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Carnivorous plants
Dragonflies and
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Cover photo: (© Jeremy Holden/ Fauna & Flora International) The pitcher plant *Nepenthes bokorensis* was first described in 2009 by French Cambodian botanist François Sockhom Mey. This carnivorous plant is believed to be endemic to Phnom (Mount) Bokor. See Mey (this volume) for further information.

Editorial - Taxonomy and conservation go hand-in-hand

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It is apparent that mainland Southeast Asia, including Cambodia, is a 'hotspot' for rare and endemic biodiversity (Mittermeier *et al.*, 1999). Unfortunately, it is also a sobering fact that some 40% of the region's fauna and flora face extinction by the end of the century, making it one of the world's most threatened areas for biodiversity (SCBD, 2010). National governments, supported by international NGOs, are formally committed to wildlife conservation and seek to deliver relevant initiatives. Excepting certain larger mammals and some other charismatic groups, however, there are too few scientists or conservationists, nationally or internationally, who can identify and provide authoritative data on the species composition, distribution, ecology and status of much of Southeast Asia's diverse and endangered wildlife.

Taxonomists, with their identification guides, keys, databases, and specialist knowledge of particular animal or botanical groups, are uniquely qualified to identify, describe and document the biodiversity of ecosystems and thereby support the work of ecologists and conservationists. They can advise on priorities for species and site-based conservation and help monitor biodiversity loss from the impacts of climate change and habitat fragmentation. They can assess the spread of invasive alien species and identify the host species in the study of zoonoses (the transmission of disease from animals to man). With the introduction of international laws such as CITES - the Convention on International Trade on Endangered Species of Wild Fauna and Flora - taxonomists can assist with specialist identifications to enable customs officers, police and other enforcers to control the trade in wildlife.

Ironically, even as human pressures on the environment increased and the need for taxonomic

expertise grew - especially in the biodiversity-rich tropics - the availability of taxonomists declined substantially in the great natural history museums of Europe and North America. Towards the end of the 20th Century, Western governments tended to view research on biodiversity as a luxury, especially when the biodiversity being studied was not their own, but rather in countries thousands of miles away from London, Paris, New York or Moscow. Meanwhile, conservation organisations, fighting for their own resources, gave little support or, in many cases, much appreciation to the scientists or their institutions that historically had provided much of the information on which their conservation initiatives were based.

Taxonomy had few friends at the beginning of the 21st Century. To many biologists, taxonomy appeared descriptive and old fashioned in their new world of DNA and cutting edge molecular science. To many conservationists, taxonomy seemed irrelevant and slow, "a victim of the narcissism of minor distinction" (Godfray & Knapp, 2004). Conversely, taxonomists viewed many conservationists as surprisingly ill-informed, with little understanding of the biodiversity they purported to be conserving and a limited understanding of the real conservation priorities that surrounded them.

Happily, this is changing. Taxonomy is experiencing a renaissance in how it is perceived and in increased recruitment to the science. This is partly due to international programmes such as the IUCN's Global Taxonomy Initiative, launched in 1998, and in part to a raised profile through enquiries and publications, such as the UK Government's Science and Technology Reports (House of Lords, 2002, 2008). Equally importantly, it is due to the developing world becoming richer, with better

communications, a more skilled workforce and, in many cases, an ambitious and knowledge-hungry university sector with a growing interest in the environmental sciences. It is now possible, perhaps the first time, for the centres of excellence to be located in the centres of biodiversity richness: in the universities, museums, and other institutes of Asia, Africa and Central and South America.

The process of capacity building and repatriation of taxonomic information has already begun. For example, in Cambodia, through the collaboration of the Royal University of Phnom Penh and Fauna & Flora International, and with financial support from the UK Government's Darwin Initiative, the MacArthur Foundation, and US Fish and Wildlife Service, a new natural history museum has been set up within the university's Centre for Biodiversity Conservation. With its growing reference collection of small mammals, reptiles, amphibians and other groups, this is becoming an archive of the country's natural history and a resource centre to promote further research of Cambodia's biodiversity. Its young Cambodian curator, Ith Saveng, recently completed his MSc in mammal taxonomy. Saveng is now beginning to publish his own taxonomic, first-authored papers in international journals and embarking on a taxonomic PhD. Other Cambodian scientists are also being introduced to the world of biodiversity research, with a view to studying a broad range of taxonomic groups.

So what are the prospects for a young taxonomist beginning his or her career in Southeast Asia? Without doubt they are exciting. For example, in the first issue of this journal, Jenny Daltry wrote a thought-provoking editorial in which she catalogued the remarkable ongoing revolution in our understanding of Cambodia's wildlife. Among the many statistics she quoted was the increase in the number of known bird, mammal and reptile species in the kingdom by 35%, 47% and 101% respectively between the early 1990s and 2008 (Daltry, 2008). More recently, a paper by Francis *et al.* (2010), based on the results of DNA barcoding, suggested that the diversity of mainland Southeast Asian bats may be twice what it is thought to be today. If correct, this

would imply there are somewhere in excess of 300 species of bats. My own institution has been part of a team of international taxonomists who, since 2004, have described five new species of Asian bat, at least one of which (Harrison's tube-nosed bat *Murina harrisoni*) is thought to be endemic to Cambodia (Csorba & Bates, 2005). Other bats are now in the process of being described and, in addition, many new country records have been added in a series of papers by taxonomists from Hungary, Ireland, Russia, and the United Kingdom. Of course, new discoveries are not confined to bats. New bird species have been described from Laos (Woxvold *et al.*, 2009) whilst the number of bird species recorded from Thailand has increased by 25% in the last 45 years (Phil Round, pers. comm.).

