Cambodian Journal of Natural History

ISSN 2226–969X

Editors
Email: Editor.CJNH@gmail.com

- Dr Neil M. Furey, Chief Editor, Fauna & Flora International, Cambodia.
- Dr Jenny C. Daltry, Senior Conservation Biologist, Fauna & Flora International, UK.
- Dr Nicholas J. Souter, Mekong Case Study Manager, Conservation International, Cambodia.
- Dr Ith Saveng, Project Manager, University Capacity Building Project, Fauna & Flora International, Cambodia.
- Dr L. Lee Grismer, La Sierra University, California, USA.
- Dr Knud E. Heller, Nykøbing Falster Zoo, Denmark.

International Editorial Board

- Prof. Leonid Averyanov, Komarov Botanical Institute, Russia.
- Dr Hugo de Boer, University of Oslo, Norway.
- Prof. Rafe Brown, University of Kansas, USA.
- Prof. Brendan Buckley, Lamont-Doherty Earth Observatory, USA.
- Dr Rainer Bussmann, Missouri Botanical Garden, USA.
- Dr Nicole Duplaix, Oregon State University, USA.
- Dr Jackson Frechette, Fauna & Flora International, Cambodia.
- Dr Peter Geissler, Staatliches Museum für Naturkunde Stuttgart, Germany.
- Dr Timo Hartmann, Zoological Research Museum Alexander Koenig, Germany.
- Dr Sovannmoly Hul, Muséum National d’Histoire Naturelle, Paris, France.
- Dr Brad Pettitt, Murdoch University, Australia.
- Dr Campbell O. Webb, Harvard University Herbaria, USA.
- Dr Syed Ainul Hussain, Wildlife Institute of India.
- Dr Mamoru Kanzaki, Kyoto University, Japan.
- Neang Thy, Ministry of Environment, Cambodia.
- Dr Nguyen Quang Truong, Institute of Ecology and Biological Resources, Vietnam.
- Dr Shoko Sakai, Kyoto University, Japan.
- Dr Bryan Stuart, North Carolina Museum of Natural Sciences, USA.
- Dr Phillip Thomas, Royal Botanical Garden, Edinburgh, UK.
- Dr Santi Wathana, Suranaree University of Technology, Thailand.

Other peer reviewers for this volume

- Dr Sovannmoly Hul, Muséum National d’Histoire Naturelle, Paris, France.
- Dr Brad Pettitt, Murdoch University, Australia.
- Dr Campbell O. Webb, Harvard University Herbaria, USA.

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

Cover image: Chocolate chip seastars (Protoreaster nodosus) in a seagrass meadow near Koh Rong Island (© Paul Colley).

The Royal Government of Cambodia declared the country’s first large-scale marine protected area around the islands of Koh Rong and Koh Rong Sanloem in June 2016 (page 83).
Editorial — Links between biodiversity and health: consequences and opportunities for collaboration

Mathieu PRUVOT1,* & Serge MORAND2,3,4

1 Wildlife Conservation Society, Wildlife Health and Health Policy program, PO Box 1620, No. 21, Street 21, Tonle Bassac, Phnom Penh, 12000, Cambodia.
2 Centre National de Recherche Scientifique and Centre de Coopération Internationale en Recherche Agronomique pour le Développement, Animal et Gestion Intégrée des Risques, F-34398, Montpellier, France.
3 Centre d’Infectiologie Christophe Mérieux du Laos, Vientiane, Laos.
4 Department of Helminthology, Faculty of Tropical Medicine, Mahidol University, Bangkok, Thailand.

* Corresponding author. Email mpruvot@wcs.org

The relationships between biodiversity and the health of people, livestock, and wildlife have been increasingly recognized and documented in recent decades (Millennium Ecosystem Assessment, 2005; Myers et al., 2013; Hough, 2014; WHO, 2015). In attempting to understand the practical implications of these links, one inevitably stumbles on their complexity and sometimes contradictory nature. One consequence of this is difficulty in aligning the policy agendas and activities of the conservation and health sectors (Chivian & Bernstein, 2008; Hough, 2014). In the interests of promoting beneficial collaborations between these sectors, we briefly illustrate the diversity of these relationships using examples from Cambodia, and highlight the complementary nature of conservation and health initiatives through examples of ongoing projects and potential opportunities.

Strong economic growth in Cambodia, with a stable 7% GDP growth over the past six years, has led to improvements in several development and health indicators (World Bank, 2016). However, rapid rates of deforestation, agricultural growth, and urbanization represent major challenges to ecosystem and biodiversity conservation, and offer mixed prospects for animal and public health (NBSC, 2014).

One of the most obvious connections between biodiversity and health is through provisioning services (Millennium Ecosystem Assessment, 2005). Many of Cambodia’s rural communities still rely heavily on wildlife and non-timber forest products for their subsistence and nutritional needs, similar to other parts of Southeast Asia and the world (Golden et al., 2011; Johnson et al., 2012). However, wildlife consumption has also caused major infectious disease outbreaks (e.g., SARS, HIV, Ebola) and continues to be a driver of disease emergence (Karesh & Noble, 2009; Greatorex et al., 2016). Overfishing and over-hunting are also driving biodiversity declines in many of Cambodia’s landscapes (Valbo-Jørgensen et al., 2009; Gray et al., 2012), further affecting food chains in these ecosystems and compromising the nutritional status and survival of wildlife (O’Kelly et al., 2012). Conversion of biodiverse areas to monocultures and agriculture intensification have increased chemical pollution with severe health consequences for wildlife, livestock, and humans (Monirith et al., 1999; Neufeld et al., 2010; Wang et al., 2011; WCS, 2016). Smoke from forest fires used to clear land also cause significant respiratory issues, particularly in children (Jayachandran, 2009). When natural habitats are destroyed, the vegetal and microbial diversity that have allowed many biomedical discoveries supporting human and animal health (e.g., anti-microbial drugs) are also lost. These biota also support the health of rural and indigenous communities through traditional medicine (Hout et al., 2006; Chea et al., 2007). Although conservation of medicinal plants can be used to promote sustainable use and forest protection (e.g., Laval et al., 2011), some of the beliefs and practices involving the use of animal parts for traditional medicine pose a considerable threat to wildlife (Sodhi et al., 2004; Starr et al., 2010) and will likely continue to result in species extinctions (Courchamp et al., 2006).

A wide range of regulating and supporting ecosystem services (Millennium Ecosystem Assessment, 2005) are related to wildlife, livestock, and human health. Intact ecosystems may help in regulating pests and infectious diseases (WHO, 2015). However, the relationships between biodiversity and infectious diseases are complex, highly context-dependent, and much debated (Johnson & Thieltges, 2010; Randolph & Dobson, 2012; Ostfeld, 2013). In some circumstances, diversity of host species plays a regulating role through the combined
action of host competition and differential host susceptibility to pathogens (i.e. the dilution effect) (Keesing et al., 2010), while in others, it can be a source of pathogens and result in their amplification (Randolph & Dobson, 2012). Higher biodiversity often results in higher pathogen diversity, but a pathogen-rich ecosystem may not necessarily be an issue; rather it is the loss of ecosystem integrity and increased contact with invasive hosts (including humans and livestock) that may increase disease emergence risks (Patz et al., 2004). For instance, the overall richness of infectious diseases in the Asia-Pacific region is positively correlated with the richness of birds and mammals, but the number of zoonotic disease outbreaks are positively correlated with the number of threatened wildlife species, while vector-borne disease outbreaks are negatively correlated to the percentage of forest cover (Morand et al., 2014). Encroachment into natural areas, logging and road development, increased contact between wildlife, livestock and humans, and modification of host and vector communities are some of the factors linking ecosystem disturbance to disease emergence (Horby et al., 2013; Jones et al., 2013). Threats of disease emergence are by no means limited to humans and livestock, and their consequences for wildlife conservation can be dire. Large epidemics of chytrid fungus in amphibians and canine distemper virus in wild carnivores, for instance, are driving declines in many species (Hatcher et al., 2012; Kolby & Daszak, 2016). In Cambodia, there is still much to learn about how infectious diseases may challenge conservation efforts, and the current interest in wildlife farming (intended to reduce hunting pressure on wild populations) is likely to create more interfaces that increase the risk of disease emergence (WCS & FPD, 2008). Finally, most regulating or supporting ecosystem services have direct or indirect impacts on animal and human health at various scales. Water and nutrient cycles, carbon sequestration, and pollination all have complex relationships with factors that influence pathogen transmission, nutrition and other health outcomes. Exposure of humans to biocultural environments has also been linked to the ability to mount adequate immune response and prevent autoimmune diseases (WHO, 2015). The social and psychological impact of habitat degradation on society is also increasingly documented (Speldewinde et al., 2009), as is the positive effect of experiencing nature on mental and physical well-being (Bratman et al., 2012).

Given the diverse relationships between biodiversity and health, any policy or intervention directed to one sector will inevitably affect the other (Walther et al., 2016). In recognition of the complex connections between the environment, wildlife, livestock, humans and pathogens, the concepts of “One Health”, “EcoHealth” and “Planetary Health” have emerged to promote integrative and trans-disciplinary approaches to their study (Roger et al., 2016). These are all initiatives and frameworks that foster collaboration between the livestock, human and wildlife health sectors, and encourage an ecosystem approach to health. Although these efforts have improved coordination between public and animal health, much more can be done to increase collaboration between health sectors and conservation initiatives.

Field personnel in protected areas and individuals that directly work with wildlife (e.g., law enforcement, wildlife monitoring) are typically at the forefront of unusual events in wildlife and constitute an important interface with wild animals and the pathogens they carry. Such field capacity is invaluable for wildlife health surveillance. Biodiversity monitoring is in many cases a powerful indicator of health-related factors (e.g., lichens and air quality, arthropods and soils, aquatic organisms and aquatic systems) (WHO, 2015). Disease outbreak and mass mortalities in wildlife can also provide a warning sign for health issues in livestock and humans, irrespective of whether the origin is infectious (e.g., West-Nile virus, Yellow fever, Ebola) or non-infectious. The latter is illustrated by the recent detection of wildlife deaths in Preah Vihear Province from pesticide contamination of the environment, also affecting livestock and humans (WCS, 2016). An important consequence is that staff working in protected areas need to understand the risks of zoonotic disease transmission and other health risks, and to adopt adequate protective measures in their activities. Collaboration between conservation and health organizations could do much to improve detection of these events and ensure prompt identification of the underlying issues and appropriate responses. This is currently being done under a EU-funded LACANET (Lao PDR – Cambodia One Health Network) project which links field capacity and wildlife health expertise (within the Wildlife Conservation Society) with animal and public health partners, and trains staff in Cambodia’s protected areas to organize wildlife health surveillance (LACANET, 2016). The project is also conducting research on the factors that are driving biodiversity loss and disease emergence (e.g., land-use change, wildlife trade). This presents an opportunity to address conservation challenges in a new way, as health is a value broadly shared across cultural and socio-economic groups, and can be used to generate support for conservation initiatives when overlapping objectives are identified. In addition, many conservation NGOs have long-standing relationships with local communities and particular landscapes, which makes them particularly well-positioned to facilitate health-related projects and interven-
tions. Engagement on health issues could also strengthen these ties. Conservation organizations should include health as one of their conservation tools, and reach out to health organizations to identify potential collaborations. In a resource-limited context, it is also imperative to optimize the use of resources, and take advantage of these potential synergies. This includes the appropriate use of wildlife by limiting the use of lethal sampling for health studies, and collaborating with local collections (such as the zoological collection of the Centre for Biodiversity Conservation at the Royal University of Phnom Penh [RUPP]) and bio-banking efforts (such as the RUPP Conservation Genetics laboratory) when wildlife mortality is beyond the control of project implementers.

The complementarity of the conservation and health sectors should be better utilized as part of the multiple projects that follow the “One Health” framework (i.e. multi-disciplinary ecosystem approach to health), and could improve assessments of the respective impacts of health and conservation interventions on conservation and health outcomes. For instance, when community access to wildlife is critical to maintain nutrition in protected areas, but no longer acceptable due to population declines, conservation organizations could seek the support of animal production and animal health partners to find alternative strategies addressing such issues. Similarly, disease risks related to wildlife consumption, when appropriately documented, may also be a strong argument to encourage reductions in wildlife hunting and trade, and the health sectors should work closely with conservation partners to translate findings into useful outreach material. Additionally, because strategies used by conservationists in Cambodia are diversifying (e.g., the Wildlife Conservation Society and Fauna & Flora International support the recovery of wild populations of Mangrove Terrapin (*Batagur affinis*) and Siamese crocodile (*Crocodylus siamensis*) through headstarting, captive breeding and reintroduction, whereas BirdLife International use livestock to perform the ecological roles once played by large ungulate populations in Western Siem Pang), needs for expertise in veterinary care, animal health and husbandry must be appropriately assessed to ensure the health and well-being of the animals, and ultimately the success of these efforts. Consultation with appropriate animal health expertise at the planning stage is therefore essential, as reactive measures usually come too late to adequately identify and address underlying issues. Similarly, although many wildlife health projects in Cambodia in recent years have been implemented under the One Health umbrella, their links to conservation have often been an after-thought. Maintaining a dialogue between wildlife health and conservation actors is essential to ensure that the wildlife health activities also meet questions and needs related to species conservation, and identifies these during the onset of projects.

In short, improving collaboration between conservationists and practitioners from the human, livestock and wildlife health sectors is critical. Joint planning should aim at identifying complementarity and aligning objectives, and organize coordinated activity implementation and integrated actions. This is not only a morally responsible use of resources, but is also necessary to harness synergies that already exist in nature.

References


LACANET (2016) Lao PDR-Cambodia One Health Surveillance and Laboratory Network. [accessed 23 August 2016].


Learning from observational data to improve protected area management

Hunting is a key driver of biodiversity loss, particularly in Southeast Asia where the illegal trade in wildlife is rife. To effectively prevent poaching, protected area (PA) managers require reliable, accurate information about poaching prevalence, poacher identities and behaviour. In many PAs managers rely on ranger-collected data and tools such as SMART to collect this information, monitor threats and plan law enforcement strategies. While ranger-collected data can provide important information, their potential can only be realised when biases inherent in the data collection process are properly accounted for. Recording of illegal activities is influenced by many factors, most importantly that the fundamental purpose of patrols is to change the behaviour of offenders. This makes the analysis of ranger-collected data extremely complex.

In January 2016 a research project entitled “Learning from observational data to improve PA management” was launched to improve the use of ranger-collected data for PA management. The project is funded by the UK’s Natural Environment Research Council and is a three-year collaboration between scientists at the Universities of Edinburgh, Oxford and York in the UK and the Wildlife Conservation Society in Cambodia. An inception workshop was held in Phnom Penh and Keo Seima Wildlife Sanctuary (KSWS), Mondulkiri in May 2016 and was attended by government and NGO representatives. The project has two strands: 1) a modelling component simulating patrol and poacher behaviour to understand how patrol data can best be used to inform law enforcement strategies; 2) a fieldwork component based in KSWS which will investigate poaching prevalence and poacher decision-making, determine how patrol efforts affect snare detection rates and assess the factors that motivate rangers on patrol, and provide data to empirically validate our models. Our overall objectives are to create simple, practical rules of thumb to enable PA managers to accurately interpret their patrol data, and to provide specific information to support management of KSWS.

Dr Aidan KEANE (University of Edinburgh), Harriet IBBETT (University of Oxford) & Prof E.J. MILNER-GULLAND (University of Oxford). Email: aidan.keane@ed.ac.uk, harriet.ibbett@zoo.ox.ac.uk, ej.milner-gulland@zoo.ox.ac.uk

Development of guidelines for wetland wise use in Cambodia

The Wildfowl and Wetlands Trust (UK) is working with the Department of Freshwater Wetlands Conservation in the Cambodian Ministry of Environment and BirdLife International (Cambodia) to develop “Guidelines for wetland wise use”. The guidelines will appear in the form of a handbook for wetland site managers and other stakeholders and will include practical information on approaches and techniques that can be used to effectively manage wetlands for the benefit of people and biodiversity, specifically focussing on the issues and challenges that wetlands face in Cambodia.

To facilitate development of the guidelines, a consultation workshop was held in August 2016 at the Sunway Hotel in Phnom Penh. This was attended by over 40 participants, including representatives from the Cambodian Ministry of Environment and other government ministries, the Royal University of Phnom Penh, Panhasasra University and several NGOs. The workshop introduced the rationale behind the need for guidelines to promote wise use of wetlands in Cambodia, and provided an opportunity for stakeholders to discuss management challenges and important aspects that should be included in the guidelines.

Following the workshop, an accompanying study tour took place to Boeung Prek Lapouv Protected Landscape in Takeo Province, one of the largest remnants of seasonally-inundated grassland in the Lower Mekong region. The study tour acted as a learning experience, providing participants with an opportunity to see wetland management in practice. The trip also facilitated further discussions on wise uses of wetlands and its outcomes will be used to inform development of the guidelines.

Work has now begun on drafting the guidelines, with a draft due to be released for comments in January 2017. The effort is funded by the UK Government’s Darwin Initiative and the Critical Ecosystem Partnership Fund.

Dr Grace BLACKHAM, Wildfowl and Wetlands Trust, UK. Email: grace.blackham@wwt.org.uk
News

Cambodia’s first large-scale marine protected area declared in the Koh Rong Archipelago

Cambodia achieved a landmark for national marine conservation on 16th June 2016 when the Ministry of Agriculture, Forestry and Fisheries signed a Prakas declaring a 405 km² Marine Fisheries Management Area (MFMA) around the islands of Koh Rong and Koh Rong Sanloem, the country’s first large-scale marine protected area.

This internationally-recognised marine protected area will promote sustainable fishing through government leadership and community-driven action. The Cambodian Fisheries Administration and conservation organisations including Fauna & Flora International and the Song Saa Foundation have worked within the archipelago for over five years to develop the protected area, consulting with local stakeholders and communities and gathering baseline socioeconomic and biological data to support the designation of different zones inside the MFMA.

These zones will ensure that the MFMA supports both people and biodiversity by protecting important and vulnerable habitats (such as nursery and breeding sites), while also allowing for activities such as research, education, sustainable fishing and responsible tourism in other zones. This means that the protected area can sustain vital fisheries while protecting habitats, promoting ecotourism and reducing poverty.

The MFMA is situated approximately 20 km off the coast of Sihanoukville and is home to coral reef, seagrass and mangrove habitats, which support many charismatic species including sea turtles and seahorses. Three Community Fisheries located across the Prek Svay, Daem Thkov, Koh Touch, M’Pai Bai and Sok San villages are represented by locally-elected teams of fishermen who patrol and protect their fishing waters, keeping watch over the MFMA zones and representing their communities at local and national meetings.

Kate WEST & Marianne TEOH, Fauna & Flora International, Cambodia. Email: kate.west@fauna-flora.org, marianneteoh@gmail.com

Capacity building conference for conservation in Asia

Conservation organisations in Asia face a growing diversity of serious environmental issues. Long-term solutions to these problems will require actions by organisations, individuals and communities with the capacity to undertake a range of technical and process-based activities.

The third in a series of four international conferences on capacity building for conservation will be hosted by Pune University, India from 18 to 21 March 2017. The meeting is being organised by Ecological Research & Training Ltd. (UK), the Indian Herpetological Society and Pune University, and will provide a pan-Asian opportunity to review existing capacity initiatives, exchange ideas, develop and enhance networks, and formulate effective solutions to common capacity issues.

The conference has been designed to promote innovative and creative thinking around key issues and to draw on the experience and participation of conference attendees. Five thematic sessions will be led by Asian organisations and begin with invited talks, followed by facilitated workshops with specific tasks. The invited talks will act as demonstration projects to identify core issues, barriers, problems and potential solutions. This will be achieved through structured and facilitated group discussions. The thematic sessions will include:

- Developing and maintaining taxonomic skills in Asia
- Conservation science: building capacity to really use our species and habitat data for conservation action
- Learning from leaders: lessons in achieving organisational goals from five Asian conservation leaders
- Is it working: how can we evaluate the impact of our capacity building efforts?
- Developing a community of practice in Asia

One day of the meeting has also been set-aside to provide conference delegates with a wide range of free training events. Further information and registration forms can be found at the conference website (www.ert-conservation.co.uk/asia_capacity_intro.php).

