volume 2013, Number 2

Contents