Some may question whether it is important to know about the diversity of animals and plants that live in the different parts of the world. Well, the community of nations obviously believes it is. Since its inception in 1992, 193 countries, including Cambodia, have signed the Convention on Biological Diversity or CBD (see <http://www.cbd.int/convention/text/>). Comprising 42 articles, it lays down legally binding commitments for the individual countries relating to their wildlife. For example, Article 7 states that each nation shall 'identify components of biodiversity important for its conservation and sustainable use'. The CBD also requires countries to build in-country capacity to ensure that this process can be undertaken. Thus, Article 12 states that countries should establish scientific training programmes for the identification, conservation and sustainable use of biodiversity. Other articles take this process one step further. Recognising that much biodiversity information is held in foreign institutions, they specifically require that biodiversity information is exchanged and repatriated (Article 17). There is also a commitment to international scientific co-operation between institutions in promoting and enhancing biodiversity conservation (Article 18).

Today, it is encouraging to see how rapidly taxonomic capacity is growing amongst a new cohort of young, enthusiastic and dedicated scientists in

Southeast Asia. In our own projects in collaboration with a range of institutions in Southeast Asia, and also supported by the Darwin Initiative, the results to date have been more than encouraging. Four students from Cambodia, Laos and Thailand have completed their MSc studies in taxonomy and are now embarking on their PhD research on mammals and birds. In addition, we have been able to place one PhD student from Vietnam in the University of Tübingen in Germany. There is also a new generation of younger students coming through with an interest in a wide range of vertebrates and invertebrates. As part of our programme, collaborative field studies have taken place throughout mainland Southeast Asia and taxonomic workshops have been held in Myanmar, Thailand, Laos, Cambodia, and Vietnam. Our student team, together with their supervisors, have published eight taxonomic papers and are currently preparing a further 14 for international journals.

Mace (2004) wrote "Taxonomy and conservation go hand in hand. We cannot necessarily expect to conserve organisms that we cannot identify, and our attempts to understand the consequences of environmental change and degradation are compromised fatally if we cannot recognise and describe the interacting components of natural ecosystems". Taxonomists are not necessarily conservationists. However, there is no doubt that the work of taxonomists becomes more meaningful if it is guided by a desire to facilitate and promote conservation. In the same way, conservationists who ignore the knowledge and experience of the taxonomic community are at best misguided and at worst wilful in their disregard of an expert resource. Taxonomists working together with conservationists can provide an invaluable insight into local, regional and global priorities and help design more meaningful and targeted conservation programmes. After 2010 - the International Year of Biodiversity - it is perhaps more important than ever that all sides work together to conserve the unique, but highly threatened biodiversity of Southeast Asia.

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News

Announcing the Cambodia Climate Change Alliance

The Cambodia Climate Change Alliance (CCCA) is a multi-donor supported climate change programme with the funding support from the European Union (EU), Sweden (SIDA), Denmark (DANIDA) and United Nations Development Programme (UNDP)/United Nations Environment Programme (UNEP) for the period of 2010 to 2012. The initiative aims to enable Cambodia to align climate change interventions with national development priorities. The Ministry of Environment, on behalf of the National Climate Change Committee (NCCC), is the leading Government institution to manage and implement the initiative.

The partnership was launched in February 2010 and the CCCA will strengthen the key institutions – including the NCCC and other key climate change functional units within sectors at national and sub-national levels. The aim is to support the integration of climate change considerations into policy and planning processes.

The CCCA will also strengthen the emerging community of practice among government, private sector and civil society. It will promote awareness

of climate change challenges and opportunities, improve access to accurate and timely data, disseminate knowledge, and promote research and learning on climate change through a national knowledge and learning platform.

The CCCA will provide a small grant facility to support climate change mainstreaming and capacity development for government and civil society organizations engaged in key sectors.

Owned by the Government - aligned with its Strategic Development objectives and priorities - supported by a unified group of Development Partners, and based on achieving measurable, meaningful results, the CCCA embodies the principles of the Paris Declaration on Aid Effectiveness.

For more information, please see the EU Delegation website ([Http://ec.europa.eu/delegations/cambodia/](http://ec.europa.eu/delegations/cambodia/)) or contact Poun Pok, Press and Information Officer, Delegation of the European Union to Cambodia (email pok.poun@ec.europa.eu) or Koen Everaert, Natural Resources Management and Climate Change Officer, Delegation of the European Union to Cambodia (email below).

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Letter to the Editor

This section presents informative contributions of fewer than 650 words, usually in response to material published in the Journal. Letters to the Editors are not peer-reviewed (unlike Short Communications and Full Papers), but may be edited for length and grammar.

Building conservation genetic capacity in Cambodia

Nowadays, most people working in conservation are aware of genetics, but exactly how it can help is unclear to many, and even fewer truly appreciate its full scope. This letter aims to inform or remind the conservation community of the relevance and scope of molecular genetics in conservation management. By working closely with the national universities, we hope to educate and build capacity, to bring through a generation of Khmer geneticists.

Conservation genetics presents myriad opportunities to support and inform the management of biodiversity, from identifying significant taxonomic units to understanding and producing methods to control pathogens (organisms that cause diseases). Presented here are a number of examples where conservation genetics has been, or could be, used to inform conservation management in Cambodia.

Correct identification of species. It is not always easy to differentiate between similar species based on their physical appearance alone. Recently, for example, a genetics study revealed a new, undescribed species of snakehead fish (*Channa* sp.) in the Sekong River (Adamson *et al.*, 2010).