Dr Mark O’CONNELL, Ecological Research & Training Ltd., UK. Email: mark@ert-conservation.co.uk
Short Communication

New records of Orchidaceae from Cambodia III

André SCHUITEMAN1,*, Christopher RYAN2, NUT Menghor3, NAY Sikhoeun3 & ATT Sreynak3

1 Royal Botanic Gardens, Kew, Richmond, Surrey, TW9 3AB, United Kingdom.
2 Chester Zoo, Upton-by-Chester, Chester, CH2 1LH, United Kingdom.
3 Department of Wildlife & Biodiversity, Forestry Administration, Ministry of Agriculture Forestry and Fisheries, 40 Preah Norodom Boulevard, Phnom Penh, Cambodia.

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

Paper submitted 30 September 2016, revised manuscript accepted 27 October 2016.

In continuation of Schuiteman et al. (2015) and Schuiteman et al. (2016), we here report and illustrate nine orchid species not previously recorded from Cambodia. All but one were found in sterile condition in the field and could only be fully identified once the living specimens collected in November 2013 and May 2015 flowered in the glasshouses at the Royal Botanic Gardens, Kew (UK). The one exception is Cleisostoma birmanicum, which was in full flower when we encountered it. The following are new generic records for Cambodia: Diploprora, Sarcoglyphis, and Stichorkis.

In the interests of conservation we do not provide exact localities. Global distribution data follow Govaerts et al. (2016), unless indicated otherwise. Vouchers of all specimens mentioned are kept in the Kew Spirit Collection.

Species recorded

Cleisostoma birmanicum (Schltr.) Garay (Kew cult. 2015-1358; Figs 1 & 2)

This monopodial epiphyte was found in flower on 15 May 2015, growing in a patch of scrub-like forest on the summit of Mt. Bokor at 1,000 m asl (above sea level). It was previously recorded from Myanmar, Thailand, China (Hainan), Laos (Schuiteman et al., 2008) and Vietnam.

Dendrobium heterocarpum Wall. ex Lindl. (Kew cult. 2013-1685; Fig. 3)

Most of the species of Dendrobium sect. Dendrobium, to which D. heterocarpum belongs, are highly sought after by collectors, both for the horticultural trade and for traditional Chinese medicine (Schuiteman et al., 2008). This may explain why we only found a single specimen of this species in evergreen forest in the southern foothills of the Cardamom Mountains, lying on a forest trail, with its roots cleanly detached from whatever its support had been. It looked as if it had been accidentally dropped by a collector. This is a widespread species, ranging from Sri Lanka and India throughout tropical continental Asia to the Philippines and Indonesia, as far east as Sulawesi.

Dendrobium oligophyllum Simond ex Gagnep. (Kew cult. 2015-1258; Fig. 4)

This small member of Dendrobium sect. Distichophyllae was found about 46 km north of Sen Monorom, Mondulkiri Province, growing as an epiphyte in dry, open forest at 315 m asl. It was previously recorded from Thailand, Laos, and Vietnam.

Diploprora championii (Lindl.) Hook.f. (Kew cult. 2013-1718; Fig. 5)

This small monopodial orchid was found as an epiphyte in rather dry primary evergreen montane forest with little undergrowth at ca. 895 m asl. It is interesting to note that this species and C. birmanicum mentioned above both have a similar forked appendage at the lip apex, the
Nine new orchid records

Fig. 1 *Cleisostoma birmanicum* (Schltr.) Garay. In situ, Mt. Bokor.

Fig. 2 *Cleisostoma birmanicum* (Schltr.) Garay. Flowers.

Fig. 3 *Dendrobium heterocarpum* Wall. ex Lindl. Flower. Kew cult. 2013-1685.

Fig. 4 *Dendrobium oligophyllum* Simond ex Gagnep. Flowering plant. Kew cult. 2015-1258.
Fig. 5 *Diploprora championii* (Lindl.) Hook. f. Flowering plant. Kew cult. 2013-1718.

Fig. 6 *Oberonia falcata* King & Pantl. Inflorescence. Kew cult. 2015-1311.

Fig. 7 *Phalaenopsis difformis* (Wall. ex Lindl.) Kocyan & Schuit. Flowers. Kew cult. 2015-1166.

Fig. 8 *Sarcoglyphis thailandica* Seidenf. Flowers. Kew cult. 2015-1147.
function of which (if any) is unknown. This widespread species ranges from Sri Lanka through tropical continental Asia, including Laos (Schuiteman et al., 2008), to Taiwan.

**Oberonia falcata** King & Pantl. (Kew cult. 2015-1311; Fig. 6)

With its somewhat anthropomorphic flowers this species resembles *O. anthropophora* Lindl. and *O. rufilabris* LindL., both of which may occur in Cambodia, although only the latter has so far been found there. *Oberonia falcata* is easily distinguished by the elongate stems, as opposed to the stemless, fan-shaped habit of the two other species, and also by the very short floral bracts, which are (much) longer than the ovary in the other species. It was found as an epiphyte in evergreen montane forest at 940 m asl on Mt. Bokor, Kampot Province. This species was previously recorded from NE India, Nepal, Myanmar, China (Yunnan), Thailand, Laos (Schuiteman et al., 2008), Vietnam, and North Sumatra.

**Fig. 9** *Stichorkis gibbosa* (Finet) J.J.Wood. Plant habit. Kew cult. 2015-1312.

**Fig. 10** *Stichorkis gibbosa* (Finet) J.J.Wood. Inflorescence. Kew cult. 2015-1312.

**Fig. 11** *Thrixspermum pauciflorum* (Hook.f.) Kuntze. Flowers. Kew cult. 2015-1120.
Phalaenopsis difformis (Wall. ex Lindl.) Kocyán & Schuit. (Kew cult. 2015-1166; Fig. 7)

Until recently this taxon was better known as Ornithochilus difformis (Wall. ex Lindl.) Schlr., but DNA evidence has suggested its placement in Phalaenopsis. This is one of many orchid species of which the occurrence in Cambodia was entirely predictable. We encountered it as an epiphyte in semi-deciduous forest at ca. 595 m asl, ca. 8.5 km north of Sen Monorom, Mondulkiri Province, and probably also in more humid, evergreen forest remnants near a waterfall at 640 m asl, ca. 14 km southeast of Sen Monorom, Mondulkiri Province, and an epiphyte in semi-deciduous forest at ca. 595 m asl, ca. 4.5 km north of Sen Monorom, Mondulkiri Province, but we have not seen the latter specimens in flower. This species, of which the flowers are striking close up but inconspicuous from a distance, was previously recorded from N & NE India, Nepal, Myanmar, southern China, Thailand, Laos, Vietnam, Peninsular Malaysia, Sumatra, and Borneo.

Sarcoglyphis thailandica Seidenf. (Kew cult. 2015-1147; Fig. 8)

Along with Thrixspermum pauciflorum, this is the least common of the species reported in this paper. Until now this monopodial orchid was believed to be endemic to Thailand, but we found it at a considerable distance from the Thai border in eastern Cambodia, in the Seima Wildlife Sanctuary, Mondulkiri Province. There it occurred as an epiphyte in disturbed evergreen dipterocarp forest at 340 m asl.

Stichorkis gibbosa (Finet) J.J.Wood (Kew cult. 2015-1312; Figs 9 & 10)

The last word has not been spoken on the complex taxonomy of subtribe Malaxidinae, which in Cambodia is represented by the genera Crepidium, Liparis, Oberonia, and now also by Stichorkis. The genus Stichorkis was usually considered to fall within the limits of the large genus Liparis, but molecular studies have shown that Liparis is polyphyletic (Cameron, 2005; Tang et al., 2015). One clearly monophyletic group within Liparis s.l. includes the present species; all its members are characterized by having distichous, flattened floral bracts, with the flowers opening in succession over a long period of time (not unlike many species of Thrixspermum). Stichorkis gibbosa is the most widespread taxon in the genus, being recorded from Myanmar, Thailand, Laos, Peninsular Malaysia, many parts of Indonesia, the Solomon islands, Vanuatu, and New Caledonia. We found it as an epiphyte in evergreen montane forest on Mt. Bokor, Kampot Province, at 940 m asl.

Thrixspermum pauciflorum (Hook.f.) Kuntze (Kew cult. 2015-1120; Fig. 11).


Due to its short-lived flowers, the genus Thrixspermum is among the least well represented orchid genera in herbaria. The present species is among the lesser known members of the genus, having been found once in Peninsular Malaysia and once in Vietnam, according to Seidenfaden (1992). However, T. simondii from Vietnam, which was described from a painting by Simond, reproduced in Seidenfaden (1992), appears indistinguishable from T. pauciflorum. It is not clear to us on what grounds Seidenfaden chose to regard it as a synonym of T. centipedoides Lour., albeit with a question mark. Judging from the illustrations in the protologue, T. odoratum from Hainan is very close to, if not conspecific with T. pauciflorum. We can here report T. pauciflorum from 15 km SE of Sen Monorom, Mondulkiri Province, where it occurred as an epiphyte in patches of secondary forest in anthropogenic grassland at 900 m asl.

Conclusions

Many new records of orchids are still to be expected from Cambodia, of which a large number can be predicted on the basis of known distribution ranges and ecology. Almost all the species here recorded, with the possible exceptions of S. thailandica and T. pauciflorum, are such predictable cases. The two last-mentioned species demonstrate, however, that there are still surprises in store, and that certainly not the entire orchid flora of Cambodia is as easily predictable as, say, the occurrence of P. difformis in the country.

Acknowledgements

We thank Dr Keo Omaliss of the Cambodia Forestry Administration, for his invaluable help before and during our visit, as well as Mr. Cedric Jancloes for sharing much useful information. Christopher Ryan was supported by a Scott Marshall Travel Award and the Royal Horticultural Society, while André Schuiteman received grants from the American Society Board of the Kew Foundation and the Bentham-Moxon Trust. We are grateful to CITES Cambodia and CITES UK for providing the necessary permits. The living specimens were imported into the UK under Defra Plant Health Licence Numbers 2149/194627-1 and 2149/194627-3. All photos were taken by André Schuiteman.
References


Dacrydium elatum (Podocarpaceae) in the montane cloud forest of Bokor Mountain, Cambodia

Philip W. RUNDEL1,*, M. Rasoul SHARIFI1, Judith KING-RUNDEL2 & David J. MIDDLETON3

1 Department of Ecology and Evolutionary Biology, University of California, 621 Charles E. Young Drive South, Los Angeles, California 90095, USA.
2 Department of Earth Sciences, California State University, Dominguez Hills, 1000 E. Victoria Street, Carson, California 90747, USA.
3 Singapore Botanic Gardens, National Parks Board, 1 Cluny Road, Singapore 259569, Singapore.

* Corresponding author. Email rundel@biology.ucla.edu

Paper submitted 20 May 2016, revised manuscript accepted 29 July 2016.

Abstract
A classic example of a dwarf montane tropical forest can be seen in the plateau area of the Elephant Mountains in Bokor National Park. The steep south-facing slopes of the range and close proximity of the ocean produces unusually wet conditions with more than 5,000 mm of rainfall annually, and skeletal and highly leached acid soils. These conditions produce a dwarf forest and sclerophyllous shrubland dominated by Dacrydium elatum (Podocarpaceae). A distinct gradient in tree size is present, ranging from heights of only 5–7 m near the escarpment through a transition zone to heights of 15 m about 4 km inland near the Popokvil Falls. The scale-like foliage of mature trees and linear-lanceolate foliage of saplings of D. elatum display distinctive light response curves for photosynthesis, with both showing adaptations to the cloudy conditions of their habitat on Bokor Mountain. Both forms reached 50% of maximum rates of net assimilation at a low irradiance of only 200 μmol m−2 sec−1. Maximum assimilation rates peaked at about 800 μmol m−2 sec−1 in both forms, but were higher in the sapling foliage. Higher rates of photosynthesis come at the expense of declining water use efficiency.

Key Words Bokor National Park, Dacrydium, Podocarpaceae, tropical cloud forest, photosynthetic rate.
Introduction

Although tropical montane cloud forests throughout the world exhibit a characteristic structure of dwarfed stature and low productivity, there is no single environmental factor, with the exception of physically low cloud cover, that is shared by all of these forests (Brujinzeel & Veneklaas, 1998). High winds, saturated soils, impeded root respiration, physiological drought, high soil leaching with low nutrient availability, limited rooting volume of shallow soils, reduced solar insolation, and high humidity with reduced transpiration rates have individually or in combination been suggested as causal agents in stunting (Grubb, 1971, 1977; Weaver et al., 1973). It has also been suggested that the collective influence of these limiting factors may be seen in low rates of canopy photosynthesis (Brujinzeel & Veneklaas, 1998).

The plateau areas of the Cardamom and Elephant Mountains in southern Cambodia provide classic examples of dwarf tropical montane forests. While lower elevations support a rich wet evergreen forest community of angiosperm trees, the shallow soils and waterlogged depressions on the summits of these mountains are dominated by local mosaics of low sclerophyllous evergreen forest no more than 12–16 m in height. These dwarf forests can occur at any elevation, but are most typical of depressions on the summits or windward ridges of hills at 900–1,400 m elevation on poorly drained sites in a matrix of taller wet evergreen forest (Dy Phon, 1970; Rollet, 1972; Ayervanov et al., 2003). The dominant species in these waterlogged sites are commonly Dacrydium elatum (Roxb.) Wall. ex Hook. (Podocarpaceae) and Tristaniopsis merguensis (Griff.) P.G.Wilson & J.T.Waterh. (Myrtaceae). A mixture of other tree species may be present, commonly including the conifers Podocarpus pilgeri Fossw. and Dacrycarpus imbricatus (Blume) de Laub. (Podocarpaceae). Although differing in floristic composition, these dwarf evergreen forests share many ecological features with the better-known kerangas heath forests of Borneo, as well as in the presence of Dacrydium elatum as a dominant or co-dominant tree (Brüning, 1974).

Our research has been focused on the massif of the Elephant Mountains in Bokor (Preah Monivong) National Park which rises abruptly from a narrow coastal plain along the Gulf of Thailand in southern Cambodia to an elevation of more than 1,000 m asl (above sea level), forming a vertical escarpment at its southern face (Fig. 1). The combination of the steep south-facing slopes of the range and close proximity of the ocean produces unusually wet conditions on the upper plateau of this range where more than 5,000 mm of rain falls annually and the dry season is relatively short (Averyanov et al., 2003). This heavy rainfall has acted on the quartz sandstone substrate of the plateau of the Elephant Mountains to produce skeletal and highly leached acid soils. As a result of these conditions, the plateau supports unusual communities of dwarf forest and sclerophyllous shrubland (Fig. 2) despite the high rainfall (Dy Phon, 1970). Within this matrix of dwarf forest and shrubland are small areas of permanent bog habitat where soils remain saturated throughout the year because of indurated soil layers (Rundel et al., 2003).

There were two objectives to our study. The first was to assess patterns of canopy architecture in Dacrydium elatum, the dominant canopy tree on the Bokor Plateau, in a gradient of sites from near Popokvil Falls to the southern escarpment of Bokor Mountain 4 km to the southwest. This gradient followed declining forest height, shallower soil profiles, and inferred increases in rainfall, cloud cover, and strength of wind. Our second objective was to collect ecophysiological data on the relationship of photosynthesis to solar irradiance in the foliage of D. elatum to assess its adaptation to the reduced irradiance caused by frequent cloud cover on Bokor Mountain, and to compare its responses to that of other conifers, both within tropical cloud forests and outside these habitats.

Methods

Study species

Dacrydium elatum is a relatively widespread species of Podocarpaceae with a range of distribution that includes southern China, Myanmar, Cambodia, Thailand, Laos, Vietnam, Malaysia (Peninsular, Sabah, and Sarawak), western Sumatra, and the Philippines where it is commonly found in montane or hill evergreen forests at elevations of 700–2,000 m (Ridley, 1911; Smitinand, 1968; Nguyen & Vidal, 1996; Rundel, 2001; Farjon 2010). It is one of only seven conifer species known from Cambodia (Thomas et al., 2007). Despite its characteristic montane habitat, D. elatum is tolerant of saturated soil and oligotrophic conditions and occurs in lowland kerangas forests in Malaysia and Indonesia (Mead, 1925; Kartawinata, 1980; Maloney & McCormac, 1996; Farjon, 2010). In the Cardamom and Elephant Mountains of southern Cambodia it occurs in low evergreen forest, frequently with Dacrycarpus imbricatus (Blume) de Laub. (Nguyen & Vidal, 1996).

Under favourable growing conditions, Dacrydium elatum forms a tree of moderate size with heights up to 35 m or more and diameters up to 120 cm. The trunk is typically straight with ascending branches that form a
domed canopy. The rough red bark of the trunk splits along vertical fissures and develops peeling strips. One of the unusual features of the species is the dimorphic form of foliage between saplings and mature trees. Juvenile foliage characteristic of young trees is comprised of spreading linear-lanceolate leaves up to 15–20 mm in length and keeled on four sides. In contrast, the foliage on mature trees consists of small and scale-like triangular leaves pressed to the branch shoots (Fig. 3).

Site description

Field studies were carried out from 3–13 March, 2001, on the plateau area of the Elephant Mountains in Bokor National Park, Kampot Province, Cambodia. Bokor National Park was established in 1997 and covers an area of 140,000 ha, much of it relatively undisturbed because of the steep topography (Rundel et al., 2003).

The relatively high plateau of the southern Elephant Mountains slopes gently northward from its peak elevation of 1,062 m at the Bokor Palace Hotel at the edge of the escarpment (10°39’21.82”N, 104°01’35.20”E). Elevation drops 140 m over a 4 km distance from this high point to the site of Popokvil Falls (10°39’29.34”N, 104°03’04.38”E). This distance formed our study gradient and there is a significant change in the height of the dominant vegetation cover. Although environmental microclimates along our gradient were not quantified, the uplift of winds off the Gulf of Thailand produce the strongest wind speeds and highest amounts of rainfall near the south-facing escarpment, and these factors decrease in significance moving inland.

The sandstone substrate of the plateau of the Elephant Mountains weathers into an acidic coarse white sand. Soil profiles of the sphagnum bog, as described by Dy Phon (1970), consisted of upper sandy A horizons 90 cm thick with declining organic matter and increasing saturation with depth. The B horizon at 90–105 cm was an indurated layer of white sand, with yellowish sandstone parent material below this level. We measured the pH of

Fig. 1 Location of the study site in the Elephant Mountains Plateau of Bokor National Park. Phnom Bokor (Bokor Mountain) at 1,079 m, is the high point on the plateau. From Rundel et al. (2003).
the soil solution as 4.6 in spot measurements made along the margin of the bog and in bog soils.

The impacted area around the sites of the old hotel and casino complex of Bokor were heavily disturbed and at the time of study (2001) were slowly undergoing a succession from weedy grasses and *Pteridium aquilinum* (L.) Kuhn to a scattered cover of low colonizing shrubs such as *Rhodaninia dumetorum* (DC.) Merr. & L.M. Perry (Myrtaceae), *Melastoma malabathricum* L. (Melastomataceae), *Ardisia crenata* Sims subsp. *crassinervosa* (E. Walker) C.M. Hu & J.E. Vidal, and *A. smaragdina* Pit. (Primulaceae). Most of this area has since been transformed with the development of new infrastructure and a hotel.

Rainfall is extremely high on the Bokor Plateau, averaging more than 5,000 mm annually. Records for Bokor (950 m elevation) at the southern end of the plateau show a mean annual rainfall of 5,309 mm (Tixier, 1979), while the Val d’Emeraude on the southeast margin of the plateau receives a mean of 5,384 mm (Dy Phon, 1970). The distribution of this rain is strongly seasonal, however, peaking in July and August and dropping to 50 mm or less per month in January and February at both stations. The Val d’Emeraude experiences rain almost every day from May through October, but on only 12 days on average in March (Dy Phon, 1970), the month of our sampling. Mornings during our field studies were typically semi-sunny with scattered clouds moving overhead, while heavier overcast conditions and brief periods of intense rain occurred almost every afternoon. Mean monthly temperatures are relatively constant throughout the year on Bokor Mountain, varying only from a low of 19.2 °C in July and August to a high of 21.5 °C in April (Dy Phon, 1970).