Assessment of hybrids. It is also important to determine whether hybridization is occurring between closely-related taxa. Genetic assessment of captive crocodiles at Phnom Tamao Wildlife Rescue Centre, for example, helped to separate 23 pure-bred Siamese crocodiles *Crocodylus siamensis* from a larger number of hybrids between *C. siamensis* and two other species. This has enabled the Forestry

Administration to select the correct individuals for captive breeding and release (Starr *et al.*, 2010). Recently, Heng *et al.* (2010) detected hybridization between two macaque species in northeastern Cambodia from intermediate morphological characters, and genetic analysis could assist a regional investigation of the extent of this hybridization.

Identify species and individuals from faeces. Few species can be definitely identified from the visual appearance of their scats. The faeces of the Asian wild dog or dhole *Cuon alpinus*, for example, look like those of a domestic dog *Canis lupus familiaris*. Extracting DNA from cells excreted on the surface of the faeces makes it possible to identify which species is present. Furthermore, studies of microsatellites (highly variable stretches of DNA) allow us to identify individuals, which can provide accurate population estimates. The genetic profiles obtained from microsatellites can also show how individuals in the population are related, and therefore provide an understanding of population dynamics.

Tracking migration and dispersal. Having a unique genetic profile for an individual acts as a 'tag'. Scats collected from different geographic locations can trace the movement patterns of individuals, providing information on home-range size or dispersal. The collection of elephant dung in the Cardamom Mountains range, for example, could be used to answer questions with regard to the connectivity and movement of elephant populations.

These are just a few examples of how genetics can help detect and solve management problems for Cambodia's wildlife. For further information, or if you would like details of how to incorporate genetics into survey methodologies, including a quote, please contact Vittoria Elliott.

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Short Communication

Recent camera trap records of globally threatened species from the Eastern Plains Landscape, Mondulkiri

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The Mondulkiri Protected Forest (MPF) and the contiguous Phnom Prich Wildlife Sanctuary (PPWS) in eastern Cambodia form part of the Eastern Plains Landscape, one of the largest protected area complexes in tropical Asia. Both protected areas are dominated by deciduous dipterocarp forest with smaller areas of mixed deciduous, semi-evergreen and, in PPWS, evergreen forest in higher areas and along rivers. The core areas of MPF and PPWS have been identified as conservation priorities in the Lower Mekong Dry Forest Ecoregion (Tordoff *et al.*, 2005) and support a largely intact community of large mammals and birds with recent (post-2005) records of some of Asia's most threatened species including wild water buffalo *Bubalus arnee*, tiger *Panthera tigris*, Siamese crocodile *Crocodylus siamensis*, giant ibis *Pseudibis gigantea*, and white-shouldered ibis *P. davisoni* (WWF unpublished data). However, there are few published data on the biodiversity of either protected area (but see Long *et al.*, 2000; Timmins & Ou, 2001). This short communication summarises the results of intensive camera trapping carried out in the core areas of MPF and eastern PPWS throughout 2009, with details of all globally threatened species recorded.

One hundred and five camera trap locations (65 in MPF and 40 in PPWS; Fig. 1) were employed for a total of 7,295 camera trap-nights (3,571 in MPF and 3,724 in PPWS) between January and December 2009 (mean camera trap-nights per location =

69 ± SD 46; range 3-235 nights) using commercially available infrared, remote-trip digital camera units (Reconyx RapidFire Professional PC90; Wisconsin,

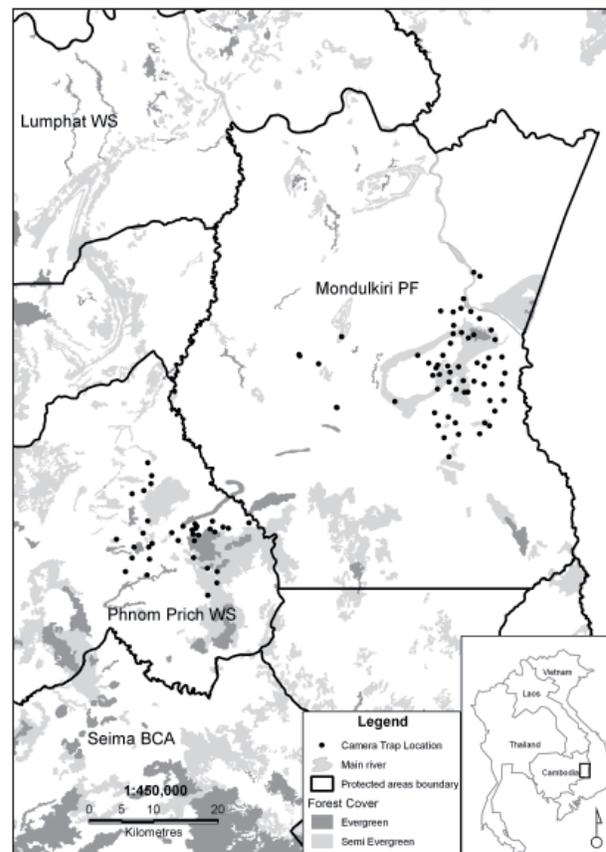


Fig. 1 Map showing the locations of camera traps (•) in Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, eastern Cambodia.

Fig. 2 Camera trap images from Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, Mondulkiri, Cambodia 2009.



(a) Siamese crocodile *Crocodylus siamensis*.



(b) Asian elephants *Elephas maximus*.



(c) Pig-tailed macaques *Macaca nemestrina*.



(d) Banteng *Bos javanicus*.



(e) Leopard *Panthera pardus*.