**Sampling design**

We sampled stem diameters at breast height and heights of 12–20 individual *D. elatum* at three positions along our study gradient: near Popokvil Falls, about 700–800 m north of the old Bokor Hotel, and roughly midway between these locations. Replicated gas exchange measurements were carried out over the course of the study at the intermediate site to evaluate the photosynthetic responses of mature foliage of both sapling and mature tree leaf morphologies. Net photosynthetic rate (*A*), stomatal conductance (*g*), transpiration (*E*), instantaneous (*A/E*) water-use efficiency (WUE), intrinsic WUE (*A/g*) and internal CO₂ concentration (*Cᵢ*) were determined using a LI-6400 portable gas exchange system (LI-COR Inc., Lincoln, Nebraska, USA). The LI-6400 maintains steady-state conditions with respect to temperature, CO₂ and water vapour concentration within the assimila-
The CO₂ concentration inside the leaf chamber was kept constant at 375 μmol mol⁻¹ during the light response conditions. Field measurements were made by slowly increasing irradiance (PFD) from 0 to 1,400 μmol m⁻² sec⁻¹. The ambient temperature inside the leaf chamber was kept at 20°C. This temperature was close to the maximum ambient daytime temperature when the measurements were made. The leaf-to-air vapour pressure deficit (VPD) was maintained at 0.5–0.9 kPa. The CO₂ concentration inside the leaf chamber was kept constant at 375 mmol mol⁻¹ during the light response curves with CO₂ supplied from a pressurized 12 gram gas cylinder. Light was provided by an internal red/blue LED light source (LI6400-02B). The projected leaf area of foliage used in each measurement was determined after gas exchange measurement using millimetre graph paper.

**Results**

Small pockets of dwarf forest trees first appeared about 500 m north of the escarpment and more commonly about 1 km distant where we sampled dwarf populations of *D. elatum*. In these mosaic pockets, woody species with a clear tree-like growth form were found in fissures in the sandstone substrate where organic material had collected and soils had developed. In addition to *D. elatum*, common species of trees 3–5 m in height were *Neolitsea ze Yanica* (Nees & T. Nees) Merr. (Lauraceae), *Vaccinium viscidifolium* King & Gamble (Ericaceae), *Garcinia munguensis* Wight. (Clusiaceae), *Lithocarpus leptophyllus* A. Camus (Fagaceae), *P. pilgeri* (Podocarpaceae), *Dacrycarpus imbricatus* (Podocarpaceae), and *Syzygium formosum* (Wall.) Masam. (Myrtaceae). *Pandanus cf. capusii* Mart. (Pandancaceae) was also present as a common subcanopy species. Two semi-woody climbers occurred among the shrubs and treellets: *Jasminum nobile* C.B. Clark (Oleaceae) and *Smilax davidiana* A.DC. (Smilacaceae). Open areas of rocky outcrop with shallow and seasonally inundated soils occurred as openings in the sclerophyll scrub, supporting stands of herbaceous species dominated by *Leptocarpus disjunctus* Mast. (Restionaceae) and the clump-forming sedge *Carex indica* L.

Mature individuals of *Dacrydium elatum* in these pockets of dwarf forest had diameters of up to 20–23 cm but reached only 5–7 m in height (Fig. 4). Moving inland along the gradient to a position roughly midway from the old Bokor Hotel to Popokvil Falls, there was a clear transition zone where soils were less shallow, with a more diverse set of associated species, and here mature individuals of *D. elatum* were 30–35 cm in diameter and 8–10 m in height. Finally, moving along the gradient approximately four km inland onto deeper soils in the area round Popokvil Falls, diameters of *D. elatum* reached 45–50 cm or more and heights up to 15 m. This area had a closed forest canopy with associated canopy trees that included taller individuals of those listed above as well as *Machilus odoratissimus* Nees (Lauraceae), *Syzygium lineatum* (DC.) Merr. & L.M. Perry (Myrtaceae), *Acro nychia pedunculata* (L.) Miq. (Rutaceae), and *Calophyllum calaba* L. var. cuneatum (Symington ex M.R. Henderson & Wyatt-Smith) P.F. Stevens (Calophyllaceae). These are all trees that can reach 30–40 m in height under favorable growing conditions, although their height was comparable to *D. elatum* at the site.

Both mature and juvenile leaf morphologies of *D. elatum* have a light response curve for photosynthesis that shows adaptations to the cloudy conditions of their habitat on Bokor Mountain. Both forms reached 50% of maximum rates of net assimilation at an irradiance of only 200 μmol m⁻² sec⁻¹ (Fig. 5). Maximum assimilation rates peaked at about 800 μmol m⁻² sec⁻¹ in both forms but with very divergent maximum rates of net assimilation. Mature foliage reached light saturation at about 800 μmol m⁻² sec⁻¹ with a maximum assimilation rate of about 6 μmol m⁻² sec⁻¹. While juvenile foliage morphology peaked at the same level of irradiance, it peaked at a much higher assimilation rate of about 10.5 μmol m⁻² sec⁻¹.

Because transpiration rates increased faster than assimilation rates in both leaf morphologies as irradiance increased beyond about 400 μmol m⁻² sec⁻¹, water use efficiency measured as the ratio of assimilation to transpiration peaked at this relatively low light level (Fig. 6). Higher rates of photosynthesis thus come at the expense of declining water use efficiency (Fig. 7).

**Discussion**

Only rarely are Podocarpaceae able to establish stand dominance in competition with angiosperm trees. Such a pattern is most common in azonal tropical montane sites with stressful conditions for plant growth, as in heath and swamp forests and in areas with skeletal oligotrophic soils. The dominance of *D. elatum*, with the associated *Dacrycarpus imbricatus* and *Podocarpus pilgeri*, on the Bokor Plateau fits a pattern seen widely in such habitats in Malesia and New Guinea (Enright & Jaffré, 2011). The causal factors for this dominance can be understood...
in traits broadly present in the Podocarpaceae. Although outcompeted on more productive sites, these conifers are able to persist in tropical forests using anatomical and morphological adaptations that increase the efficiency of light harvesting (Brodribb, 2011). Like many conifers, their slow growth also provides them a competitive advantage on oligotrophic soils. However, the Achilles heel of Podocarpaceae lies in the structure of their xylem systems and wood anatomy which makes them vulnerable to cavitation and thus drought stress (Brodribb, 2011).
and acidic beach terraces are locally present in an area in County in northern California where highly leached soils are not restricted to the Podocarpaceae and tropical montane cloud forests. A classic example of these can be seen in the cool Mediterranean-climate of Mendocino montane cloud forests. A classic example of these can be seen in the cool Mediterranean-climate of Mendocino montane cloud forests. A classic example of these can be seen in the cool Mediterranean-climate of Mendocino montane cloud forests.

The specific causal factors in the observed gradient in stature of D. elatum on Bokor Mountain are clearly complex, a pattern observed in other dwarf montane cloud forests (Bruijnzeel & Veneklaas, 1998). Increased dwarfing in growth form is associated with greater wind speeds, higher rainfall, shallower oligotrophic soils, and increased water logging. Photosynthetic measurements indicate that physiological limitations for carbon fixation may be less important than the abiotic stressors. The light response curve in foliage of D. elatum demonstrates clear adaptation to the low light levels present under the frequent cloud cover on Bokor Mountain. Moreover, the maximum rates of photosynthesis are high in comparison to published values for other Podocarpaceae (Meinzer et al., 1984; Rundel et al., 2001; Lusk et al., 2003; Brodribb et al., 2007). It is difficult to speculate about the possible significance of the higher rate of assimilation measured in juvenile foliage. The morphological differences in adult and juvenile foliage may have selective significance in promoting early growth and establishment of saplings in these oligotrophic conditions.

Globally, dwarf stands of conifers on oligotrophic soils are not restricted to the Podocarpaceae and tropical montane cloud forests. A classic example of these can be seen in the cool Mediterranean-climate of Mendocino County in northern California where highly leached and acidic beach terraces are locally present in an area known as the Pygmy Forest. Here, the endemic Hesperocyparis pygmaea (Lemmon) Bartel. (pygmy cypress), and Pinus contorta Loudon. subsp. bolanderi (Parl.) Critchf. (Bolander pine) often reach no more than 1–2 m in height after a century of growth (Westman, 1975).

The montane cloud forest of Bokor National Park is an important conservation resource deserving of additional study and protection. Much of this area, however, has been subject to recent development and clearing, putting many of the rare species and habitat at risk.

Acknowledgements

We thank Meng Monyrak, Sok Sothea, and Hong Lork for field assistance, and the Department of Nature Conservation and Protection in the Cambodian Ministry of the Environment for arranging permission to work in Bokor National Park. We gratefully acknowledge the logistical support of the national park staff in providing housing. This project was funded by the UCLA Asian Studies Center.

References


Short Communication

Reproductive size thresholds of dipterocarps in Cambodian dry forests

Eriko ITO1,*, CHANN Sophal2, TITH Bora2, KETH Samkol2, LY Chandararity2, OP Phallaphearaoth2, Naoyuki FURUYA1 & Yukako MONDA3

1 Hokkaido Research Center, Forestry and Forest Products Research Institute, 7 Hitsujigaoka, Toyohira, Sapporo, Hokkaido, 062-8516 Japan.
2 Institute of Forest and Wildlife Research and Development, Forestry Administration, Hanoi Street 1019, Phum Rongchak, Sankat Phnom Penh Thmei, Khan Sen Sok, Phnom Penh, Cambodia.
3 Graduate School of Agriculture, Kyoto University, Kyoto City, Kyoto, 606-8502 Japan.
* Corresponding author. Email iter@affrc.go.jp

Paper submitted 25 May 2016, revised manuscript accepted 25 July 2016.

Tree size at the transition from juvenile (sterile) to adult (fertile) is an important species-specific character used to gain insight into the mechanisms governing forest structure and species coexistence. Various studies of this relationship in tropical forests have been attempted (Wright et al., 2005). From a conservation perspective, such information also has practical applications. Seasonal tropical forest, representing 42% of tropical forests, is one of the most threatened ecosystems in the tropics (Murphy & Lugo, 1986). Currently, human population growth is causing deforestation pressure in Cambodia. For aseasonal dipterocarp forests, it has been proposed that management programmes should ensure genetic diversity and pollination efficacy (Tani et al., 2009, 2012). To develop guidelines for sustainable forest use in Cambodia, basic information on forest stands and their regeneration is necessary. To this end, we determined the flowering size for components of a Cambodian dry dipterocarp forest.

The study was conducted in two permanent sample plots established in typical dry dipterocarp forests in Cambodia (Fig. 1). The first was a 4 ha (200 m × 200 m) study plot centered on a flux tower in Kratie Province (KRC, 12.9°N, 106.2°E; elevation: 74–85 m). The KRC plot has three dominant deciduous dipterocarp species: *Dipterocarpus tuberculatus* Roxb. (ca. 31% of stand basal area and 20% of stand tree number), *Shorea siamensis* Miq. (19% and 40%, respectively), and *S. obtusa* Wall. ex Blume (18% and 9%, respectively), which are associated with *Terminalia alata* Heyne ex Roth (13% and 14%, respectively). Tree density and basal area for stems with a diameter at breast height (DBH, 1.3 m above ground level) of ≥ 5 cm were 557 stem ha⁻¹ and 13.6 m² ha⁻¹, respectively. Tertiary and quaternary sedimentary rocks underlie much of the forest (Toriyama et al., 2010), and the soil type is plinthic hydromorphic. The KRC plot, in part, experiences an annual fire regime based on a plentiful supply of grasses as fuel and usually involves man-made fires created while hunting for wildlife.

The second plot was a 0.24 ha (30 m × 80 m) study plot located in Kampong Thom Province (KPT, 12.8°N, 105.5°E; elevation: 70 m). The KPT plot has one dominant dipterocarp species, *Dipterocarpus obtusifolius* Teijsm. ex Miq. (ca. 50% of stand basal area and 60% of stand tree number), which is associated with *Gluta laccifera* (Pierre) Ding Hou (35% and 6%, respectively) (Hiramatsu et al., 2007). The forest does not show distinct deciduousness, but irregular, incomplete leaf shedding of its components (Ito et al., 2007). Nevertheless, the forest is placed in the deciduous forest category in the Cambodian forest type classification (Forestry Administration, 2011). Tree density and basal area for stems with DBH ≥ 5 cm were
Reproductive thresholds of dipterocarps

The climate of the research areas is seasonal tropical, and the months from November through April are dry. Mean annual temperature is 27 °C. Annual rainfall (mean ± SD) is 1,643 ± 272 mm in KRC and 1,542 ± 248 mm in KPT (2000–2010: NIS, 2012).

We investigated the reproductive size thresholds of the four dipterocarp species mentioned above. We recorded the presence/absence of reproductive organs on trees within the KRC study plot in February 2009 (n = 68), 2010 (n = 68), 2011 (n = 1,186), 2012 (n = 953), and January–February 2014 (n = 1,550, all trees). The same was done for all living trees within the KPT study plot in May 2003 and 2005, and in December 2005 and 2009. For all four dipterocarp species, flowers and flower buds were found in the dry season (December–February), while fruits were found in the subsequent early wet season (May). During our censuses, we measured the DBH of stems to the nearest 1 mm for all standing woody stems with DBH ≥ 5 cm. Tree size with and without reproduction was defined as DBH at the first recorded presence of reproductive organs and the last recorded absence of reproductive organs, respectively. We then determined the minimum tree size for reproduction in *D. obtusifolius*, *D. tuberculatus*, *S. obtusa*, and *S. siamensis* using nominal logistic regression models.

Sist et al. (2003) recommended a procedure for setting diameter-based cutting limits for trees according to their diameter at the onset of reproduction. All of the dipterocarps we studied are included in official guidelines which indicate their diameter-based cutting limits (0.50 m DBH for *D. tuberculatus*, 0.45 m DBH for the other species: MAFF, 2005). We found the mean diameters of reproductive trees were lower than these diameter limit criteria (Table 1). A reproductive tree population could therefore persist despite selective logging using these criteria (Fig. 2). Tree size significantly predicted the presence/absence of reproduction for all of our study species (p<0.0001). Nominal logistic regression models also indicated that >90% of individual trees start reproduction at smaller tree sizes than the diameter limit criteria (Fig. 3). These data suggest that the MAFF (2005) guidelines are sustainable in terms of diameter cutting limits for all of the dry dipterocarp species we studied.

Table 1 Minimum tree size for reproduction and reproductive tree density of dipterocarp species in Cambodian dry forests.

<table>
<thead>
<tr>
<th></th>
<th><em>D. obtusifolius</em></th>
<th><em>D. tuberculatus</em></th>
<th><em>S. obtusa</em></th>
<th><em>S. siamensis</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Density (all trees)</td>
<td>254</td>
<td>112</td>
<td>50</td>
<td>229</td>
</tr>
<tr>
<td>Density (reproductive trees)</td>
<td>83</td>
<td>85</td>
<td>32</td>
<td>34</td>
</tr>
<tr>
<td>Tree DBH (all trees)</td>
<td>15.5 ± 8.6 (46.4)</td>
<td>20.1 ± 8.7 (52.5)</td>
<td>23.6 ± 10.0 (55.8)</td>
<td>11.0 ± 5.3 (46.5)</td>
</tr>
<tr>
<td>Tree DBH (reproductive trees)</td>
<td>22.8 ± 9.6 (12.0)</td>
<td>23.0 ± 7.4 (10.8)</td>
<td>27.4 ± 8.5 (9.8)</td>
<td>18.4 ± 6.8 (5.6)</td>
</tr>
<tr>
<td>DBH at 50% of tree reproduction</td>
<td>18.8 (16.2–23.9)</td>
<td>12.3 (11.1–13.3)</td>
<td>17.9 (15.2–20.1)</td>
<td>18.1 (17.3–19.1)</td>
</tr>
<tr>
<td>DBH at 90% of tree reproduction</td>
<td>27.1 (22.7–42.5)</td>
<td>20.0 (18.6–21.8)</td>
<td>31.5 (28.2–37.3)</td>
<td>24.3 (22.9–26.3)</td>
</tr>
</tbody>
</table>

1 Stem ha⁻¹
2 Mean ± SD (max.) [cm]
3 Mean ± SD (min.) [cm]
4 Estimated (95% CI) [cm]

Fig. 1 Location of sample plots in Cambodia. KPT: Kampong Thom Province; KRC: Kratie Province.
Reproductive target tree densities have been proposed as an acceptable vulnerability index value (>5 reproductive trees ha\(^{-1}\)) for Bolivian seasonally dry forests (Pinard et al., 1999). The reproductive tree densities recorded in our study plots far exceeded this value (32–85 stems ha\(^{-1}\), Table 1). However, total basal areas in the Bolivian forests were three times higher than the values in the dry dipterocarp forests we studied. A basal area mismatch of this magnitude indicates that the criteria for vulnerability index scoring should be independently verified in Cambodian forests.

The distribution of diameters differed among the species in our study (Fig. 2). Only *S. siamensis* showed a negative exponential distribution, indicating continual recruitment of juvenile trees, whereas *D. tuberculatus* and *S. obtusa* had unimodal distributions with peaks in the 15–25 cm DBH class. These data suggest low recruitment rates in *D. tuberculatus* and *S. obtusa*. This was obviously not due to a lack of flowering trees. Micro-sites suitable for the establishment of dipterocarp seedlings may be limited by topography or light conditions (Yagihashi et al., 1999).

![Fig. 2 Size (diameter at breast height, DBH) distribution of dipterocarp species in the study plots. Gray and white areas indicate trees with and without reproductive organs, respectively. Tree size with and without reproduction was defined as DBH at the first recorded presence of reproductive organs and the last recorded absence of reproductive organs, respectively.](image1)

![Fig. 3 Probability of reproduction based on the DBH estimated using nominal logistic regression for four dipterocarp species in Cambodian dry forests: A) *Dipterocarpus* spp.; B) *Shorea* spp. Horizontal arrows indicate the estimated 95% confidence interval of DBH at 50% and 90% probability of reproduction.](image2)
In addition, fire in the dry season and grass shading in the wet season may inhibit seedlings in the KRC plot. In turn, the relatively higher recruitment of S. siamensis may be due to its frequent occurrence in rocky soils (Rollet, 1972) as the lower grass biomass of these areas would weaken the impacts of fire and shading. For sustainable management, reproductive target tree densities should remain at high levels until the exact reasons for these differences in recruitment are known.

Acknowledgements

This paper reports results obtained by the “Estimation and Simulation of Carbon Stock Change of Tropical Forests in Asia (2011–2014)” project funded by the Ministry of Agriculture, Forestry and Fisheries of Japan. The authors are deeply indebted to H.E. Dr Ty Sokhun, Secretariat of State, to H.E. Dr Chheng Kimsun, Delegate of the Royal Government, Head of the Forestry Administration within the Ministry of Agriculture, Forestry and Fisheries, and to Dr Sokheng Heng, Director of the Institute of Forest and Wildlife Research and Development within the Forestry Administration for permission to use permanent sample plot data and undertake field research. Some field research was also conducted as part of the global environment research coordination system funded by the Ministry of the Environment in Japan, and the emergency project to promote REDD action supported by the Forestry Agency of Japan.

References


The hairy-nosed otter *Lutra sumatrana* in Cambodia: distribution and notes on ecology and conservation

HENG Sokrith1,*, DONG Tangkor1, HON Naven1 & Annette OLSSON2

1 Conservation International – Greater Mekong Program, 4th floor, Building B1, Phnom Penh Center, Sothearas coner Sihanouk Boulevard, Sangkat Tonle Bassac, Khan Chamkarmorn, Phnom Penh, Cambodia.

2 Conservation International, Betty and Gordon Moore Center for Science and Oceans, 318 Tanglin Road, #01-30 Block B, Singapore 247979, Singapore.

* Corresponding author. Email sheng@conservation.org

Paper submitted 16 September 2016, revised manuscript accepted 28 October 2016.

**Abstract**

The hairy-nosed otter *Lutra sumatrana* is endemic to Southeast Asia, however, records are few, and knowledge of the species is limited. This study was carried out in a range of wetland habitats throughout Cambodia between 2006 and 2013. Field methods included interviews with local communities, direct observations, and track and sign surveys combined with camera trapping. Hairy-nosed otters were confirmed from four regions in Cambodia: Tonle Sap Lake, Cardamom Mountains, Bassac Marsh and coastal areas in Koh Kong province. Records comprised eight live captive individuals, 18 skins, and 71 camera trap photographs from 26 trap locations. The species was recorded from several different habitats including flooded forest, mangrove and *Melaleuca* forest, marsh land and forest streams. Based on our records, we suggest the hairy-nosed otter in Cambodia may breed between November and March and give birth between April and June. We found the species was most active during dusk and at night, and although its diet mainly consists of fish, this is supplemented in Tonle Sap Lake with water snakes, crabs, and other small prey when the oppor-
tunity arises. We recommend further surveys along the Mekong River between the Tonle Sap Lake and the Vietnamese border and at coastal sites such as Ream National Park to improve understanding of the distribution of the species in Cambodia.