USA). The cameras were left on their default factory settings, which gave satisfactory performance, with three consecutive exposures when tripped followed by a three-minute interval to the next exposure. The interval between checking cameras and replacing memory cards varied depending upon staff availability and accessibility, but most camera trap locations were visited every 30-40 days. The camera traps were largely deployed in locations designed to maximize the chances of encountering terrestrial mammals. Forty camera trap locations were along motorbike trails and footpaths, 27 along dry stream

and river beds, 22 alongside animal trails, and 16 at other locations including ridge-lines, seasonal waterholes, natural springs and two sandbars on the Srepok River in MPF. All cameras were placed on trees between 20 cm and 150 cm above the ground (mean = 57 cm) with 82 camera trap locations in areas dominated by deciduous dipterocarp forest and 23 in semi-evergreen and mixed deciduous forest (Fig. 1). Fifty camera traps in the core area of MPF were arranged in a grid pattern, with a spacing of approximately two-to-three kilometres between adjacent cameras, following the protocols

Table 1 Species recorded in 105 camera trap locations in Mondulkiri Protected Forest (MPF) and Phnom Prich Wildlife Sanctuary (PPWS), in descending order of frequency. The table shows the most frequently encountered species, and all globally threatened species, recorded between January and December 2009. IUCN Status follows IUCN (2010): LC = Least Concern; NT = Near Threatened; DD = Data Deficient; VU = Vulnerable; EN = Endangered; CR = Critically Endangered.

Common name	Scientific name	IUCN Status	Number of encounters	Number of locations (%)	MPF	PPWS
Red muntjac	<i>Muntiacus muntjak</i>	LC	402	83 (79)	x	x
Wild pig	<i>Sus scrofa</i>	LC	330	75 (71)	x	x
Banteng	<i>Bos javanicus</i>	EN	160	45 (43)	x	x
Leopard	<i>Panthera pardus</i>	NT	148	52 (50)	x	x
Asian elephant	<i>Elephas maximus</i>	EN	114	38 (36)	x	x
Large Indian civet	<i>Viverra zibetha</i>	NT	76	29 (28)	x	x
East Asian porcupine	<i>Hystrix brachyura</i>	LC	57	28 (27)	x	x
Green peafowl	<i>Pavo muticus</i>	EN	59	27 (26)	x	x
Common palm civet	<i>Paradoxurus hermaphroditus</i>	LC	56	29 (28)	x	x
Dhole	<i>Cuon alpinus</i>	EN	35	20 (19)	x	x
Gaur	<i>Bos gaurus</i>	VU	26	14 (13)	x	x
Pig-tailed macaque	<i>Macaca nemestrina</i>	VU	18	8 (8)	x	x
Large-spotted civet	<i>Viverra megaspilla</i>	VU	17	10 (10)	x	x
Lesser adjutant	<i>Lepotilos javanicus</i>	VU	7	6 (6)	x	x
Siamese crocodile	<i>Crocodylus siamensis</i>	CR	6	2 (2)	x	-
Hog badger	<i>Arctonyx collaris</i>	NT	5	3 (3)	x	x
Sun bear	<i>Ursus malayanus</i>	VU	5	4 (4)	x	x
Siamese fireback	<i>Lophura diardi</i>	NT	4	3 (3)	x	x
Sambar	<i>Cervus unicolor</i>	VU	2	2 (2)	x	-
Clouded leopard	<i>Neofelis nebulosa</i>	VU	1	1 (1)	-	x
Ferret badger	<i>Melogale</i> sp.	DD	1	1 (1)	x	-
White-winged duck	<i>Asarcornis scutulata</i>	EN	1	1 (1)	-	x

of Nichols & Karanth (2002) for closed population capture-recapture studies on large carnivores. This grid was operational between 18 April and 30 June 2009. Camera traps in PPWS were set on a largely ad hoc basis, based on staff availability, targeting areas with concentrations of large mammal signs. No two cameras were placed closer than one kilometre from each other.

A total of 1,606 independent encounters (defined as successive photographs of the same species separated by >20 minutes) of 43 vertebrate species (28 mammals, 11 birds and three reptiles) were recorded. The species detected ranged in size from Asian elephant *Elephas maximus* (Fig. 2b) to Berdmore's squirrel *Menetes berdmorei* and blue-winged pitta *Pitta moluccensis*. Eighteen globally threatened species (13 mammal, four birds and one reptile) were photographed including six Critically Endangered (CR) and Endangered (EN) species (Table 1).

Two widespread and generalist ungulates - the red muntjac *Muntiacus muntjak* and wild pig *Sus scrofa* - were the most frequently encountered species, recorded from more than three-quarters of camera trap locations. Leopards *Panthera pardus*, recorded from half the camera trap locations (Fig. 2e), were the fourth most regularly encountered species and the most frequent of the four cat species recorded (the other three being the leopard cat *Prionailurus bengalensis*, jungle cat *Felis chaus* and clouded leopard *Neofelis nebulosa*). The high number of encounters of wild cattle (banteng *Bos javanicus*, the third most frequently recorded species [Fig. 2c], and gaur *B. gaurus*), Asian elephant, dhole *Cuon alpinus*, and leopard (Table 1) suggest the presence of globally significant populations of these threatened species. A capture-mark-recapture analysis of camera trap data from the core area of MPF indicated a density of 4.0 ± 1.0 leopards per 100km² (Gray & Prum, submitted) whilst robust population estimates for banteng and Asian elephant in both protected areas will soon be available from distance-based line transect and faecal DNA analysis respectively.

Of concern was the lack of evidence of tigers despite intensive camera trapping in the core area of MPF close to where a single female tiger was photographed in November 2007 (WWF unpublished data). This suggests that if still extant, tigers now occur at very low densities in both protected areas. Encounter rates of cervid deer were also very low, suggesting their populations have been severely depressed by hunting. Sambar *Cervus unicornis* were photographed on only two occasions whilst Eld's deer *C. eldii*, which occur in scattered groups in both protected areas (WWF unpublished data), were not recorded.

Significant non-mammal records include green peafowl *Pavo muticus*, which is widespread in both protected areas, white-winged duck *Asarcornis scutulata* (the first confirmed record from PPWS/MPF, although this species has been recorded in the adjacent Seima Protected Forest and Yok Don National Park, Vietnam) and Siamese crocodiles *Crocodylus siamensis* (Fig. 2a). The latter were photographed from specifically targeted cameras at two locations along the Srepok River downstream from Koh Mereuch in MPF.

The major threats to globally threatened species within MPF and PPWS are hunting and habitat loss resulting from agricultural expansion, illegal mining, social and economic land concessions and infrastructure developments including hydro-power and roads. However, active management by the Forestry Administration (MPF) and the Ministry of the Environment (PPWS), with technical and financial support from WWF-Cambodia, is working to reduce and mitigate these threats. Key activities include strict enforcement of the Cambodian Forest, Land and Protected Areas Laws, alternative livelihoods work with communities adjacent to the protected areas, and engagement with local communities and the provincial government to plan land use. It is hoped that the continued application of these strategies will mitigate the worst of the threats and ensure the persistence of the irreplaceably globally significant biodiversity characteristic of MPF and PPWS.

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Short Communication

New records of threatened mammals in Southwest Cambodia

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During a camera trap study of Siamese crocodiles (*Crocodylus siamensis*) by the Cambodian Crocodile Conservation Programme (CCCP) in 2010, photographs were taken of a Vulnerable (CITES Appendix I) marbled cat (*Pardofelis marmorata*) and an Endangered (CITES Appendix II) Indochinese lutung (*Trachypithecus germaini*). The study was conducted in Dong Peng Commune, Sre Ambel District, Koh Kong Province. Although there have been records of both species in the nearby Central Cardamoms Protected Forest, these are the first records in this locality.

The CCCP first became active in Dong Peng commune in 2007, after our surveys revealed a significant population of Critically Endangered Siamese crocodiles in the Kampong Ta Chey River watershed. Since then, the CCCP has been implementing a community-based conservation project with several local villages, as well as annual transect surveys to monitor the status of the crocodile population (currently estimated to contain at least 15 adults). The study area is a gently inclined valley with lowland dry evergreen to submontane semi-evergreen forest, situated in state forest between the Central Cardamom Protected Forest, Phnom Aural Wildlife Sanctuary and Kirirom National Park.

The CCCP conducted the camera trap survey along the Kampong Ta Chey River to photograph and potentially identify individual adult crocodiles to supplement other ongoing monitoring methods.

Five Reconyx RC55 digital infrared camera traps with heat/ motion sensors were used in this study. This model was selected due to its infrared night vision capability, memory cards with capacity to hold thousands of photos, long battery life (up to three months in the field), and a sufficiently durable build to withstand tropical climates. The units were set to take three or five consecutive images every time the sensors were tripped at 'high sensitivity'.

On 13 January 2010, four camera traps were placed at key sites along the Kampong Ta Chey River where crocodiles were reported to come onto land (three sandy banks and one small forest clearing next to the river) and a fifth was placed at Trapeang Peang, a large marsh adjacent to the river. All cameras were set at approximately human knee-height on trees to obtain ground level photographs. The units were monitored by the Forestry Administration's CCCP staff approximately once every two weeks to verify they had not been damaged or stolen, and to change the memory cards. On 6 April 2010, after 84 days of continuous operation, the units were removed due to fears of the river flooding once the monsoon rains began.

During this study, 2,864 photographs were taken, recording 17 different species (not including humans, domestic dogs and domestic water buffalo). Unfortunately, no Siamese crocodiles were captured on any of the traps during this period, despite the CCCP having successfully pho-



Fig. 1 Marbled cat *Pardofelis marmorata*.

tographed this species at other sites in Cambodia using similar methods (e.g. Holden, 2007). Possible reasons were the limited available sites for camera placement, the small number of units used, and/or there are so few crocodiles in this area that they are easily missed. The CCCP team was initially concerned that the camera units would not be able to capture images of cold-blooded animals, but this was dispelled when photographs were taken of a clouded monitor lizard *Varanus nebulosus* and a Chinese water dragon *Physignathus cocincinus*.

Although this study did not achieve its overall goal, what could be considered successful is the range of biodiversity captured by these traps in Dong Peng Commune. Multiple photos were taken of long-tailed macaques *Macaca fascicularis*, wild pigs *Sus scrofa*, East Asian porcupines *Hystrix brachyura*, leopard cats *Prionailurus bengalensis* and globally Vulnerable smooth-coated otters *Lutrogale perspicillata*. However, the most important photographs were three frames of a single marbled cat (Fig. 1) and five frames of an Indochinese lutung (Fig. 2): the first records of these species in the study area.

The marbled cat was photographed at UTM P48 371587E, 1269499N, 32 metres above sea level, on 23 March 2010 at 0839h. This species has previously been recorded in Northeast Cambodia in Seima Protected Area and Phnom Prich Wildlife Sanctuary (Mondulhiri Province), as well as in Kratie



Fig. 2 Indochinese lutung *Trachypithecus germaini*.

Province. Other records of this species have been obtained in southern Cambodia: in Bokor National Park (Kampot Province), Phnom Samkos Wildlife Sanctuary (Pursat Province) at approximately 1,100 m (Holden, 2006), and the Central Cardamoms Protected Forest (Koh Kong Province) at an elevation of over 500 m (Conservation International, unpublished data, 2006). Cambodia has had a relatively large number of records of this species, compared to other cats (Duckworth *et al.*, 2005). This species is thought to inhabit higher elevation moist and mixed deciduous-evergreen tropical hill forest (Hearn *et al.*, 2008). At an elevation of only 32 m, this record is believed to be the lowest. The cat's presence in the study area may suggest there have been pressures upon its normal habitat in the surrounding hills, or that this species uses a much wider range of elevations and habitats than previously thought. Further studies are required to determine this.