**Keywords**

**Introduction**

The hairy-nosed otter *Lutra sumatrana* is endemic to Southeast Asia, with a historic range throughout the region (Aadrean et al., 2016). Little is known about the species and until 2008, it was mostly classified as insufficiently known or data deficient by the IUCN/SSC Otter Specialist Group (Hussein et al., 2008). It was also believed by some to be extinct after several years of no field records in the 1990s (Wright et al., 2008). The discovery of hairy-nosed otters in a peat swamp forest in Thailand in 1999 by Kanchanasaka (2000), followed by confirmed records from Vietnam, Peninsular Malaysia and Indonesia (Hussein et al., 2008) indicates that the species still occurs in these countries, although probably at low densities at few and little surveyed sites. Poole (2003) provided the first confirmed record of hairy-nosed otters in Cambodia through records of captive animals in floating houses on the Tonle Sap Lake.

As information has slowly increased on the hairy-nosed otter, the species is now listed as Endangered A2cde on the IUCN Red List (Aadrean et al., 2015) due to a suspected population decline of at least 50% over the last three generations, extensive habitat destruction and conversion throughout its range, coupled with poaching for its skin and persecution as a pest (Yoxon, 2007). However, confirmed records are still few and far between, and knowledge of the species remains limited, making identification and prioritization of appropriate conservation measures difficult. Apart from a single individual held at the Phnom Tamao Zoological Garden and Rescue Center in Phnom Penh, Cambodia, no other captive individuals or breeding programs currently exist to the authors knowledge.

In this paper we document the presence and distribution of hairy-nosed otter in Cambodia and provide information on its ecology, which can inform efficient protection of the species and its habitats.

**Methods**

We carried out surveys in a range of wetland habitats throughout Cambodia between 2006 and 2013. These included Virachey National Park in northeastern Cambodia, along the Mekong River between the Stung Treng and Kratie provinces, the eastern plains of Cambodia, Tonle Sap Lake, Bassac Marsh, Cardamom Mountains, Ream National Park and coastal areas in Koh Kong Province (Fig. 1, Table 1). Survey areas were chosen based on the habitat requirements of otters, unconfirmed reports of their occurrence and relative ease of access.

**Survey sites**

Virachey National Park covers an area of 3,325 km² in the Ratanakiri and Stung Treng provinces of northeastern Cambodia and comprises lowland, hill and montane evergreen forest, as well as upland savannah, bamboo and patches of mixed deciduous forest (Hon et al., 2010). Surveys were conducted along Tabok and Ka shep streams in evergreen and bamboo forest.

Survey sites along the Mekong River in the Kratie and Stung Treng provinces were located near the villages of Sambour, O’Krieng, O’yeye, Achen and Kompong Chrey, at the islands of Koh Dombong and Kbal O’chom and at sites in Prey Lang Wildlife Sanctuary. The Mekong River has a lot of deep pools, as well as numerous small islands and sandbanks during the dry season, which are important habitats for wildlife (Poulson et al., 2002). Prey Lang Wildlife Sanctuary is located in the Kratie, Stung Treng and Preah Vihear provinces and mainly comprises lowland evergreen and deciduous forest. Survey sites within the wildlife sanctuary included the O’krack, Ponnor, O’long and Kbal Damrey streams, which are connected to the Mekong River (Olsson et al., 2007).

Several sites were surveyed within Keo Siema Wildlife Sanctuary in Mondulkiri province and Sre Pok Wildlife Sanctuary in Ratanakiri Province. In Keo Siema, we surveyed along the Opam, Khlong Khnong, and Pour streams, which are surrounded by evergreen and bamboo forests (Keo & Evans, 2013). Surveys in Sre Pok Wildlife Sanctuary focused on the Sre Pok River, a major tributary of the Mekong River, which is surrounded by dense lowland evergreen forest (Constable, 2015).

The Tonle Sap Lake is the largest wetland in Southeast Asia, with a unique flood-pulse system, high biodiversity, and very productive fisheries (Arias et al., 2013). Located in central Cambodia, the dominant habitat of the
floodplain surrounding the lake is generally described as ‘seasonally flooded forest’. This is divided into several vegetation types, and large areas are inundated by up to nine meters of water during the wet season between July and November. Gallery forests with trees between 7 and 15 m tall occur on the inner edge of the lake near open water, rivers, streams, and ponds where the ground rarely dries up. Lower tree cover and scrubland occurs on a larger proportion of the floodplain, with vegetation reaching heights of up to 4 m. Stationary and floating aquatic vegetation and grasslands are also common. These can reach a height of up to 3 m, and floating islands of vegetation occur along the edge of the lake and in canals (McDonald et al., 1997).

The Bassac Marsh is located between the Bassac and Mekong Rivers in Kandal Province, 40 km south of Phnom Penh. It consists of swamp forest and wetlands similar to Tonle Sap, with scattered trees and scrubs such as Barringtonia acutangula and most of the associated emergent plants comprising Sesbania rixburghii, Eichhornia crassipes and Utricularia aurea (UNEP, 2008). The marsh is inundated by up to 3 m of water during the wet season between July and November, and forms a wetland surrounding a narrow body of open water during the dry season. Due to its proximity to Phnom Penh and demand for land for rice cultivation, the site faces intense human pressure from agriculture and other development, such that the wetland is being converted to agriculture, landfills and human habitation (Heng, 2010).

The Cardamom Mountains span southwest Cambodia and neighbouring areas of Thailand. The mountains are heavily forested with hill and lowland evergreen forest and contain many rivers and streams which flow southwards into the sea and northwards into Tonle Sap Lake (Campbell et al., 2006). On the northern side of the mountains, the Takong stream flows into the Pursat River and subsequently into Tonle Sap Lake. The stream is rich in fish and surrounded by evergreen forest. Little water is present in the stream during the dry season, especially in April, except in deep pools. A large flooded grassland is located next to the stream, which provides suitable habitat for otters.

The coastal zone of southwest Cambodia is dominated by rivers draining the Cardamom Mountains, estuaries, mangrove and Melaleuca forest, with evergreen and bamboo forests occurring further upstream. Peam Krasop Wildlife Sanctuary is located in this area and is dominated by mangrove and Melaleuca forests (UNEP, 2008). These are intermixed with agriculture areas and grasslands. The rivers are rich in marine and freshwater fish and provide good habitat for otters. Sand-dredging in the rivers, hunting and land conversion are major threats to otters and other wildlife at the site (Dong et al., 2010), and interviews indicate that local otter populations are in decline. Ream National Park, located in the coastal area of Sihanoukville Province, comprises similar habitats (Heng, 2010).

**Sampling methods**

Survey methods included semi-structured interviews of fishermen, hunters, rangers, and village chiefs whom often have good knowledge of local wildlife. Reference photographs of the otter species that occur in Cambodia were used during the interviews to aid species identification, although confirmed records of otter presence were not based on interview data alone. Interview results guided site selection for track and sign surveys and camera trapping.

As Hussain & Choudhury (1997) found otter signs were located within 12.5 m of water bodies, track and sign surveys were conducted within 20 m of water edges along rivers, streams and dry season ponds. Signs sought for included spraints, food remains, footprints, dens, and resting sites. The wetlands of Tonle Sap and Bassac Marsh are difficult to navigate through due to dense vegetation, which in some cases diverted survey effort. During the rainy season, boats were used to move around these areas. Although tracks of hairy-nosed otter and Eurasian otter Lutra lutra are very similar and difficult to distinguish (Kanchanasaka, 2001), the team learned to recognise spraints produced by different otter species from the IUCN Otter Specialist Group Chair Nicole Duplaix and so could confidently identify those produced by hairy-nosed otters. Despite this, records of otters were not regarded as confirmed unless substantiated by a camera trap photograph, skin or direct observation.

Camera traps were set at a total of 228 locations across the areas surveyed (Table 1). Different camera traps were used during the survey (Reconyx, Bushnell, and Woodland Outdoor Sport) and were deployed at all sites where signs of otters were found. These were attached to trees approximately 50 cm above the ground, on branches over the water, or on floating logs and vegetation. Camera traps were typically left in place for 3–4 weeks, and at some locations were used several times during the year. Habitats at the survey sites were described and recorded.

**Results**

Our surveys confirm the presence of the hairy-nosed otter in four areas of Cambodia: Tonle Sap Lake, Cardamom Mountains, coastal areas in Koh Kong province, and Bassac Marsh. No evidence of the species was found at

© Centre for Biodiversity Conservation, Phnom Penh

Cambodian Journal of Natural History 2016 (2) 102–110
Fig. 1 Survey areas and confirmed records for hairy-nosed otter *Lutra sumatrana* in Cambodia.

Table 1 Survey effort and confirmed records for the hairy-nosed otter and other otter species in Cambodia. LS = hairy-nosed otter *Lutra sumatrana*; LP = smooth-coated otter *Lutrogale perspicillata*; AC = Asian small-clawed otter *Aonyx cinereus*.
other survey sites, which included the lowland evergreen and swamp forests of Prey Long Wildlife Sanctuary and riparian sites along the Mekong River in the Kratie and Stung Treng provinces, and riparian forest along the Sre Pok River and tributaries in northeast Cambodia in the Ratanakiri and Mondulkiri provinces.

Records of hairy-nosed otter comprised eight live captive individuals and 18 skins found in local houses and 71 camera trap photographs (Table 1). Of the 228 locations surveyed with camera traps, hairy-nosed otter was confirmed at 26 (Fig. 1). Smooth-coated otter Lutrogale perspicillata was also confirmed at all sites where hairy-nosed otters were confirmed and these two species evidently live sympatrically in parts of their ranges. Smooth-coated otter was also recorded from the Sre Pok River and Asian small-clawed otter Aonyx cinereus at sites within and nearby Virachey National Park.

Most records of hairy-nosed otter were from Tonle Sap Lake, where ten skins, 66 camera trap photographs, and seven live individuals were registered (Table 1). Results from the camera trap and sign surveys suggest that the species here is mostly associated with gallery forest habitat with wide canopies during the wet season. Spraints were found mostly on the following tree species: Xanthophyllum glaucum, Terminalia cambodiana, Coccoceras anisopodum, Barringtonia acutangula and Combretum trifoliatum, and individuals were caught on camera moving about the branches of these trees (Fig. 2). In the dry season when waters subside, hairy-nosed otters were predominantly recorded along streams and ponds in areas of the the floodplain that still contained water.

Most of the records (camera trap photos, scat, skins and live animals) from Tonle Sap Lake were from Boeng Tonle Chmmar, a Ramsar site and one of three core zones of the Tonle Sap UNESCO Man and Biosphere Reserve. This area contains some of the best remaining habitat for the species at Tonle Sap, with intact and dense high-canopy flooded forests and scrub. Interviewees reported that fish diversity and abundance is high, and the area also supports seasonal colonies of water birds that use the site for feeding and nesting.

Two hairy-nosed otter skins were recorded during interviews at local houses in Bassac Marsh, both of which came from animals that had been by-catch in fishing gear. One of the interviewees previously acted as a middleman, buying otter skins from villagers and selling these onwards to traders. This individual and other interviewees reported that local otter populations were declining due to development and hunting. Otters are sometimes seen in the swamp forest by local residents and are occasionally caught in fishing gear. A single hairy-nosed otter skin was also found in a household near the Takong stream in the Veal Veng district of the Cardamom Mountains. This animal had been caught by dogs near the stream between 700–800 m asl (above sea level) during the dry season when the stream contained little water. Packs of three to six dogs are regularly used by villagers to hunt mammals and reptiles such as otters, turtles, and lizards.

Hairy-nosed and smooth-coated otters were both recorded in the coastal region, with most records being of the latter. Records of hairy-nosed otters comprised five camera trap photographs, five skins, and one live individual kept as a pet, whereas smooth-coated otter records comprised 322 camera trap photographs and three skins (Table 1).

Discussion

Distribution and habitat use

Our data suggests hairy-nosed otters inhabit several habitats in Cambodia, namely flooded forest and scrub around the Tonle Sap Lake, marshland and coastal mangrove and Melaleuca forest. This matches the findings of Kanchanasaka et al. (1998, 2003) who found the species in peat swamp and Melaleuca forest in Thailand, as well as Nguyen et al. (2001) and Nguyen (2005) who found it in the low-lying peat swamp forests of U Minh Thuong Nature Reserve near the Cambodian border in Vietnam. Hairy-nosed otter also occurs in coastal areas in Indonesia, especially in mangrove forest (Hussain et al., 2008). Sivashothi & Burhanuddin (1994) suggest the species may inhabit streams >300 m asl in Malaysia, although most records in the Cardamom Mountains appear to be from lakes and wetlands at lower elevations. Our findings also match those of Heng (2010), who found the species inhabits flooded forest and scrub around the Tonle Sap Lake, using ponds and drainage canals in the dry season.

Our results indicate that hairy-nosed otters and smooth-coated otters share the same habitats in the Tonle Sap Lake. However, smooth-coated otters were more often found in open habitats such as floating logs and bare river/lake banks, whereas hairy-nosed otters appeared to prefer areas sheltered by trees and vegetation such as gallery forest and scrublands (Heng, 2010). Heng (2010) also recorded both species at the same sites in Tonle Sap Lake, as did Kanchanasaka et al. (1998) in peat swamp forest in Thailand.
Previous records from Cambodia

The first record of hairy-nosed otter was of two captive otters photographed in 1998 by Frederic Goes at Prek Toal village in the floodplain of Tonle Sap Lake (Poole, 2003). A mounted specimen was found at Phnom Tamao Zoo (now Phnom Tamao Zoological Park and Wildlife Rescue Center, PTWRC) in 1999, which may have originated from Mondulkiri province (although this remains unconfirmed). In 2000, a live hairy-nosed otter was photographed at Sre Khlong village, Kompong Speu Province, which reportedly originated from the area (unconfirmed). Poole (2003) also reported secondary records of the species from Melaleuca swamp forests north and west of Sre Ambel in Koh Kong province. In addition, unconfirmed records of the species at Tonle Sap Lake are included in several reports (Bonheur, 1997; Goes, 2005; Davidson, 2006). Holden & Thy (2009) reported a skin of hairy-nosed otter found at a hunter’s house in Chhe Teal Chrum village, Pursat Province. This was reportedly caught in 2006 from the Ang Krang River at the foot of Phnom Samkos in the Cardamom Mountains. The Ang Krang is a small stream which flows through hilly primary and secondary forest at approximately 400 m asl. Holden & Thy (2009) also reported camera trap photos of hairy-nosed otters from Veal Veng marsh at 560 m asl in the Cardamom Mountains between 2007 and 2008.

Most of the above records fall within the same regions where we recorded the species. We suspect the reason for the relative paucity of hairy-nosed otter records in Cambodia is due to a combination of the species being naturally shy and secretive (compared to smooth-coated otter for instance), its natural occurrence at low densities and probably solitary nature, coupled with confusion with other otter species and the fact that areas where the species is now confirmed have been little surveyed until recently, due to their poor accessibility and years of civil conflict.

Breeding

Most of our camera trap photographs were of a single individual, which suggests that the hairy-nosed otter is mainly solitary, similar to the Eurasian otter *Lutra lutra* (Yoxon & Yoxon, 2014). Only eight of our photographs were of two adults, whereas one set of photographs showed two adults with two cubs and three sets were of a female with cubs. As the latter were taken within weeks of each other in the same area, these may represent a family group comprising one female and three cubs.

The breeding season of the hairy-nosed otter in Cambodia is unclear. Wright et al. (2008) concluded that the gestation period for hairy-nosed otters (and other
Activity patterns

Although camera traps recorded hairy-nosed otters at all times of day and night, most photographs were taken between 17:00 and 01:00 hrs, suggesting the species is most active during this time. In contrast, smooth-coated otters were equally active during the day and night at our survey sites.

Conservation threats and recommendations

Hairy-nosed otters have been confiscated from or donated by hunters and fishermen on several occasions in Cambodia. Some of these individuals have been released, but when injured or deemed unhealthy, others have been transferred to the PTWRC.

In November 2008, one hairy-nosed otter was caught and kept as a pet by a fisherman near Koh Kong Khnong village in Kong Kong Province, but later confiscated and brought to PTWRC. In June 2009, one animal caught by a fisherman near a dry season pond in the Boeng Tonle Chmmar area of Tonle Sap Lake was confiscated and brought to PTWRC. Four adult individuals were also caught at Boeng Tonle Chmmar in 2010 and 2011, and subsequently released. In July 2010, two sub-adult animals left by their mother along a stream were caught by a fisherman from Anlong Rieng village near Kompong Prak Fish Sanctuary, Pursat Province and also released.

All otter species in Cambodia are threatened by illegal wildlife trade, destruction of habitats, loss of food sources, and persecution as pests. Otter fur is popular for use in fashion and traditional clothing, particularly in China, and because pelts fetch high prices on the illegal market (Bennetto, 2009), this demand threatens otters throughout Asia. In Cambodia, a good quality pelt can sell for up to US$200 and this creates a strong incentive for fishermen and hunters to target otters (Heng, 2010).

Degradation and conversion of wetlands and wet forests into rice fields, shrimp farms, and other land uses is steadily reducing habitat for otters, while overfishing is depleting their food sources. Otters are often targeted and killed by fishermen who view them as pests that compete for fish and damage fishing gear. Additionally, disturbance of wetlands has escalated as human populations increase in neighbouring areas, which raises a concern for shy and secretive species such as the hairy-nosed otter. More broadly, as climate change and infrastructure development on the Mekong River, its tributaries, and in the delta are altering water flows and ecological processes, this will impact otters and other wildlife that depend on these ecosystems (MRC, 2010). If action is not taken to preserve the habitats used by hairy-nosed otter and to combat illegal wildlife trade, extinction of this species, as previously feared in 1998, will likely become a reality. In clarifying the current range of hairy-nosed otter in Cambodia, our study should aid development of conservation and management plans for the species nationally.

Tonle Sap Lake is linked to the Bassac Marsh by the Mekong River which in turn connects to the U Minh Thuong wetlands in Vietnam. Our finding that the hairy-nosed otter occurs at all of these sites is to be expected given the presumed historical range of the species. Existing records from the northern side of the Cardamom Mountains are from streams and wetlands drained by the Pursat River, which originates in the mountains and flows into the Tonle Sap Lake. As rivers on the southern side of the Cardamom Mountains in Koh Kong province belong to a different catchment, populations of hairy-nosed otter inhabiting these waterways are unlikely to be connected to the population at Tonle Sap Lake. Historically however, the species likely occurred all along the east coast of Thailand through Cambodia and Vietnam (Wright et al., 2008). We recommend further surveys in suitable habitats along the Mekong River between the Tonle Sap Lake and the Vietnamese border and at coastal sites such as Ream National Park to improve under-
standing of the distribution and status of hairy-nosed otter in Cambodia.

Acknowledgements
The authors would like to thank the reviewers for comments which improved this manuscript. Thanks are also extended to the local researchers who work with Conservation International at Tonle Sap Lake and greatly contributed to data collection. Funding for this study was provided by Conservation International, Disney Wildlife Conservation Fund, International Otter Survival Fund and the Critical Ecosystem Partnership Fund.

References


Short Communication

New provincial record and range extension of the parachute gecko Ptychozoon lionotum Annandale, 1905 in Cambodia, with notes on habitat use

Mark W. HERR¹,* & Deborah S. LEE²

¹ Department of Biology, The Pennsylvania State University, 208 Mueller Lab, University Park, Pennsylvania 16802, USA.
² Department of Biomedical Engineering, The Pennsylvania State University, 205 Hallowell Building, University Park, Pennsylvania 16802, USA.
* Corresponding author. Email mwherr@gmail.com

Paper submitted 24 July 2016, revised manuscript accepted 17 September 2016.

Parachute geckos, genus Ptychozoon, are small to medium sized arboreal geckos known for their enigmatic gliding behaviour (Heyer et al., 1970; Young et al., 2002). The genus consists of nine recognized species distributed from eastern India (Pawar & Biswas, 2001) and southern China (Wang et al., 2016) in the north, southwards through Indochina (Taylor, 1963) and the Malay Peninsula (Grismer, 2011) to the Greater Sunda Islands (Min & Das, 2012). Ptychozoon species are also known from the Nicobar Islands (Das & Vijayakumar, 2009) and the Philippine Archipelago (Brown et al., 1997). The geographic distribution of this poorly known genus is only now beginning to be reliably understood, and significant gaps in knowledge remain (Brown et al., 2012). Two species of Ptychozoon are known from Cambodia, each of which was first recorded recently (within the last decade) and both on the basis of only a single locality (Stuart & Emmett, 2006; Hartmann et al., 2014).