The photographs of the Indochinese lutung were taken at UTM P48 369486E, 1270459N, 22 metres above sea level, on 23 March 2010 at 0808h. Two species of silvered langur occur in Cambodia, *T. germaini* in the West and *T. margarita* in the East, which are believed to be separated by the Mekong River (Roos *et al.*, 2008). Although listed as Endangered, the Indochinese lutung still has a wide range throughout Cambodia and has been recorded in Preah Vihear Protected Forest (Prey Vihear Province), Phnom Prich Wildlife Sanctuary and Seima Protected Forest (Mondulhiri Province), western

Ratanakiri Province, Phnom Samkos Wildlife Sanctuary (Pursat Province) and the Central Cardamoms Protected Forest (Koh Kong Province), and along stretches of the Mekong and Tonle Sap Great Lake (Rawson, 2010). Nadler *et al.* (2008) describe *T. germaini* as a primarily lowland species that prefers evergreen and semi-evergreen, mixed deciduous, riverine and gallery forests. There have been few records of this species at high elevations. Given the riverine forest habitat in which the study took place, the presence of this species is not surprising, but it is a new record for this location.

Perhaps what is of equal interest, if not concern, were the multiple threats documented during the study. The camera traps also took photographs of bush fires, electro-fishers, monkey-hunters, roaming domesticated cattle and dogs, and other signs of heavy human presence. Given that this locality is now known to contain several globally threatened species, ranging from Vulnerable to Critically Endangered, there is a greater urgency to reduce such pressures and apply appropriate conservation actions to protect them.

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Short Communication

Incidental records of dragonflies and damselflies (Order Odonata) in Cambodia

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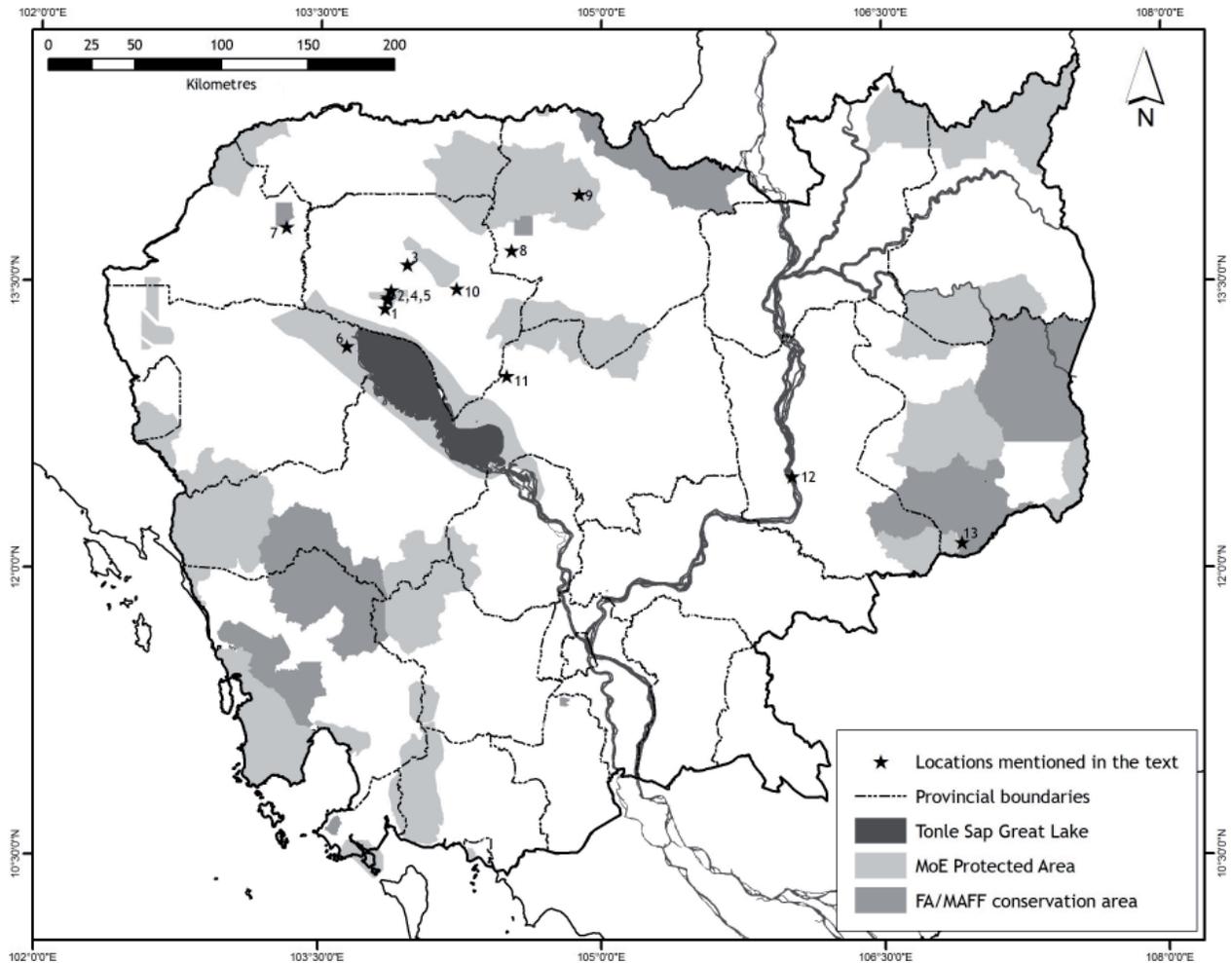
Much of the information in this paper, including photographs, first appeared in Agrion - the Newsletter of the Worldwide Dragonfly Association in July 2010. This updated version of Roland & Roland (2010) is being published with the kind permission of the Agrion editorial team.