The rare Ptychozoon trinotaterra is known from Cambodia on the basis of a single specimen photographed at Preah Khan Temple in Siem Reap Province (Hartmann et al., 2014) (Fig. 1). The smooth-backed parachute gecko P. lionotum is known in Cambodia from four specimens collected by Stuart & Emmett (2006) at a single locality in Kirirom National Park in the Cardamom Mountains of southwestern Cambodia (Fig. 1). Here we present the second known locality for P. lionotum in Cambodia, and substantially extend the known range of the species within the country.

On 30 May 2016 at approximately 1130 hrs, DSL observed a single unsexed adult P. lionotum in a cleared parking area approximately 160 meters west of Phnom Kulen Waterfall, Phnom Kulen National Park, Svay Leu District, Siem Reap Province (Fig. 1). The individual was observed when it glided from a nearby tree, landing on the shirt of a startled tourist bystander who quickly brushed it off. Once on the ground the lizard was photographed and the specimen was later identified on the basis of the photograph (Fig. 2).

The individual was positively identified as P. lionotum on the basis of: 1) four dark dorsal chevrons between the axilla and the groin (versus three in P. trinotaterra and P. kaengkrachanense); and, 2) a non-expanded tail terminus (as opposed to P. kuhl, which possesses a widely expanded terminal flap: Brown et al., 1997). This identification was verified by Rafe M. Brown (University of Kansas Biodiversity Institute) and the photo voucher was deposited in the University of Kansas Digital Archives (KUDA 012461).

This new locality extends the known distribution of P. lionotum in Cambodia approximately 250 km north from the only other known locality in Kirirom National Park in the Cardamom Mountains (Stuart & Emmett, 2006).

This substantial extension indicates that *P. lionotum* is likely to occur throughout the country in areas where appropriate evergreen or semi-evergreen forest habitat persists. Outside of Cambodia, *P. lionotum* is known from extreme eastern India (Pawar & Biswas, 2001), Myanmar (including the type locality: Pegu, Myanmar; Annandale, 1905; Smith, 1935), Thailand (Taylor, 1963), Peninsular Malaysia (Das & Yaakob, 2005; Grismer, 2011), and southern Vietnam (Nguyen et al., 2009). To our knowledge, the species is not known from Laos, but given the proximity of this new locality (ca. 140 km southwest of the Laotian border) it is possible that future surveys may reveal its presence there as well.

Interestingly, our individual was encountered in a small disturbed area (a parking lot) within a forested national park. This observation mirrors earlier reports of *P. lionotum* being encountered near sites of anthropogenic disturbance, but within protected areas (Stuart & Emmett, 2006). Brown (1999) mentions that, with the exception of the disturbance-tolerant *P. kuhlii*, the paucity of records for most *Ptychozoon* species is likely a result of their being forest canopy obligates which are rarely encountered. We agree with this assertion, but add that within such forest habitats *Ptychozoon* species may be tolerant of small scale disturbance and may utilize edge habitats and man-made structures with some frequency (Grismer, 2011; Sumanntha et al., 2012). The paucity of records may therefore be first and foremost a function of the highly cryptic nature of these animals.

**References**


Short Communication

First record of the Buonluoi forest skink *Sphenomorphus buenloicus* Darevsky & Nguyen, 1983 (Squamata: Scincidae) from Cambodia

**NEANG Thy**¹,* & Nikolay A. **POYARKOV**²,³

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

² Lomonosov Moscow State University, Biological Faculty, Department of Vertebrate Zoology, Leninskiye Gory, Moscow, GSP-1, 119991, Russia.

³ Joint Russian-Vietnamese Tropical Research and Technological Center, 3, Street 3/2, 10 District, Ho Chi Minh City, Vietnam.

* Corresponding author. Email nthymoef@gmail.com

Paper submitted 5 October 2016, revised manuscript accepted 31 October 2016.

The family Scincidae (skinks) is a globally diverse group of lizards with 154 genera and 1,605 species currently recognised worldwide (Uetz et al., 2016). Among these genera, the genus *Sphenomorphus* Fitzinger, 1843 currently comprises 109 species following recent taxonomic revisions which have transferred numerous species of *Sphenomorphus* to the newly established genera *Tytthoscincus* and *Pinoyscincus* (Linkem et al., 2011; Grismer et al., 2016) and back-and-forth placement of taxa between the morphologically similar genera *Sphenomorphus*, *Leptoseps*, *Livorimica*, *Paralipinia*, *Lipinia*, and *Scincella* (Darevsky, 1990; Nguyen et al., 2011). Following the allocation of *Sphenomorphus rufocaudatus* to the genus *Scincella* (Darevsky, 1990; Nguyen et al., 2011), which we follow herein, the genus *Sphenomorphus* is represented by only four species in Cambodia: *S. indicus* (Gray, 1853), *S. lineopunctulatus* Taylor, 1962, *S. maculatus* (Blyth, 1853), and *S. stellatus* (Boulenger, 1900) (Grismer et al., 2008; Hartmann et al., 2010).

Phnom Namlyr Wildlife Sanctuary is located in the eastern plains of Cambodia beside the Vietnamese border in Mondulkiri Province (Fig. 1, locality 9). Knowledge of the herpetofauna of this area is very limited as only one survey has been undertaken there since 2000 (Stuart et al., 2006). During a field visit to the wildlife sanctuary on 29 December 2014, the first author collected three skink specimens which could not be assigned to any of the four *Sphenomorphus* species currently known from Cambodia: CBC02769–70, two males; CBC02771 – one female (coordinates: 12°19'26.2"N, 107°23'38.0"E). One specimen (CBC02769) was encountered moving among leaf litter on a forest trail while the remaining two (CBC02770–71) were found underneath rotten logs. All were found during the day in evergreen forest between 10:30 and 14:20 hrs. The specimens were preserved in 10% formalin.

and later transferred to 70% ethanol and deposited in the zoological collection of the Royal University of Phnom Penh, Cambodia. Examination of morphometric and meristic characters followed Darevsky & Nguyen (1983) and Nguyen et al. (2011).

The morphometric and meristic characters of the three Sphenomorphus specimens match those of S. buenloicus Darevsky & Nguyen, 1983, including the following (all measurements are given in mm): snout to vent length 53.2–56.1; tail length 25.8–30; prefrontals in contact; lower eyelids scaly; supraoculars 10–13; supralabials 7, the 4th and 5th located underneath the eye; infralabials 6; primary temporal 1; supraocular 4; parietals in contact posteriorly; mid-body scale rows 32–34; ventral scales 62–66; limbs well-developed, each with 5 digits; subdigital lamellae under fourth toe 17–21; hemipenis bifurcating near the tip. In life (Fig. 2), Cambodian specimens have reddish brown colouration on the dorsum, flanks, and tail; scattered, small dark spots on the dorsum and labial region; an indistinct dark stripe from the nostril to the anterior corner of eye, passing the postocular and temporal region and running along the dorsolateral region to the base of tail; lower flanks, especially in the axillary region reddish-brown, with pinkish spotting in the region between posterior axilla and body; scattered tiny elongated light bars along the body and tail flanks; and dorsal surface of limbs with dark blotches. The colouration of specimens of S. buenloicus from Mondulkiri Province (Fig. 2A) is quite similar to that of the population from the type locality in Gia Lai Province, Vietnam (Fig. 2B).

Cambodian specimens differ slightly from S. buenloicus specimens from the type locality in certain morphological attributes based on the original description by Darevsky & Nguyen (1983): e.g., in having 10–13 supraoculars (versus 9 in S. buenloicus); 32–34 mid-body scale rows (versus 30–34 in S. buenloicus); and 62–66 ventral scales (versus 55–58 in S. buenloicus). These differences may be due to population variation; however further studies including examination of genetic differentiation are required to understand the taxonomic importance of morphological differences between Cambodian and Vietnamese populations of S. buenloicus.

Sphenomorphus buenloicus was originally described from Buon Luoi in Gia Lai-Kon Tum Province of Vietnam (now Gia Lai Province, forest in the type locality is destroyed; Fig. 1, locality 7) and later reported from several localities in the mountainous regions of Tay Nguyen Plateau in Gia Lai and Kon Tum provinces of Vietnam (Fig. 1, localities 3–8). It was also recorded in Chu Mom Ray National Park in Kon Tum Province (Fig. 1, locality 3), adjacent to Virachey National Park.
Fig. 2 Sphenomorphus buenloicus in life: A) adult male from Phnom Namlyr Wildlife Sanctuary, Mondulkiri, Cambodia; B) adult male from Kon Chu Rang Nature Reserve, Gia Lai, Vietnam (© Neang Thy & Nikolay Poyarkov).
in Cambodia. Recently, *S. buenloicus* was found in the Loc Bac forest, Lam Dong Province (Fig. 1, locality 10) and Nam Cat Tien National Park, Dong Nai Province of Vietnam (Fig. 1, locality 11). The hilly area of the Lam Dong and Dong Nai provinces share many herpetofaunal elements with hilly areas in the eastern area of Mondulkiri Province, Cambodia (Fig. 1, locality 9; Stuart et al., 2006). However, as some localities where *S. buenloicus* has been recorded in the northern part of central Vietnam (Fig. 1, localities 1–2) and southern Vietnam (Fig. 1, locality 12) are distant from what appears to be the main range of the species, their status should be clarified.

The present report extends the known range of *S. buenloicus* from its type locality in Gia Lai Province of Vietnam approximately 235 km southwest to Phnom Namlyr Wildlife Sanctuary in Cambodia, which coincides with its recent discovery in the Dong Nai and Lam Dong provinces of southern Vietnam (Vassilieva et al., 2016). Discovery of *S. buenloicus* can also been anticipated in north-eastern montane Cambodia (Virachey National Park). This is the first record of *S. buenloicus* outside Vietnam and constitutes the fifth species of *Sphenomorphus* documented in Cambodia. Our discovery highlights the current incompleteness of information on reptiles in the eastern plains of Cambodia. This area has close affinities to the Annamite Mountains where many new species and herpetofaunal records have recently been documented (Nazarov et al., 2012; Hartmann et al., 2013; Nguyen et al., 2013; Poyarkov et al., 2014, 2015a, 2015b; Rowley et al., 2016).

**Acknowledgements**

The first author is grateful to Lee Grismer, Rafe Brown, and Nguyen Quang Truong for sharing literature and to Neil Furey for commenting on the manuscript. The second author thanks the Russian Foundation of Basic Research (RFBR 15-04-08393) and the Russian Science Foundation (RSF grant No. 14-50-00029) for financial support.

**References**


Neang T. & N.A. Poyarkov


Postpartum phytomedicine and its future in maternal healthcare in Prey Lang, Cambodia

Victoria H. GRAPE1,* , Nerea TURREIRA-GARCIA1, Lars HOLGER-SCHmidt1, CHHANG Phourin2 & Prachaya SRISANGA3

1 Department of Food and Resource Economics, University of Copenhagen, Rolighedsvej 25, 1958 Frederiksberg C, Denmark.
2 Forest and Wildlife Research Institute, Forestry Administration, Hanoi Street 1019, Phum Rongchak, Sankat Phnom Penh Thmei, Khan Sen Sok, Phnom Penh, Cambodia.
3 Queen Sirikit Botanic Garden, Herbarium, Chiang Mai, 50180, Thailand.

* Corresponding author. Email grapevictoria@gmail.com

Paper submitted 1 October 2016, revised manuscript accepted 21 November 2016.

Abstract

Cambodia has reduced maternal mortality rates by modernizing provincial health centres and referral hospitals as well as by banning traditional birthing attendants (TBAs) from practicing. The implications this will have on ethnobotanical knowledge and the local culture are unknown. Because postpartum mortality is a dire reality in Cambodia, this study aimed to document knowledge on traditional phytomedicine for the prevention and treatment of postpartum complications.


Cambodian Journal of Natural History 2016 (2) 119–133 © Centre for Biodiversity Conservation, Phnom Penh
cations. Sixty-eight plant species belonging to 33 families were recorded, the most prevalent being Rubiaceae ($n=10$), Lauraceae ($n=4$), Leguminosae ($n=4$) and Smilaceae ($n=3$). The most common uses were appetite stimulation (34.2%), improving blood circulation (25.7%) and stimulating milk production (22.8%). Mothers from two villages in northern Prey Lang, Cambodia, recognized 50–60% of postpartum plants collected by TBAs and there was no significant correlation between plant recognition and the mother’s age, nor with the number of pregnancies had. A shift from home births with TBAs towards hospital births in the villages of Chamraeun and Spong was observed. There are similarities and differences in the diversity of Cambodian postpartum plants and their uses compared to neighbouring Laos and Thailand. We suggest an integrative approach to maternity services is needed in which traditional medicine supplements modern postpartum healthcare, while preserving bio-cultural heritage and potential pharmacological discoveries.

**Keywords**
Ethnobotany, indigenous, Kuy, Kui, Kuoy, local ecological knowledge, midwifery, traditional ecological knowledge.

**Introduction**
Indigenous communities’ knowledge and use of medicinal plants is increasingly vulnerable in developing nations, its threat having both cultural and pharmacological repercussions (Bodeker & Kronenberg, 2002; Shanley & Lutz, 2003; Bolson et al., 2015). Factors including deforestation, rural exodus, and modernisation of health services could potentially influence the way developing societies relate to and use their surrounding environments. Estimates from 2005 reveal that 70–95% of people living in Asia, Latin America, and the Middle East use traditional medicine as their main form of health care (Rocha et al., 2016).

High maternal mortality is of major health concern in most developing countries. In 2010, an estimated 287,000 deaths worldwide were due to avoidable maternal complications, and most occurred in countries with living standards at or below middle-class, making it vital to focus attention on prevention and treatment of ailments related to pregnancy in these areas (Say et al., 2014). Estimates also suggest that half of maternal deaths occur during the postpartum period, the time immediately following birth and extending up to six weeks afterwards, when a mother’s body returns to its non-pregnant state. Similar trends have been observed in Cambodia, where high fertility and high maternal mortality indicates that motherhood encompasses risks and challenges across the nation. The World Health Organization (WHO, 2013) estimated a maternal mortality rate (MMR) of 170 deaths per 100,000 births in Cambodia, a 15% decrease since 2009. While a promising reduction in a short time period, this remains far higher than MMRs in developing countries which average 12 deaths per 100,000 births (WHO, 2014). In Cambodia, fertility is currently observed at 3.3 children per woman in rural areas compared to 2.2 in urban areas and this contributes to a higher risk of maternal mortality in the countryside (Kalaichandran & Zakus, 2007; Liljestrand & Sambath, 2012).

The unregulated nature and varying quality of traditional birthing practices in Cambodia led to a ban on traditional birthing attendants (TBAs) in 2006 and setting of national standards for obligatory midwife certification programs (Ith et al., 2012; Wang & Hong, 2015). This effectively increased facility deliveries by trained personnel by 78.6% from 2006 to 2011, whereas births by TBAs decreased by 81.5%, contributing to the reduction in MMR nationally (Ir et al., 2015). What has been ignored under this development, however, is how healthcare modernisation may influence future traditional knowledge on medicinal plants when TBAs abandon their practices or when mothers lose interest and trust in their use. Though the efficacy and safety of traditional medicine poses a concern, the cultural value of traditional medicine and its potential to supplement modern practices remains relevant in developing countries such as Cambodia. The risk that valuable information about traditional medicinal plants may vanish is pertinent because many people live far from modern facilities and are often dependent upon traditional medicine (Bodeker & Kronenberg, 2002; Lundh, 2007; Ansari & Inamdar, 2010; Bolson et al., 2015). Integration of traditional medicinal practices in modern times has been documented in Ghana, Nicaragua, and China, and these studies provide insights on how the same could be achieved in Cambodia (Carrie et al., 2015; Chan et al., 2015; Boateng et al., 2016).

Cultural beliefs regarding health often guide indigenous peoples in their choices of plants to prevent and heal ailments. In many cultures around the world, notably in Central America and Asia, there reigns a theory of hot and cold internal balance in the body. Traditional healers prescribe plant medicines according to their balancing effect upon the body’s thermal state (Fishman et al., 1988; Nestler, 2002; de la Cruz et al., 2014; García-Hernández, 2015; Teixidor-Toneu et al., 2016). This practice is also prevalent amongst the Khmer and Kuy ethnic groups in Cambodia, who deem preg-
nancy as a “hot” state and postpartum as a “cool” state and target the latter with traditional medicines that have a warming effect (Tea, 2002; White, 2004). Another cultural aspect of health referenced by TBAs is the belief in “toas”, a form of relapse caused by foods or activities deemed inappropriate, particularly after giving birth. This state manifests in many ways including diarrhoea, nausea, loss of appetite, and general weakness, yet has no English translation (White, 2002). Medical explanations for toas are disputed, some deeming it a culture-bound syndrome comprising a combination of psychiatric and somatic symptoms (Tea, 2010).

Literature is sparse on the traditional use of phytomedicine (i.e. herbal medicine) to prevent and treat postpartum complications in Cambodia. Only a handful of articles on the postpartum traditions of the Khmer and Kuy ethnic groups can be found, and documentation on specific plants used in this regard is lacking (Hoban, 2002; White, 2002, 2004). More in-depth information on plants used can be gathered from neighbouring countries, particularly Laos (Lundh, 2007; Lamxay et al., 2011; de Boer et al., 2011), where ecological and demographic conditions are in several ways similar to Cambodia. Prey Lang Wildlife Sanctuary covers 431,683 ha in the Stung Treng, Stung Treng, and Kratie provinces and protects Cambodia’s largest remaining area of lowland evergreen forest (Souter et al., 2016). Social development and resource extraction has been detrimental to cultural and biological conservation at the site, with increasing pressure from illegal logging, resin tapping, economic land concessions and agricultural land conversion (Strange et al., 2007). Multi-genus botanical surveys on postpartum plants in Preah Vihear and Stung Treng, two provinces that stretch across the north of the wildlife sanctuary, have yet to be published (Koung, 2007). Lamxay et al. (2011) referred to a French materia medica study from 1930 in their comparison of postpartum species from Laos to Cambodian equivalents, but did not specify their regional origins. Of medicinal plants used by the Kuy, an ethnic group in Prey Lang, almost 30% are used to treat postpartum ailments (Turreira-Garcia, 2015), thus such knowledge is an important part of the Kuy ethno-botanical heritage.

This study aimed to document postpartum medicinal plants and address their relation to health and cultural preservation by answering the following questions: 1) what plants are used for postpartum ailments by women and TBAs in northern Prey Lang; and, 2) does the changing healthcare system affect women’s knowledge and use of postpartum medicinal plants?

Methods

Fieldwork took place at four villages within and near the forests of Prey Lang from 23 April to 11 May, 2015 (Fig. 1). The order of remoteness and proximity to old growth forest of the study villages from least to greatest was: Chamraeu, Thmea, Phneak Roluek, and Spong. The populations of these villages are roughly 940 people in Chamraeu, 578 people in Phneak Roluek, 497 people in Spong, and 2,024 in Thmea (NCSNDD, 2010). Local residents practice subsistence farming and mainly obtain their income from cultivation of rice and other staple products as well as tapping resin. Most of the population is of Kuy descent (62%), either fully or with one Kuy parent.

Data collection was undertaken through interviews with mothers, focus group discussions with TBAs, interviews with personnel at a provincial health centre, and collection of voucher specimens of postpartum plants. In group and individual interviews, practices for harvesting and preparation of medicinal plants were explored. As the sensitive nature of the study warranted attention to participant willingness to collaborate, consideration for their privacy was of the utmost importance. All participants were informed of the objective of the study and agreed to share their knowledge. Respondent ages in the Chamraeu and Spong villages ranged from 19 to 80 years old and the mean age of respondents was 42 years (Appendix 1). Both the interviewer and translator were female.

Focus group discussions were held with three former TBAs in Chamraeu village and one former TBA in Spong village. In these villages, TBAs were asked to collect as many as five of the most common postpartum plant species used. These were then used in a knowledge pattern analysis whereby mothers were asked to state their ethnospecies name (common name) and describe their use. This allowed cross-checking of their knowledge with information provided by TBAs. Five plant species were collected from Chamraeu village (ampil, lerneet kerbal pous, ploosbart, protiel tlem kmov, and teab buy) and four from Spong village (ampil, kandang-bay, potrea, and teab buy). Forty plant recognition interviews were undertaken with mothers (Chamraeu: n=22; Spong: n=18). Additionally, 47 women, including three former TBAs (Appendix 1), were interviewed about their birthing experiences and future preferences. Selection of women for interviews was random, the only criteria being that they had to have given birth at least once.

Free listings, whereby participants drew upon their memory of postpartum medicinal plants to create a list of useful species, were held in each village and plant collec-
tion started from villages into the surrounding vegetation. The collection from Chamreun was unfortunately lost in transportation. Several nights were also spent in the forest to obtain species in less accessible areas. The overall goal was to collect all plants mentioned during the free listings, and any other postpartum medicinal plants recognised in the field. Voucher specimens were collected and initially retained in the Forest and Wildlife Research Institute, Forestry Administration in Phnom Penh, Cambodia. These were later transferred to the Queen Sirikit Botanic Garden (QSBG) in Chiang Mai, Thailand for secondary inspection and identification. All permits required for the study were in accordance with the Nagoya Protocol on Access and Benefit Sharing.

Paired T-tests were undertaken using RStudio© (Version 0.99.441, 2015) to assess whether number of plants recognized by respondents differed between age groups or numbers of pregnancies carried to term by mothers.

Results

Postpartum phytomedicine in Prey Lang

Sixty-eight species used for the postpartum period were collected belonging to 33 families, with Rubiaceae (ten species), Lauraceae (four species), Leguminosae (four species), and Smilaceae (three species) being the most represented (Table 1). Preparation of these was primarily as an infusion in tea (61 species, 89.7%), and four plant species were also taken as a tincture in rice wine. Preparation practices for the remaining plant species were not specified. Villages differed on ethnospecies names, uses and/or application methods for seven plant species. Plants used for their postpartum effects in addition to supporting uterine (18 species, 26.5%) and general health (five species, 7.4%) included: orexigenic (i.e. stimulating appetite, 24 species, 35.3%); improving blood circulation including building “stronger” veins (17 species, 25%); galactagogue (i.e. stimulating milk production, 16 species, 23.5%); treating pain (i.e. body, joint, uterine) or a cold feeling in the uterus (nine species, 13.2%); uterotonic (i.e. inducing contraction of the uterus, in some cases reducing postpartum haemorrhage, seven species, 10.3%); and soas (three species, 4.4%). Three plant species (4.4%) were used for stopping blood loss, while two species were used to improve skin health and improve sleep/rest (2.9% for each category respectively). Lastly, one plant species was used to treat uterine prolapse, food poisoning, joint dislocation, boost the immune system, improve strength and flexibility, and provide refreshment (1.5% for each category respectively) (Fig. 2).
### Table 1

Medicinal plants at Prey Lang with reported preparation methods and uses during the postpartum period. Voucher specimen numbers are given in parenthesis and voucher specimens are deposited in the Queen Sirikit Botanic Garden, Chiang Mai, Thailand. Village: PR – Phneak Roluek; SP – Spong; TH – Thmea. * Plant species used in knowledge pattern analysis.

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Ethnospecies Name (Voucher No.)</th>
<th>Village</th>
<th>Postpartum Uses</th>
<th>Parts Used</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>ACHARIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hydnocarpus anthelminthicus Pierre ex Laness.</td>
<td>Krorbao (130)</td>
<td>PR, SP</td>
<td>Galactagogue, uterine pain</td>
<td>Bark &amp; wood</td>
<td>Infusion</td>
</tr>
<tr>
<td><strong>ANNONACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dasyanthes macracalyx Finet &amp; Gagnep.</td>
<td>Cheungchab (40)</td>
<td>SP</td>
<td>Galactagogue, orexigenic, sleep/rest</td>
<td>Root</td>
<td>Infusion</td>
</tr>
<tr>
<td>Goniothalamus repevensis Pierre ex Fin. &amp; Gagnep.</td>
<td>Krovan (136)</td>
<td>PR</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td>Goniothalamus tamirensis Pierre ex Finet &amp; Gagnep.</td>
<td>Moom (160)</td>
<td>PR, SP</td>
<td>Orexigenic, uterotonics, blood circulation</td>
<td>Root</td>
<td>Infusion</td>
</tr>
<tr>
<td><strong>APOCYNACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Holarrhena curtisii King &amp; Gamble</td>
<td>Tekdors (302)</td>
<td>PR</td>
<td>Blood circulation, galactagogue</td>
<td>Bark &amp; wood</td>
<td>Infusion with Ploosbart</td>
</tr>
<tr>
<td><strong>ARECACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Calamus viminalis Willd.</td>
<td>Chongpdao (63)</td>
<td>SP, TH</td>
<td>Pain</td>
<td>Root</td>
<td>Infusion</td>
</tr>
<tr>
<td><strong>ASPARAGACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dracaena angustifolia (Medik.) Roxb.</td>
<td>Angraedaek (5)</td>
<td>PR, SP</td>
<td>Galactagogue, orexigenic, general health</td>
<td>Leaves &amp; flower</td>
<td>Infusion</td>
</tr>
<tr>
<td>Peliosanthes teta Andrews</td>
<td>Tbaldaek (301)</td>
<td>SP</td>
<td>Uteronic</td>
<td>Root</td>
<td>Infusion: roots of Angraedaek &amp; Skun</td>
</tr>
<tr>
<td><strong>ASPHEDELACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dianella ensifolia (L.) DC.</td>
<td>Kontoykror-per (114)</td>
<td>SP</td>
<td>Orexigenic, refreshment</td>
<td>Root &amp; leaf base</td>
<td>Roast, then infusion</td>
</tr>
<tr>
<td><strong>BORAGINACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Markhamia stipulata (Wall.) Seem.</td>
<td>Dakpor (74)</td>
<td>PR</td>
<td>Uterine health</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td><strong>CELASTRACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Euonymus cochinchinensis Pierre</td>
<td>Koomouy (115)</td>
<td>PR, SP</td>
<td>Galactagogue, orexigenic</td>
<td>Bark, root &amp; wood</td>
<td>Infusion</td>
</tr>
<tr>
<td><strong>CLUSIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garcinia mungens Wight</td>
<td>Kres (126)</td>
<td>PR</td>
<td>Not specified</td>
<td>Bark</td>
<td>Not specified</td>
</tr>
<tr>
<td><strong>CAPPARACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Capparis micrantha DC.</td>
<td>Kounh Chur beay dach (120)</td>
<td>PR</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
</tr>
<tr>
<td><strong>CESTRACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salacia chinensis L.</td>
<td>Rorveay (247)</td>
<td>PR, SP</td>
<td>Uterine prolapse</td>
<td>Wood &amp; nodes</td>
<td>Infusion</td>
</tr>
<tr>
<td>Salacia cochinchinensis Lour.</td>
<td>Vor Kondabcho-ngae (351)</td>
<td>PR</td>
<td>Not specified</td>
<td>Bark &amp; wood</td>
<td>Infusion</td>
</tr>
<tr>
<td><strong>GARCINIA</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Garcinia sp. 2</td>
<td>Yeam (381)</td>
<td>PR, SP</td>
<td>Blood circulation</td>
<td>Bark, root &amp; wood</td>
<td>Infusion</td>
</tr>
<tr>
<td>Scientific name</td>
<td>Ethnospecies Name (Voucher No.)</td>
<td>Village</td>
<td>Postpartum Uses</td>
<td>Parts Used</td>
<td>Preparation</td>
</tr>
<tr>
<td>--------------------------</td>
<td>---------------------------------</td>
<td>---------</td>
<td>-----------------</td>
<td>------------</td>
<td>---------------------------------------</td>
</tr>
<tr>
<td><strong>CONNARACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ellipanthus tomentosus</em></td>
<td>Kurz Kd Komprok (96) PR, SP</td>
<td>Orexigenic</td>
<td>Root</td>
<td>Infusion with Reum</td>
<td></td>
</tr>
<tr>
<td><strong>DILLENIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Dillenia hookeri</em> Pierre</td>
<td>Ploosbar* (187) PR, TH</td>
<td>Galactagogue, general health, food poisoning</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>EBENACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Diospyros ehretioides</em></td>
<td>Wall. ex G. Don (161) PR</td>
<td>Blood circulation</td>
<td>Bark &amp; root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Diospyros sylvatica</em></td>
<td>Roxb. (98) PR</td>
<td>Uterine health</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Diospyros undulata</em></td>
<td>Wall. ex G. Don (44) SP</td>
<td>1. Galactagogue; 2. Pain &amp; cold in uterus</td>
<td>1. Root (best) or bark; 2. Bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>ERYTHROXYLACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Erythroxylum cambodianum</em></td>
<td>Pierre Chompussek (60) PR, SP</td>
<td>Blood circulation, orexigenic</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>EUPHORBIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Antidesma ghaesembilla</em></td>
<td>Gaertn. Dongkeabk-dam (82) PR, SP</td>
<td>General health</td>
<td>Bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Croton sp.</em></td>
<td>Montek (159) PR</td>
<td>Toas</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Suregada multiflora</em></td>
<td>(A. Juss.) Baill. Tronoumseik (321) PR, SP</td>
<td>Galactagogue, orexigenic, blood circulation</td>
<td>Bark, root &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>LAMIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Gmelina asiatica</em> L.*</td>
<td>Anhcharnh (7) PR, SP</td>
<td>Joint dislocation</td>
<td>Root</td>
<td>Dry, then infusion Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Vitex pinnata</em> L.*</td>
<td>Porpool (200) PR, SP, TH</td>
<td>Galactagogue, orexigenic, general health</td>
<td>Bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Vitex sp.</em></td>
<td>Protespray (223) PR</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Not specified</td>
<td></td>
</tr>
<tr>
<td><strong>LAURACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Cinnamomum bezolghota</em></td>
<td>(Buch-Ham.) Sweet Sroumdav (293) PR, TH</td>
<td>Blood circulation, uterine health</td>
<td>Root, bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Cinnamomum polyadelphum</em></td>
<td>(Lour.) Kosterm. Slapok (267) PR, SP, TH</td>
<td>Not specified, Pain &amp; cold feeling in uterus, joint &amp; body pain</td>
<td>Root</td>
<td>Infusion, infusion with bark &amp; Chherplerng wood, or tincture</td>
<td></td>
</tr>
<tr>
<td><em>Cinnamomum sp.</em></td>
<td>Sromday (284) PR</td>
<td>Not specified</td>
<td>Root &amp; bark</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Ocotea lanceifolia</em></td>
<td>(Schott) Mez Kolor (127) PR</td>
<td>Galactagogue, orexigenic</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>LEGUMINOSAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Acacia sp.</em></td>
<td>Vor Torleng (376) PR</td>
<td>Orexigenic</td>
<td>Bark &amp; wood</td>
<td>Infusion or rice wine tincture</td>
<td></td>
</tr>
<tr>
<td><em>Tadehagi triquetrum</em></td>
<td>(L.) H.Ohashi Angkrong (4) PR</td>
<td>Joint or bone pain, orexigenic</td>
<td>Whole plant</td>
<td>Infusion</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (Continued)

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Ethnospecies Name (Voucher No.)</th>
<th>Village</th>
<th>Postpartum Uses</th>
<th>Parts Used</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>Uraria</em> sp.</td>
<td>Chang Kesang Kre-ang (36)</td>
<td>PR</td>
<td>Blood circulation</td>
<td>Root &amp; bark</td>
<td>Dry, then infusion</td>
</tr>
<tr>
<td><em>Xylia xylocarpa</em> (Roxb.) Taub.</td>
<td>Chkrom (56) SP, TH</td>
<td>Skin health</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>LYTHRACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Lagerstroemia speciosa</em> (L.) Pers.</td>
<td>Kraol (123) PR, SP, TH</td>
<td>Orexigenic, boost immune system, skin health</td>
<td>Bark</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>MALVACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Colona auriculata</em> (Desf.) Craib</td>
<td>Preal (208) PR, SP</td>
<td>Uterotonic, uterine pain</td>
<td>Root</td>
<td>Infusion with Dakun root (<em>Tetracera loureiri</em>)</td>
<td></td>
</tr>
<tr>
<td><em>Waltheria indica</em> L.</td>
<td>Preash Proa Veal (211) TH</td>
<td>Uterine health</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>MELASTOMATACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Melastoma malabathricum</em> L.</td>
<td>Baynhenh (20) PR</td>
<td>Orexigenic</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Melastoma saigonense</em> (Kuntze) Merr.</td>
<td>Baynhenh (22) SP</td>
<td>“Stronger” veins, galactagogue, orexigenic</td>
<td>Root</td>
<td>Infusion with root of male plant</td>
<td></td>
</tr>
<tr>
<td><em>Melastoma sanguineum</em> Sims</td>
<td>Baynhenh (21) PR, SP</td>
<td>“Stronger” veins, galactagogue, orexigenic</td>
<td>Root</td>
<td>Infusion with root of female plant</td>
<td></td>
</tr>
<tr>
<td><strong>MORACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ficus racemosa</em> L.</td>
<td>Lovear (149) PR</td>
<td>Galactagogue</td>
<td>Outer part of seed</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>MYRTACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Syzygium zeylanicum</em> (L.) DC.</td>
<td>Smarch (271) PR, SP, TH</td>
<td>Not specified</td>
<td>Bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>OCHNACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ochna integerrima</em> (Lour.) Merr.</td>
<td>Angkea (3) PR, SP</td>
<td>Blood circulation, orexigenic, uterotonic</td>
<td>Root, bark &amp; wood</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>PHYLLANTHACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>PINACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Pinus merkusii</em> Jungh. &amp; de Vriese</td>
<td>Srorl (286) SP</td>
<td>Body pain</td>
<td>Root &amp; bark</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>RHAMNACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Ventilago cristata</em> Pierre (unresolved name)</td>
<td>Vor Tonlueng (375) SP</td>
<td>Blood circulation</td>
<td>Vine</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>Ziziphus oenopolia</strong> (L.) Mill.</td>
<td>Vor Sangkher, also Vor Sangkhbouch or Sangkher (367) PR, SP, TH</td>
<td>Galactagogue, orexigenic, stop blood loss, strength &amp; flexibility</td>
<td>Root &amp; vine</td>
<td>Infusion with other plants (not specified)</td>
<td></td>
</tr>
</tbody>
</table>
Table 1 (Continued)

<table>
<thead>
<tr>
<th>Scientific name</th>
<th>Ethnospecies Name (Voucher No.)</th>
<th>Village</th>
<th>Postpartum Uses</th>
<th>Parts Used</th>
<th>Preparation</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>RUBIACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Coptosapelta flavescens</em> Korth. Tonling (313)</td>
<td>PR</td>
<td>Blood circulation</td>
<td>Bark &amp; wood</td>
<td>Infusion or rice wine tincture</td>
<td></td>
</tr>
<tr>
<td><em>Ixora nigricans</em> R. Br. ex Wight &amp; Arn.</td>
<td>Pkamuchol (185) PR</td>
<td>Pain</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Lasianthus hirsutus</em> (Roxb.) Merr. Skun (265) PR, SP</td>
<td>Orexigenic, uterotonic</td>
<td>Root</td>
<td>Infusion with Thaldaek &amp; Angraedae root</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Mitragyna hirsuta</em> Hav. Ktom, Ktomtom (137)</td>
<td>PR</td>
<td>Not specified</td>
<td>Root</td>
<td>Infusion with Roleay</td>
<td></td>
</tr>
<tr>
<td><em>Mitragyna sp.</em> Kvav (142) PR, SP</td>
<td>Blood circulation</td>
<td>Not specified</td>
<td>Not specified</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Mitragyna speciosa</em> (Korth.) Havil. Ktumphnom (141)</td>
<td>PR</td>
<td>Not specified</td>
<td>Root &amp; bark</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><em>Nauclea orientalis</em> (L.) L. Kdol (97), Roleay (138), Roleay (223)</td>
<td>Orexigenic, blood circulation, stop blood loss, uterotonic, uterine health</td>
<td>Root (or bark)</td>
<td>Infusion or rice wine tincture</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Oxycceros horridus</em> Lour. Thnungkan-hchos (310) PR</td>
<td>Not specified</td>
<td>Root</td>
<td>Infusion or rice wine tincture</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Prismatomeris filamentosa</em> Craib Romdenh-meas (238)</td>
<td>PR, SP</td>
<td>Orexigenic, sleep/rest, general health</td>
<td>Root</td>
<td>Infusion with other plants (not specified)</td>
<td></td>
</tr>
<tr>
<td><em>Prismatomeris memecyloides</em> Craib Romdenh (237) PR</td>
<td>PR, SP</td>
<td>Stop blood loss</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>RUTACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Murraya siamensis</em> Craib (unresolved name) Brohoung-arkas (28)</td>
<td></td>
<td>Toas</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>SIMAROUBACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Brucea javanica</em> (L.) Merr. Bromatmunus (30) PR, TH</td>
<td>Not specified</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Eurycoma longifolia</em> Jack Angtongsor (6) PR, SP</td>
<td>Uterotonic</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>SMILACACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Smilax lanceifolia</em> Roxb. Porpreus (201) PR</td>
<td>Not specified</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Smilax megacarpa</em> A.DC. Porpreus Vor Rombers (362) PR</td>
<td>Blood circulation, hip pain</td>
<td>Root</td>
<td>Infusion with Chongpdao root</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Smilax sp.</em> Porpreus (203) SP</td>
<td>Orexigenic, uterotonic</td>
<td>Root</td>
<td>Infusion with Moom root</td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>VIOLACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Rinorea anguifera</em> Kuntze (unresolved name) Dom dek pro ma (78)</td>
<td></td>
<td>Uterine health</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
</tr>
<tr>
<td><strong>VITACEAE</strong></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Leea indica</em> (Burm. f.) Merr. Kandangbay* (90) SP</td>
<td>Galactagogue, orexigenic, toas</td>
<td>Root</td>
<td>Infusion</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

© Centre for Biodiversity Conservation, Phnom Penh  Cambodian Journal of Natural History 2016 (2) 119–133
Phytomedicine in Prey Lang

Toas and other postpartum ailments

An emic postpartum ailment that proved difficult to translate biomedically was related to consumption of “wrong” foods after delivery as well as resuming physical labour too quickly. There was little coherence in the recognition of different foods as “wrong” between respondents, yet the symptoms described were the same. These included “lock-jaw”, which inhibits opening of the mouth to eat, and muscle tightness and pain over the whole body. Skin rash was also mentioned. Some respondents indicated that women should abstain from eating meat (specifically chicken and beef) and eggs after delivery. Others explained that prohibited foods vary according to personal preferences and tolerances. *Leea indica* was reported to alleviate skin rash, whereas *Croton* sp. and *Murraya siamensis* helped lock-jaw. *Neonauclea sessifolia* and *Prismatomeris memecycloides* were used for treating blood-loss after birth. Information about the cause of blood-loss (e.g., haemorrhage, mechanical tear) in women was not known or described in further detail. One respondent prescribed making a paste out of Teab buy seed (not collected, but used in the plant recognition analysis) and applying it directly to the breast to treat mastitis (inflammation of the breast tissue). Others reported experiencing mild pain, but regarded this sensitivity as normal in breastfeeding.

Women’s knowledge and use of postpartum medicinal plants

Ethnospecies (local) names provided by TBAs were used as controls when investigating recognition of postpartum plants by mothers. Five plant species (*ampil*, *lermeet kerbal pous*, *ploosbart*, *protiel tlem kmov*, and *teab buy*) were used for recognition pattern analysis in Chamreun, whereas four (*ampil*, *kandangbay*, *potrea*, and *teab buy*) were used in Spong. Two plant species (*ampil* and *teab buy*) encountered in Chamreun were also found and collected in Spong. These seven species were common according to the TBAs and there was agreement about their local names. Sixty percent of plant species (three out of five species) were identified correctly by the mothers in Chamreun, whereas 50% (two out of four species) were correctly identified in Spong. No significant differences were found in terms of the number of plants recognised by different age groups ($p=0.1547$), or according to the number of pregnancies carried to term ($p=0.2563$).

Birthing experiences

No mothers reported miscarriages, yet four reported complications after birth, with one experiencing blood-loss and the others experiencing general weakness and mastitis. The remaining 43 respondents reported no complications in previous births.
Mothers specified the number of successful births they had previously had, what kind of birthing assistance they had received (provincial health centre [PHC], referral hospital [RH], TBA, own family or other) and what their future preference would be if they could theoretically choose the next time they had a child (Table 2), as follows:

Group A: These mothers were younger (19–33 years of age, n=15) and had 1.3 successful births on average, 13 of which had occurred at a PHC or RH and eight with a TBA. Of the 15 respondents, 11 preferred PHC/RH delivery, three preferred to give birth at home with their family and one preferred to give birth with TBA assistance.

Group B: Mothers between 34 and 38 years of age constituted 21.3% of our sample (n=10/47) and had collectively experienced 32 births. Twenty-nine of these births had occurred with TBA assistance, while the remaining three took place at a PHC or RH. The ratio of preference for giving birth at a PHC/RH to TBA was 3:2. None preferred to give birth at home.