Observations of dragonflies and damselflies were made during a guided birdwatching tour in Cambodia from the 12th to 26th February 2010. The emphasis on birdwatching meant that some of the locations visited were not ideal for Odonata. However, opportunistic observations were made at the following places (Fig. 1):

1. Hotel Khemara Angkor, Siem Reap (13°22.060'N, 103°50.809'E): A tiny artificial pond in the hotel grounds.
2. Angkor Wat (13°24.741'N, 103°51.526'E): Artificial ponds and canals, around the temples.
3. Banteay Srei Temple (13°35.857'N, 103°57.942'E): Flooded rice paddy, artificial ponds and ditches.
4. Banteay Samre Temple (13°27.719'N, 103°52.708'E): Flooded field south of the temple.
5. Angkor Thom (13°25.549'N, 103°51.573'E): Small artificial ponds.
6. Prek Toal (13°10.149'N, 103°38.615'E): Prek Toal flooded forest and the Great Lake.
7. Ang Trapaeng Thmor Conservation Area (13°47.388'N, 103°19.126'E): Pond adjacent to the main reservoir near the Forestry Administration office.

8. Siem Reap to Preah Vihear road (13°40.350'N, 104°31.222'E): Dry waterfall with one small puddle remaining.
9. Tmatboey village, Preah Vihear (13°58.053'N, 104°52.868'E): Various natural pools in deciduous dipterocarp forest.
10. Beng Mealea temple (13°28.286'N, 104°13.749'E): Moat around the temple.
11. Stoung, Kampong Thom (13°00.864'N, 104°29.856'E): A few remnant pools in the Tonle Sap grasslands.
12. Mekong and surroundings, Kratie (12°29.192'N, 106°00.977'E): Main stream of the Mekong River, and neighbouring rice paddy.
13. Seima Protection Forest, Mondulkiri (12°08.344'N, 106°55.046'E): Large artificial pond in evergreen forest.

Over 500 photographs of Odonata were taken at 16 locations in these 13 sites. Most photographs were of free-flying individuals. On occasion, insects were caught with a small hand net, photographed and then released. Identifications were based on Orr (2005) and by comparison to the photographs shown on <http://www.asia-dragonfly.net/index.php> (accessed March 2010). Only one species, *Pseudothemis jorina*, was not photographed, but its identification was based on field observations.

Fig. 1 Map of locations visited.

Odonata were observed at all 13 locations (Table 1). Overall, we found 25 Anisoptera (dragonfly) and eight Zygoptera (damselfly) species. The most frequently seen species were *Brachythemis contaminata* (eight sites), and *Crocothemis servilia* and *Orthetrum sabina* (at six sites each).

Five species were recorded for the first time in Cambodia:

- *Aethriamanta aethra* Ris, 1912 (Fig. 2): Seen only in Ang Trapaeng Thmor. This species is also known from Indonesia, Peninsular Malaysia, Singapore and Thailand.
- *Aethriamanta brevipennis* (Rambur, 1842) (Fig. 3): Observed in Ang Trapaeng Thmor and Seima

Protection Forest. This species has a wide range in South and Southeast Asia.

- *Aethriamanta gracilis* (Brauer, 1878) (Fig. 4): Encountered only in Seima Protection Forest. Known to be on the Malayan Peninsula (including southern Thailand), Singapore, certain Indonesian islands and the Philippines (Tsuda, 2000; Orr, 2005). It has also been recorded from Chantaburi Province in south-eastern Thailand (Kitagawa & Katatani, 2002), but has not been reported from Indochina previously. Identification of this species can be difficult, and a specimen would be desirable.
- *Brachydiplax farinosa* Krüger, 1902 (Fig. 5): Seen at small pools at Banteay Srei and Tmatboey



Fig. 2 *Aethriamanta eathra* (© U. Roland).



Fig. 3 *Aethriamanta brevipennis* (© U. Roland).



Fig. 4 *Aethriamanta gracilis* (© U. Roland).



Fig. 5 *Brachydiplax farinosa* (© H.-J. Roland).



Fig. 6 *Rhyothemis triangularis* (© U. Roland).

and the large pond in SPF. This species has a wide range in Asia from India to China, including Vietnam and Thailand.

- *Rhyothemis triangularis* Kirby, 1889 (Fig. 6): Observed only in Seima Protection Forest. A widespread species found from Sri Lanka to Taiwan, including Thailand and Vietnam.

Looking for Odonata as a by-product of a bird-watching tour is not ideal. The sites visited were chosen for their importance for birds and it is likely that only the commonest species were observed. Because there was no chance to search for Odonata along creeks and forest rivers; we missed the species of these habitats almost totally. In addition the large evergreen forest block in the south-west of the country was not visited.

Published knowledge of the Odonata of Cambodia is surprisingly scarce. Most of the records published prior to 2000 were summarized by Tsuda (2000), and some occasional records from short visits were added by Donnelly (2000), Benstead (2006), and Kosterin & Vikhrev (2006). In total these sources mention only 59 species for Cambodia to which an additional five can now be added. Hämäläinen (2004) wrote "Perhaps a total of some 70-80 species has been collected from Cambodia", but did not provide a checklist. By contrast around 340 species are known from Thailand (Hämäläinen, 2004; Ferro *et al.*, 2009). Even when one acknowledges that Thailand has a much greater biogeographical range than Cambodia, this implies that there is still a great deal to be learned about Cambodia's Odonata. That such an easily observable and identifiable order is poorly known reveals how little entomological survey work has been carried out in Cambodia.