Group C: All respondents (n=21) 39 years of age and above had not given birth at a PHC or RH. All but one had received assistance from a TBA for their deliveries. The exception was the only study respondent who had given birth (on three occasions) with assistance of family members each time. She was also the only respondent in her age group who preferred to this manner of giving birth if she were to have another child. Ten of the remaining respondents preferred to give birth at a PHC/RH, whereas nine preferred to give birth with a TBA.

These are compared below to those encountered in studies of postpartum health in Laos (Lundh, 2007; de Boer & Lamxay, 2009) and Thailand (Panyaphu et al., 2011; Srishti et al., 2012) (Grape & Turreira-Garcia, 2015).

The genus Psychotria is common in Southeast Asia, and phytochemical analyses have shown that several species within the genus contain analgesic compounds, relieving afterpains and acting as a uterotonic, inducing contraction of the uterus and in some cases reducing postpartum haemorrhage (Lundh, 2007). The Mien (Yao), 15th–19th century migrants from middle and southern China who settled in Thailand and Laos, use Psychotria to aid the secretion of waste products from the vagina (Panyaphu et al., 2011). In contrast, Psychotria species mentioned by Khmer and Kuy ethnic groups of Cambodia are described as having orexigenic (appetite stimulating) properties.

Species mentioned by Lundh (2007) such as Croton roxburghii had a galactagogue (stimulating milk production) and drying effect on the uterus, while the Croton sp. in our study was prescribed for toas related to improper food consumption. Differences in beliefs and biomedical causes and effects render categorisation of postpartum ailments and prescriptions ambiguous. For instance, the toas symptoms described as “lock-jaw” are strikingly similar to the warning signs of tetanus infection. Tetanus bacteria typically enter through a wound and as exposure of the compromised birth canal could provide such an entrance (Hassel, 2013), this warrants further investigation.

Three species of Melastoma (M. malabathricum, M. saigonense, and M. sanguineum) were reported to have orexigenic and galactagogue effects in our study, and also to improve blood circulation. Lundh (2007) referred to uterotonic properties of species in the same genus (M. candidum) that were verified on guinea pigs. Melastoma candidum was also described by Lao informants as having a contraceptive effect. Though no literature was found to this effect, stimulation of contractions in the early stages of pregnancy could perhaps instigate abortion.

Table 2

<table>
<thead>
<tr>
<th>Group</th>
<th>Age</th>
<th>No of Respondents</th>
<th>No of Births</th>
<th>Previous Birthing Assistance</th>
<th>Future Birthing Preference</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td>PHC/RH</td>
<td>TBA</td>
</tr>
<tr>
<td>A</td>
<td>19–33</td>
<td>15</td>
<td>21</td>
<td>9, 62%</td>
<td>6, 38%</td>
</tr>
<tr>
<td>B</td>
<td>34–38</td>
<td>10</td>
<td>32</td>
<td>1, 9%</td>
<td>9, 91%</td>
</tr>
<tr>
<td>C</td>
<td>39–80</td>
<td>21</td>
<td>93</td>
<td>20, 97%</td>
<td>1, 3%</td>
</tr>
</tbody>
</table>

Discussion

Plants used for postpartum ailments

The plant species collected in this study and used for postpartum ailments by women and TBAs in northern Prey Lang represent a wide range of botanical families.
in our study. Inadequate food consumption can have this reportedly had had orexigenic and uterotonic effects (Panyaphu et al., 2011). The Mien of Thailand use the strength and ability to absorb nutrients. In contrast, if a woman is malnourished, she is unlikely to produce enough milk, and it could be that F. hispida improves weight gain and the strength and ability to absorb nutrients. In contrast, the Mien of Thailand use F. auriculata to treat urinary infections (Panyaphu et al., 2011). Ochna cf. integerrima was also noted by Lundh (2007) as having galactagogue properties and a drying effect on the uterus, whereas this reportedly had had orexigenic and uterotonic effects in our study. Inadequate food consumption can have marked effects on lactation, as demonstrated on rats (Teixeira et al., 2002), and orexigenic and galactagogue properties may be related.

Ziziphus oenoplia has been reported to relieve pain in Laos and Thailand (Lundh, 2007; Panyaphu et al., 2011), whereas in Prey Lang it is reportedly used as a galactagogue and orexigenic, and also for its ability to stem blood-loss and improve postpartum strength and flexibility. Two accounts also mention pain relief for Smilax sp. from Laos (Lundh, 2007), which accords with accounts for S. megacarpa in Cambodia, although the specimen we collected of Smilax sp. was reported to have orexigenic and uterotonic properties. The Mien in Thailand also use S. lanceifolia to treat peptic ulcers (Panyaphu et al., 2011). Lea indica was reported by them to eliminate waste matter and improve blood flow (Panyaphu et al., 2011), whereas Khmer and Kuy in Prey Lang reported galactagogue and orexigenic properties for the species, as well as effects upon toas ailments during the postpartum period. In Prey Lang, Gmelina asiatica is used in for supporting joint health. Another species in the same genus, G. arborea, is used to treat infected wounds and peptic ulcers by Mien in Thailand (Panyaphu et al., 2011).

In related studies in Laos and Thailand (Lundh, 2007; de Boer & Lamxay, 2009; Panyaphu et al., 2011; Srithi et al., 2012), postpartum was unanimously the phase of pregnancy for which each ethnic group had the greatest knowledge and use of medicinal plants. Despite differences in specific uses, our study indicates that the communities of Prey Lang share this tendency. While herbal steam baths seems to be the most prevalent method of plant preparation elsewhere, Khmer and Kuy women in Prey Lang almost exclusively administer these as an infusion in tea.

Modernisation and its effects upon traditional knowledge

Traditional phytomedicine has been widely used by indigenous cultures long before the advent of modern medicine (Shanley & Lutz, 2003; Srithi et al., 2009). However, modernisation has eroded traditional ecological knowledge worldwide, raising concerns for its continued existence (Gómez-Baggethun et al., 2013). Given the short study period, the large number and range of species encountered in this study indicates the importance of Khmer and Kuy knowledge of postpartum plants at Prey Lang. Rapidly changing conditions such as forest degradation and agricultural land conversion will likely change the way people interact with their surrounding environments. The national ban on TBAs in 2006 and continued modernisation of healthcare services could also diminish traditional knowledge and use of phytomedicine in future. In this context, in serving as a reference point for future comparisons, this study may facilitate understanding of such effects.

Despite the contested efficacy of traditional medicine, botanical remedies are relevant due to their cultural importance, affordability and inherent potential for future discovery of new medicines (Laval et al., 2011; de Boer & Cotingting, 2014). The many generations worth of traditional phytomedical knowledge at Prey Lang therefore has intrinsic value and ought to be documented given the potential for its disappearance in future. Integration of such knowledge with modern science may also be an efficient way to retain and honour community traditions. The forests of Prey Lang consequently warrant further ethnobotanical research. Further pharmacological studies on the beneficial and adverse effects of postpartum plants at Prey Lang should attempt to identify the genera and species with the greatest efficacy and be integrated into modern healthcare to realise their benefits in reducing maternal mortality. Efficient integration of traditional medicine ought to encompass regulation, comprehensive educational campaigns, and capacity building. This would honour, and perhaps strengthen, cultural values were traditional medicine to complement modern medicine in a holistic and individualized prevention and treatment regime (Bodeker & Kronenberg, 2002).

The present study merely touches the surface of what remains to be learned about traditional phytomedical methods of treating and preventing ailments after childbirth. Further ethnobotanical investigations will likely reveal parallels in Kuy culture in Laos and Thailand and

_Cambodian Journal of Natural History_ 2016 (2) 119–133

© Centre for Biodiversity Conservation, Phnom Penh
phytochemical analysis may verify reported applications of plants with their true biophysical effects. Given their botanical diversity, the forests of Prey Lang present a metaphorical, and at times literal, lifeline for the people of Cambodia. Further study and use of medicinal plants at Prey Lang may be key to continued conservation of this lowland evergreen forest and ensuring sustained benefits to local people. Whether the union of traditional and modern medicine will be adopted to help reduce maternal mortality is something coming years of developing community involvement and healthcare modernization will likely reveal.

Acknowledgements

The authors express their gratitude to the people of Prey Lang who generously shared their time and knowledge about their home and culture. Special thanks are due to the mothers and midwives of Prey Lang, and our guides at the Chamraeu, Phneak Roluek and Spong villages: Cher Horn, Kun Ying, Pok Hong, Tek Soen, Soum Soun, and Lin Wet. Sincere thanks are due to the Ingenier Svend G. Fiedler og Hustrus Grant Foundation for financially supporting the research. We also thank Yim Sovann for his insights into Cambodian maternal healthcare and Nhel Sokchea for assistance during the fieldwork.

References


About the Authors

VICTORIA H. GRAPE is a Norwegian botanist studying a Masters at the University of Copenhagen, Denmark. She has held workshops in Botany for undergraduate students and worked at the University herbarium, assisting transfer of collections to the National Museum of Natural History in Copenhagen. Her interests lie in conservation biology and ethnobotany.

NEREA TURREIRA-GARCIA is a Spanish PhD candidate at Copenhagen University. She studied environmental sciences at the University of the Basque Country and forest and nature management in Copenhagen. Her research interests include local ecological knowledge and forest monitoring and she has worked in Cambodia, Vietnam, Guatemala, Spain, and The Netherlands.

LARS HOLGER-SCHMIDT is a Danish ethnobotanist and associate professor and senior advisor at Copenhagen University. He has 22 years of experience, ten of which relate to forestry projects in Asia and Africa. He teaches agroforestry and researches Allanblackia oil in Africa and forest conservation strategies in Asia.

PHOURIN CHHANG is a Cambodian botanist who works as herbarium curator and professor at the Forest and Wildlife Research Institute, Forestry Administration in Phnom Penh, Cambodia.

PRACHAYA SRISANGA is a curator at Queen Sirikit Botanic Garden Herbarium, Chiang Mai, Thailand. His research focusses on plant species diversity in mainland Southeast Asia (Laos, Myanmar, and Thailand) and and ethnobotanical practices of ethnic groups in the region.
# Appendix 1 Summary of study respondents

Village: CH – Chamraeun; SP – Spong. Job: F – Farmer; H – Healthcare; L – Logger; T – Resin tapper; S – Shop keeper. Income: Ag – Agricultural work; C – Corn; Cm – Child-minding; Ff – Food collection in forest; Lo – Logging; M – Meatballs; P – Potatoes; Re – Resin; Ri – Rice; Se – Sesame; Ss – Small shop; V – Vegetables; Wh – Wheat; Wi – Wine. 1CAD – Complications after delivery. 2TPT – Total pregnancies carried to term.

<table>
<thead>
<tr>
<th>#</th>
<th>Village</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Job</th>
<th>Income</th>
<th>CAD</th>
<th>TPT</th>
<th>Own</th>
<th>TBA</th>
<th>PHC</th>
<th>Choice</th>
<th>Reason, Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>CH</td>
<td>58</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>6</td>
<td>6</td>
<td>TBA</td>
<td>Familiar (former TBA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>CH</td>
<td>33</td>
<td>Kuy</td>
<td>F</td>
<td>Re</td>
<td>2</td>
<td>2</td>
<td>PHC</td>
<td>Easier than at home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>CH</td>
<td>47</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, P</td>
<td>4</td>
<td>4</td>
<td>TBA</td>
<td>Easier, hospital far away</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>CH</td>
<td>64</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, Ss</td>
<td>2</td>
<td>2</td>
<td>TBA</td>
<td>No comment</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>CH</td>
<td>44</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>5</td>
<td>5</td>
<td>PHC</td>
<td>Effective medicine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>CH</td>
<td>58</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, P, M, Wi</td>
<td>3</td>
<td>3</td>
<td>Own</td>
<td>Don’t trust strangers at hospital (former TBA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>CH</td>
<td>80</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>3</td>
<td>3</td>
<td>PHC</td>
<td>Reliable facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>CH</td>
<td>57</td>
<td>Khmer</td>
<td>S</td>
<td>Ss</td>
<td>1</td>
<td>4</td>
<td>4</td>
<td>PHC</td>
<td>TBAs illegal</td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>CH</td>
<td>55</td>
<td>Khmer</td>
<td>F</td>
<td>P</td>
<td>3</td>
<td>3</td>
<td>TBA</td>
<td>Easier, close to home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>CH</td>
<td>23</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, P</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Easier, TBAs not educated</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>11</td>
<td>CH</td>
<td>35</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>4</td>
<td>3</td>
<td>1</td>
<td>TBA</td>
<td>No comment</td>
<td></td>
<td></td>
</tr>
<tr>
<td>12</td>
<td>CH</td>
<td>74</td>
<td>Half</td>
<td>F</td>
<td>Ri</td>
<td>4</td>
<td>4</td>
<td>PHC</td>
<td>Better facilities</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>13</td>
<td>CH</td>
<td>19</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>CH</td>
<td>52</td>
<td>Kuy</td>
<td>F</td>
<td>Ag</td>
<td>5</td>
<td>5</td>
<td>TBA</td>
<td>TBA experienced</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>CH</td>
<td>30</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, V</td>
<td>1</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
</tr>
<tr>
<td>16</td>
<td>CH</td>
<td>20</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer, many nurses</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>CH</td>
<td>27</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, C, Wh</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>CH</td>
<td>42</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>3</td>
<td>3</td>
<td>TBA</td>
<td>Easier, close to home</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>CH</td>
<td>21</td>
<td>Khmer</td>
<td>L</td>
<td>Lo</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Better facilities, trustworthy</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>20</td>
<td>CH</td>
<td>60</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, P</td>
<td>2</td>
<td>2</td>
<td>PHC</td>
<td>Doctor more qualified for complications</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>21</td>
<td>CH</td>
<td>67</td>
<td>Kuy</td>
<td>F</td>
<td>Ff</td>
<td>9</td>
<td>9</td>
<td>TBA</td>
<td>Easier, but TBAs illegal (former TBA)</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>22</td>
<td>CH</td>
<td>33</td>
<td>Kuy</td>
<td>F</td>
<td>P, Se</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer, children healthier</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>23</td>
<td>CH</td>
<td>24</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>Own</td>
<td>Hospital &amp; TBAs both good</td>
<td></td>
<td></td>
</tr>
<tr>
<td>24</td>
<td>CH</td>
<td>20</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>2</td>
<td>2</td>
<td>Own</td>
<td>Unsure</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>25</td>
<td>CH</td>
<td>25</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>2</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer, continual care</td>
<td></td>
<td></td>
</tr>
<tr>
<td>26</td>
<td>CH</td>
<td>35</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>3</td>
<td>3</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27</td>
<td>CH</td>
<td>25</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>1</td>
<td>1</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>28</td>
<td>CH</td>
<td>35</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>2</td>
<td>2</td>
<td>TBA</td>
<td>Prefers Khmer medicine</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>29</td>
<td>SP</td>
<td>55</td>
<td>Half</td>
<td>T</td>
<td>Re</td>
<td>7</td>
<td>7</td>
<td>PHC</td>
<td>Safer</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>30</td>
<td>SP</td>
<td>62</td>
<td>Kuy</td>
<td>F</td>
<td>Ss</td>
<td>5</td>
<td>5</td>
<td>PHC</td>
<td>Safer, doctors work together, TBAs work alone</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>31</td>
<td>SP</td>
<td>30</td>
<td>Half</td>
<td>T</td>
<td>Re</td>
<td>2</td>
<td>2</td>
<td>TBA</td>
<td>Easier, hospital far away</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
### Appendix 1  (Continued)

<table>
<thead>
<tr>
<th>#</th>
<th>Village</th>
<th>Age</th>
<th>Ethnicity</th>
<th>Job</th>
<th>Income</th>
<th>Birthing Experience</th>
<th>Birthing Preference</th>
<th>Reason, Comments</th>
</tr>
</thead>
<tbody>
<tr>
<td>32</td>
<td>SP</td>
<td>38</td>
<td>Khmer</td>
<td>T</td>
<td>Re</td>
<td>3 2 1</td>
<td>PHC</td>
<td>Safer, more doctors and effective medicine</td>
</tr>
<tr>
<td>33</td>
<td>SP</td>
<td>40</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>6 6</td>
<td>PHC</td>
<td>Safer if complications</td>
</tr>
<tr>
<td>34</td>
<td>SP</td>
<td>36</td>
<td>Half</td>
<td>T</td>
<td>Re</td>
<td>3 3</td>
<td>TBA</td>
<td>Hospital too far</td>
</tr>
<tr>
<td>35</td>
<td>SP</td>
<td>50</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>1 3 3</td>
<td>PHC</td>
<td>Safer</td>
</tr>
<tr>
<td>36</td>
<td>SP</td>
<td>21</td>
<td>Khmer</td>
<td>F</td>
<td>Ri, Re</td>
<td>1 1</td>
<td>Own</td>
<td>No comment</td>
</tr>
<tr>
<td>37</td>
<td>SP</td>
<td>49</td>
<td>Kuy</td>
<td>T</td>
<td>Re</td>
<td>1 5 5</td>
<td>PHC</td>
<td>Own</td>
</tr>
<tr>
<td>38</td>
<td>SP</td>
<td>38</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, Re</td>
<td>4 4</td>
<td>PHC</td>
<td>Safer, but far away</td>
</tr>
<tr>
<td>39</td>
<td>SP</td>
<td>38</td>
<td>Khmer</td>
<td>F</td>
<td>Ss, Re</td>
<td>2 2</td>
<td>PHC</td>
<td>Safer, especially in wet season, but not accessible</td>
</tr>
<tr>
<td>40</td>
<td>SP</td>
<td>38</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, Re</td>
<td>4 4</td>
<td>TBA</td>
<td>Easier, nice to share knowledge</td>
</tr>
<tr>
<td>41</td>
<td>SP</td>
<td>45</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, Re</td>
<td>5 5</td>
<td>TBA</td>
<td>Familiar, have good experience with TBAs</td>
</tr>
<tr>
<td>42</td>
<td>SP</td>
<td>37</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>4 4</td>
<td>PHC</td>
<td>Safer</td>
</tr>
<tr>
<td>43</td>
<td>SP</td>
<td>50</td>
<td>Khmer</td>
<td>F</td>
<td>Ri, Re</td>
<td>1 5 5</td>
<td>TBA</td>
<td>Prefers Khmer medicine to pills</td>
</tr>
<tr>
<td>44</td>
<td>SP</td>
<td>35</td>
<td>Kuy</td>
<td>F</td>
<td>Ri, Re</td>
<td>3 2 1</td>
<td>PHC</td>
<td>Safer, if complications</td>
</tr>
<tr>
<td>45</td>
<td>SP</td>
<td>20</td>
<td>Khmer</td>
<td>F</td>
<td>Ri</td>
<td>1 1</td>
<td>PHC</td>
<td>No comment</td>
</tr>
<tr>
<td>46</td>
<td>SP</td>
<td>68</td>
<td>Kuy</td>
<td>F</td>
<td>Ri</td>
<td>4 4</td>
<td>No comment</td>
<td></td>
</tr>
<tr>
<td>47</td>
<td>SP</td>
<td>58</td>
<td>Khmer</td>
<td>H, S</td>
<td>Cm, Ss</td>
<td>6 6</td>
<td>PHC</td>
<td>TBA, Went to midwifery school, &gt;100 births assisted, 14 years of practice</td>
</tr>
</tbody>
</table>
Recent Master’s Theses

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

Persistence of the Critically Endangered Bengal florican Houbaropsis bengalensis in a modern agricultural system, Cambodia

SON Virak

Abstract

The Bengal florican Houbaropsis bengalensis is the rarest grassland bird species in Cambodia and listed as Critically Endangered by the IUCN due to its small and rapidly declining population. Two-thirds of the global species population occurs in grasslands and dry season rice fields in Kampong Thom Province. As effective conservation of Bengal florican requires understanding of the effects of disturbance, my study explored how these factors may affect survival of the species in the province and was undertaken during the 2015 dry season.

Four disturbance factors (people, motorbikes, motorized ploughs, and cattle) were quantified in different habitats at six study sites within the province: Stoung-Chikreang, Baray, Chong Doung, Kros Krom, Kouk Presh, and San Kor. Levels of disturbance differed between factors and sites, but overall, rice field habitats were most disturbed by cattle and people, whereas scrubland habitats were most disturbed by people and motorbike traffic. These are unlikely to be only factors disturbing local populations of Bengal florican however, and variation in food availability between sites and habitats undoubtedly also influences their persistence. Nonetheless, populations of the species persisted in dry season rice fields that were harvested early in the year and appeared to suffer in areas where these were harvested later. I conclude by recommending further studies on food availability and human activity at sites where Bengal florican occurs within the province.

The feeding biology of *Channa striata* and *Clarias batrachus* in community fish refuges and Tonle Sap Lake, Pursat Province

TAM Sreykol

Abstract

The ability of fish to catch prey differs between species and understanding of the types of prey consumed is an important aspect of species behaviour. The feeding habits of fresh water fish are consequently subject to continuous research in the fisheries management sector. My study investigated the feeding biology and diet of the freshwater fish *Channa striata* and *Clarias batrachus* at two community fish refuges (Boeng Romlech and Bong Tramcess) in Bakan district of Pursat Province and one site (Kom Ponglong flooding village) in Krakor district on the Tonle Sap Lake from February to June 2015.

Over the course of the study, 240 *C. striata* and 160 *C. batrachus* were collected at the three sites (155 fish at Boeng Romlech, 121 at Bong Tramcess, and 124 at Kom Ponglong). Laboratory analysis of stomach contents revealed 35 types of food from this sample and the two species were similar in terms of length, weight, and stomach weight. *Channa striata* consumed the most types of food in February and was found to consume 32 types of food in total, the most common items being fish-parts, plant-parts, *Spongilla* sponges, rotifers, and protozoa. *Clarias batrachus* consumed 22 types of food, the most common items being fish-parts, protozoa, plant-parts, rotifers, *Spongilla* sponges, fresh water shrimps, and water beetles. Diet composition was most diverse at Boeng Romlech with 28 types of food documented, 19 of which were consumed by *C. striata* and 15 by *C. batrachus*.

Citation: Tam S. (2016) The feeding biology of *Channa striata* and *Clarias batrachus* in community fish refuges and Tonle Sap Lake, Pursat Province. *Cambodian Journal of Natural History*, 2016, 135.
Fish diversity, biomass and survival rates in rice field refuge ponds during the dry season in Pursat Province

VANN Chanmunny

Abstract

Refugial ponds in rice fields play an important role in fish production in Cambodia, particularly during the dry season. My study was conducted at three community refuge ponds in Pursat Province in 2015 and aimed to determine: 1) fish diversity and abundance in rice field refuge ponds; 2) fish yield and biomass in rice field refuge ponds; and, 3) the survival rate of stocked fish over three months in the dry season. Three rice field ponds were selected in each refuge for sampling. Fish inhabiting these were caught and identified following measurement of total length, fork length, standard length and weight. Numbers of species and individuals were calculated and species diversity was measured using the Shannon-Weiner index and Simpson index. A random-effects model was used for comparisons before and after stocking and survival rates were calculated for each of the fish species stocked.

A total of 16,856 individuals representing 29 species in 23 genera and 12 families were caught from the nine refuge ponds sampled during the study. The most common fish species were *Esomus metallicus*, *Trichopodus microlepis*, *Anabas testudineus* and *Channa striata*. The latter two species are of high economic value. The productivity of refuge ponds was estimated as 29.75 ± 22.12 kg/season during the dry season. All individuals of fish species released into the ponds (*A. testudineus*, *C. batrachus* and *C. striata*) remained small and in a juvenile stage at the end of the study. Weight gains were noticeable in *C. batrachus*, but not in *A. testudineus* and *C. striata*. Survival rates were estimated as 56.6% ± 22.9% for *A. testudineus*, 61.4% ± 25.2% for *C. batrachus*, and 52.3% ± 18% for *C. striata*.

Citation: Vann C. (2016) Fish diversity, biomass and survival rates in rice field refuge ponds during the dry season in Pursat Province. *Cambodian Journal of Natural History, 2016, 136.*
Recent literature from Cambodia

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

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

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

New species & taxonomic reviews


A systematic review of Cyana moths in Cambodia. Seventeen species are recognized, including seven new country records and one new species to science: Cyana angkorensis. A key to Cambodian species within the genus is included with illustrations of adults and genitalia. Author: uug228@yahoo.com


A systematic review of the moth genus Chrysoscodota in Cambodia. A checklist is provided for the genus, which includes one new country record (C. cotriangulata) and one new species to science (Chrysoscodota kimsuni). Descriptions are provided for both species, including illustrations of adults and genitalia. Author: uug228@yahoo.com


Describes a new species of the terrestrial orchid genus Nerelia from material collected at several localities in the Greater Mekong region of Southeast Asia, including eastern Cambodia. Despite being superficially similar to N. aragoana, a widespread species of tropical Asia and Australasia, the new species is most closely affiliated to N. fordii, a species known from southern China and Thailand. Taxonomic notes and a conservation assessment are included. Author: stephangle@kbg.org


Two new species of Loboschiza to science are described and illustrated: L. cambodensis from Cambodia and L. flavobasis from Vietnam. The two new species bring the number of species described in the genus to 19. Author: jheppner@flmnh.ufl.edu


Describes a new species of dragonfly to science from male specimens collected in the coastal foothills of the Cardamom Mountains in Koh Kong Province. Females believed to be the same species were previously reported from Phrae Province in northern Thailand. Author: kosterin@bionet.nsc.ru


A systematic revision of the Odonata genus Merogomphus, including the description of a new species to science from Cambodia: Euthygomphus scholli. The type locality of the new species is near Sen Monorom in Mondulkiri Province. Author: kosterin@bionet.nsc.ru


This paper designates lectotypes for eight names in Eriocaulon in tropical Asia, namely E. alatum, E. hamiltonianum, E. hookerianum, E. infirmum, E. lanigerum, E. nautiliforme, E. nigrum, and E. ubonense. Additional information on the lectotype of E. quinquangulare is given. Author: p.souladeth@nuol.edu.la


A new plant species to science is described from Bokor National Park. The new species is related to Globba.
leucantha, but is distinguished by glabrous lamina, a wholly purple inflorescence and flowers and longer anther crests. Author: nobuyuki_tanaka@kahaku.go.jp


This study describes a new species of Garcinia (Clusiaceae) to science from Bokor National Park in Cambodia. Three species are also described with illustrations and photographs from Bokor National Park. Author: stagane29@gmail.com


Two new species of Machilus (Lauraceae) to science are described with illustrations and photographs from Bokor National Park. Author: stagane29@gmail.com

Biodiversity inventories


Part of a continuing series of quarterly reports, compiling bird counts and unusual records across Cambodia. Author: fredbaksey@yahoo.com


Stingless bees are restricted to the tropical regions of the world and are important pollinators of various wild and cultivated plants. This study recognizes 14 species of stingless bees in the dry season from Cambodia and Laos, three of which are first records for Cambodia: Pariotrigona pendleburyi, Tetragonula sirindhornae, and Tetrigna melanoleuca. Images of morphology, nesting behaviour, and a checklist of stingless bees in Cambodia and Laos are provided. Authors: seung@snu.ac.kr, ramkesh@iduwali@gmail.com


This note confirms the occurrence of chestnut-cheeked starling in Cambodia (the only previous record being of a captive bird of unknown provenance) and is based on observations of the species in Phnom Penh in February 2016. Author: smahood@wcs.org


This note documents the first country record of northern boobook Ninox japonica in Cambodia. Author: greg.mccann1@gmail.com


This note documents the first records of red-legged crake in Cambodia from three protected areas in August 2010 and July and November 2013. Author: mnuall@wcs.org


This study documents 22 species of Odonata from collections made in Cambodia in May 2003. These include the first country record of Sinictinogomphus claratus. Author: malte.seehausen@museum-wiesbaden.de

Species ecology & status


Field studies of Nomascus gibbons have shown that multi-female polygynous groups are quite common in

© Centre for Biodiversity Conservation, Phnom Penh

Cambodian Journal of Natural History 2016 (2) 137–141
the northernmost species. Based on research in Seima (Mondulkiri Province), this study shows that multi-
female groups are also present in the southernmost
species: *N. gabriellae*. Author: benbarca88@gmail.com

Furey, N.M., Whitten, T., Cappelle, J. & Racey, P.A. (2016) The con-
servation status of Cambodian cave bats. In *International
Speleological Project to Cambodia 2016 (Provinces of Stoeng Treng, Kampong Speu, Banteay Meanchey and Battambang)* (ed M.
Laumanns), pp. 82–95. Berliner Höhlenkundliche Berichte,
64, Berlin, Germany.

This study describes the conservation status of cave-
roosting bats in Cambodia based on rapid surveys of 98
caves in the Kampot, Kep, Battambang and Stung Treng
provinces between 2014 and 2016. Most of the caves
surveyed supported a relatively depauperate bat fauna,
although repeated surveys would likely reveal additional
species and individuals at some sites. Thirteen caves of
national significance for bat conservation are identified.
Author: neil.m.furey@gmail.com

Gonzalez-Monge, A. (2016) The socioecology, and the effects
of human activity on it, of the Annamese silvered langur
(*Trachypithecus margarita*) in northeastern Cambodia. PhD
thesis, Australian National University, Canberra, Australia.

The effects of human disturbance on langurs are
unknown, a reason for concern given the current biodi-
versity crisis in Southeast Asia. This study explores the
socioecology of the Annamese silvered langur and effects
of human disturbance on the species in Veun Sai–Siem
Pang National Park, Ratanakiri Province. Langurs were
strongly affected by logging, moving higher in the
canopy as logging intensity increased, and abandoned
areas of their home range where it was most destructive.
The study concludes that while the langur tolerates some
human disturbance, law enforcement must be main-
tained at the site.

Hon N. (2016) *Food selection by northern yellow-cheeked crested
gibbons (Nomascus annamensis) in northern Cambodia*. MSc

This study quantifies food selection by northern yellow-
cheeked crested gibbons in northern Cambodia by
investigating the main plant species consumed and the
influence of the availability of food items on their
selection. It also explores the nutritional composition
of food items consumed by the species and identifies
plant species that provide significant nutrients. Author:
navenhon@yahoo.com

Kidney, D., Rawson, B.M., Borchers, D.L., Stevenson, B.C.,
density estimation method with human detectors applied
journal.pone.0155066

Animal species such as gibbons are hard to see but easy
to hear. Standard visual methods for estimating popu-
lation density for these species are often ineffective or
inefficient, but methods based on passive acoustics show
promise. This article presents a spatially explicit capture-
recapture method for territorial vocalising species, where
humans act as acoustic detectors. The results suggest
that the method provides reliable density estimates for
gibbons and is efficient because it only requires routine
survey data. Author: darrenkidney@googlemail.com

status of otters in Prek Toal Core Area, Tonle Sap Lake,

Identification and protection of sites that support size-
able populations of otters in Southeast Asia is important
because regional populations face many threats and
are declining. This study presents the results of a rapid
camera trap survey in 2014 along one stream in the Prek
Toal Core Area, an area of flooded forest in Tonle Sap
Lake. Thirty-four photographs were obtained of otters,
24 of which could be identified as smooth-coated otter
and four as hairy-nosed otter. Author: smahood@wcs.org

**Coasts, wetlands and aquatic resources**

Chap S., Touch P. & Diepart, J.-C. (2016) *Fisheries Reforms and
Right-based Fisheries: Insights from Community Fisheries across
Cambodia*. The Learning Institute, Phnom Penh, Cambodia.

This working paper uses a rights-based approach to
to examine the recent wave of reforms in the Cambodian
fisheries sector and what these reforms mean for commu-
nity fisheries management.

Kong S. (2016) *An estimation of the production function of fish-
eries in Peam Krasab Wildlife Sanctuary in Koh Kong Province,
Cambodia*. EEPSEA Research Report, Economy and Environ-
ment Program for Southeast Asia, Philippines.

This report presents an economic analysis of the different
uses and values of mangroves in supporting nurseries
and breeding grounds for commercially important
finfish in the Koh Kong, Kep, Kampot, and Preah Sihanouk
provinces. Results show that direct and indirect
values derived from mangrove forests are very high and
that failure to conserve mangroves will result in serious
or irreversible ecological degradation and substantial
economic losses. Author: kong.sopheak@rupp.edu.kh

Pervin, R. (2016) *Identifying changes in mangroves in Trat Province,
Thailand and Koh Kong Province, Cambodia*. MSc thesis, San
Francisco State University, California, USA.

This study explores changes in the extent of mangroves
from 1996 to 2015 in the coastal areas of Trat Province,
Thailand and Koh Kong Province, Cambodia. Results indicate that mangroves decreased from 7.5% to 27.8% over this period in both areas, although they increased by 7.7% in Koh Kong between 2009 and 2015.


Little is known about the effectiveness of conservation responses such as protected areas (PAs) in protecting freshwater ecosystems and their services. This paper proposes a freshwater services metrics framework to quantify the representation of freshwater services in PAs and pilots this in Cambodia. Results indicate that conservation actions have more effectively represented freshwater regulation services than freshwater provisioning services, with major rivers remaining generally unprotected. Author: ls@conservation.org


This study investigates the ability of surveyors with different levels of experience to conduct underwater surveys using a simple coral reef survey methodology. Results indicate that experience, rather than cultural background, influences survey ability and thus suggest that locally based programmes can fill gaps in knowledge with suitable training and assessment. Author: jsavage@soton.ac.uk


This article uses a variety of remote sensing and hydrological data to generate monthly and sub-monthly terrestrial water storage estimates and quantify flood events in the Tonle Sap basin between 2002 and 2014. Results suggest that the approach is an effective tool for monitoring small-scale (82,000 km²) hydrological basins. Author: N.Tangdamrongsub@tudelft.nl

**Forests and forest resources**


This paper investigates traditional knowledge about natural medicine (plants, animals, and mushrooms) in Cambodia’s largest indigenous community, Bunong people in Mondulkiri Province. Authors: bunong people retain extensive traditional medicine knowledge and depend mainly on natural remedies for their health-care. Author: francois.chassagne@ird.fr


The deforestation rate in Vietnam is among the highest in the tropics in recent decades and is also increasing rapidly in Cambodia and Laos. This paper develops a new methodology for monitoring forest disturbances and regrowth using ALOS PALSAR data in tropical regions. The results indicate disturbance rates of −1.07% in Vietnam, −1.22% in Cambodia, and −0.94% in Laos between 2007 and 2010, with corresponding aboveground biomass losses of 60.7 Tg, 59.2 Tg and 83.8 Tg, respectively.


Appropriate and simple methods of estimating the biomass of tropical seasonal forests in central Indochina, such as allometric equations, are needed to support initiatives such as REDD+. This study destructively sampled 28 trees in a deciduous forest in Kratie Province, and develops new allometric equations for estimating the tree-level biomass of aboveground woody parts, leaves, total aboveground parts, and belowground parts. A new sampling method is also presented to reduce sampling loss of belowground parts. Author: monda.yukako.2m@kyoto-u.ac.jp


Adoption of the Paris Agreement suggests that developing countries urgently need to establish a forest reference emission level (FREL) if they wish to seek financial support to reduce carbon emissions from deforestation and forest degradation. This study analyzes forest
cover and carbon stock changes for seven forest types in Cambodia between 2002 and 2006 and estimates stocks in four carbon pools (aboveground, belowground, litter, and deadwood pools). Author: nopheas@ait.asia


This study examines the role of canopy cover in influencing above ground biomass (AGB) dynamics of an open-canopied forest and evaluates the efficacy of individual-based and plot-scale height metrics in predicting AGB variation in the tropical forests of Angkor Thom, Cambodia. Author: ms2127@cam.ac.uk


This paper explores the effects of logging, mortality and recruitment of trees on phylogenetic community structure in 32 plots in primary evergreen forest and secondary dry deciduous forest in Kampong Thom Province. Within communities, logging decreased phylogenetic diversity, and increased overall phylogenetic clustering and terminal phylogenetic evenness. Between communities, logging increased phylogenetic similarity between evergreen and deciduous plots. Recruitment had opposite effects. Author: htouyfc@kyushu-u.org


A significant part of the Reducing Emissions from Deforestation and Forest Degradation (REDD+) scheme depends on the participation of local communities in monitoring carbon and biodiversity. This paper presents evidence on how local communities are engaging in monitoring activities at a community forest in Siem Reap Province and concludes that this approach is important to engage and empower local community members in REDD+. Author: yeangdonal@gmail.com


Previous research on tropical mountains has suggested that plant species richness declines with increasing elevation. This study determined tree species richness along an elevational gradient on Mt. Bokor and explores relationships between species richness and environmental factors. Unlike previous studies, tree species richness was nearly constant along the elevation gradient where temperature and precipitation were expected to vary. Author: tet.yahara@gmail.com

### Environmental policy & practice


As the largest dam to ever be built in Cambodia, the Lower Sesan 2 (LS2) project is expected to cause serious environmental and social impacts. This article analyzes relationships between Cambodian NGOs and villagers that will be negatively impacted by the LS2, as well as relations between NGOs and the Cambodian state. It suggests that while development actors often attempt to construct narratives to control development trajectories, such attempts can meet with resistance from local people, even when facing powerful opponents. Author: ibaird@wisc.edu


Southeast Asia is an economic, biodiverse, cultural and disease hotspot. Due to rapid socio-economic and environmental changes, the role of biodiversity and ecosystems for human health ought to be examined and communicated to decision-makers and the public. This review paper summarizes the lessons and recommendations from an interdisciplinary conference convened in Cambodia in 2014 to advise Southeast Asian societies on current research efforts, future research needs, and to provide suggestions for improved education, training and science–policy interactions. Case-studies from Cambodia are included. Author: bwalther2009@gmail.com

*The Recent Literature section was compiled by Neil M. Furey, with contributions from Tagane Shuichiro.*
Purpose and Scope

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

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

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

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

Readership

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

Manuscripts Accepted

The following types of manuscripts are accepted:

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

Full Papers and Short Communications

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

- Research on the status, ecology or behaviour of wild species.
- Research on the status or ecology of habitats.
- Checklists of species, whether nationally or for a specific area.
- Discoveries of new species records or range extensions.
- Reviews of conservation policy and legislation in Cambodia.
- Conservation management plans for species, habitats or areas.
- The nature and results of conservation initiatives, including case studies.
- Research on the sustainable use of wild species.

The Journal does not normally accept formal descriptions of new species, new subspecies or other new taxa. If you wish to submit original taxonomic descriptions, please contact the editors in advance.

News

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

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

Letters to the Editors

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

Recent Literature

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

*Cambodian Journal of Natural History* 2016 (2) 142–144
How to Submit a Manuscript

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

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

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

Preparation of Manuscripts

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


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

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

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

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

Abstract: (Full papers only). This should describe, in no more than 250 words, the aims, methods, major findings and conclusions. The abstract should be informative and intelligible without reference to the text, and should not contain any references or undefined abbreviations.

Cambodian authors are strongly encouraged to submit a Khmer translation of the English abstract.

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

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

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

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

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

The following are examples of house style:

Papers:


Books and chapters:


© Centre for Biodiversity Conservation, Phnom Penh
Reports:

Theses:

Websites:

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

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

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

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

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

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

Review and Editing
All authors 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 are subject to rigorous peer review by a minimum of two qualified 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.

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.

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 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: 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 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 remain anonymous.

The Editors are grateful to our reviewers and to Regine Weckauf, Sam Leslie, Marianne Teoh and Kate West for their kind assistance with the production of this issue.
Contents

77 Editorial— Links between biodiversity and health: consequences and opportunities for collaboration, Mathieu Pruvot & Serge Morand.

82 News— Learning from observational data to improve protected area management, Aidan Keane, Harriet Ibbett & E.J. Milner-Gulland; Development of guidelines for wetland wise use in Cambodia, Grace Blackham; Cambodia’s first large scale marine protected area declared in the Koh Rong Archipelago, Kate West & Marianne Teoh; Capacity building conference for conservation in Asia, Mark O’Connell.

84 Short Communication— New records of Orchidaceae from Cambodia III, André Schuiteman, Christopher Ryan, Nut Menghor, Nay Sikhoeun & Att Sreynak.

90 Full Paper— Dacrydium elatum (Podocarpaceae) in the montane cloud forest of Bokor Mountain, Cambodia, Philip Rundel, M. Rasoul Sharifi, Judith King-Rundel & David Middleton.


102 Full Paper— The hairy-nosed otter Lutra sumatrana in Cambodia: distribution and notes on ecology and conservation, Heng Sokrith, Dong Tangkor, Hon Naven & Annette Olsson.

111 Short Communication— New provincial record and range extension of the parachute gecko Ptychozoon lionotum Annandale, 1905 in Cambodia, with notes on habitat use, Mark Herr & Deborah Lee.


134 Recent Master’s Theses— Son Virak, Tam Sreykol & Van Chanmunny.

137 Recent literature from Cambodia, Neil M. Furey.

142 Instructions for Authors.