Although none of the insects recorded in this trip are globally threatened, a recent global assessment of Odonata (Clausnitzer *et al.*, 2009) revealed that the Indo-Malayan realm (including Cambodia) has more Critically Endangered and Endangered species than any other realm (2.05%, and 3.32% of assessed species respectively). Over 50% of the Odonata from the region that have been assessed

are Globally Threatened or Near Threatened on the IUCN Red List. Throughout this region, Odonata are threatened by habitat loss and pollution of watercourses: issues which are of increasing concern in Cambodia.

Clausnitzer *et al.* (2009) noted that the Odonata are a relatively easy group to study and are good indicators of environmental health and aquatic biodiversity. Given the current poor level of knowledge in Cambodia, research priorities include a comprehensive survey of Odonata and an assessment of the potential impact of development activities such as mining, dams and plantations.

Further photographs can be seen at http://www.libellen-wetterau.de/exotische_libellen/libellen_anderer_laender.html

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The results were reviewed by Oleg Kosterin (Institute of Cytology & Genetics, University of Novosibirsk, Russia). Mr Tang Hung Bun was consulted on the identification of *Aethriamanta*. Thanks also to Oleg Kosterin for encouraging and motivating us to write up the results, and Thomas Sacher, Dr Hugo Rainey, and three anonymous reviewers for providing very valuable comments about the manuscript. Many thanks to the Cambodian Forestry Administration and Ministry of Environment for allowing access to the conservation areas. Special thanks are extended to Ms Sanh Sophoan from the Sam Vaesna Center and Dr Til Macke for guiding and Juergen Schneider of Albatros-Tours, for organising the birdwatching trip.

Table 1 List of Odonata species observed (* first record for Cambodia; • species recorded in this site).

Scientific names	Location (map code number)											
	Siem Reap (1)	Angkor (2,4,5)	Banteay Srey (3)	Prek Toal (6)	Ang Trap, Thmor (7)	Roadside (8)	Tmatboey village (9)	Beng Me-alea (10)	Stoung (11)	Kratie (12)	Seima PF (13)	
Zygoptera (damselflies)												
<i>Vestalis gracilis</i>	-	-	-	-	-	-	•	-	-	-	-	
<i>Agriocnemis minima</i>	-	•	-	-	•	-	-	-	-	-	•	
<i>Ceriagrion cerinorubellum</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Paracercion calamorum dyeri</i>	-	-	-	-	-	-	-	•	-	-	•	
<i>Pseudagrion australasiae</i>	-	-	-	-	-	-	-	•	-	-	•	
<i>Pseudagrion williamsoni</i>	-	-	-	-	•	-	-	-	-	-	-	
<i>Ischnura senegalensis</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Copera ciliata</i>	-	-	-	-	-	-	-	-	-	-	•	
Anisoptera (dragonflies)												
<i>Ictinogomphus decoratus</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Acisoma panorpoides</i>	-	-	-	-	•	-	•	-	-	-	•	
* <i>Aethriamanta aethra</i>	-	-	-	-	•	-	-	-	-	-	-	
* <i>Aethriamanta brevipennis</i>	-	-	-	-	•	-	-	-	-	-	•	
* <i>Aethriamanta gracilis</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Brachydiplax chalybea</i>	-	-	•	-	•	-	-	•	-	-	•	
* <i>Brachydiplax farinosa</i>	-	-	•	-	-	-	•	-	-	-	•	
<i>Brachythemis contaminata</i>	•	•	•	•	-	-	-	•	•	•	•	
<i>Crocothemis servilia</i>	-	•	-	-	•	-	-	•	-	-	•	
<i>Diplacodes trivialis</i>	-	-	•	•	•	-	-	-	-	•	•	
<i>Diplacodes nebulosa</i>	-	-	-	-	•	-	-	-	•	-	•	
<i>Neurothemis fluctuans</i>	-	-	•	-	-	-	-	-	-	-	•	
<i>Neurothemis fulvia</i>	-	-	•	-	-	•	-	-	-	-	•	
<i>Neurothemis intermedia atalanta</i>	-	-	-	-	-	-	•	-	-	-	•	
<i>Neurothemis tullia</i>	-	-	•	-	•	-	•	-	-	•	-	
<i>Orthetrum sabina</i>	-	•	•	-	•	-	•	•	-	-	•	
<i>Potamarcha congener</i>	-	-	-	-	-	•	-	-	-	-	-	
<i>Pseudothemis jorina</i>	-	•	-	-	-	-	-	-	-	-	-	
<i>Rhodothemis rufa</i>	-	-	•	-	-	-	-	-	-	-	•	
<i>Rhyothemis phyllis</i>	-	•	-	-	•	-	-	-	-	-	•	
* <i>Rhyothemis triangularis</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Rhyothemis variegata</i>	-	•	•	-	•	-	-	-	-	-	-	
<i>Trithemis aurora</i>	-	-	-	-	-	-	-	-	-	-	•	
<i>Trithemis pallidinervis</i>	-	•	-	-	•	-	-	-	-	-	-	
<i>Urothemis signata</i>	-	-	-	-	•	-	-	-	-	-	•	
Number of species	1	8	10	2	15	2	6	5	3	3	25	

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Short Communication

Clutch size of sarus crane *Grus antigone* in the Northern Plains of Cambodia and incidence of clutches with three eggs

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From 2003 to 2009, 254 nests of sarus crane *Grus antigone*, a globally Vulnerable species with key populations in Cambodia (Birdlife International, 2010), were recorded in the Kulen Promtep Wildlife Sanctuary and Preah Vihear Protected Forest, Preah Vihear Province, northern Cambodia (Fig. 1). For an example of nesting habitat, see Fig. 2. Most nests were reported to researchers of the Ministry of Environment, the Forestry Administration and the Wildlife Conservation Society (WCS) during the course of a bird nest protection programme in the Northern Plains landscape (Clements *et al.*, 2010).

Large bird species in these areas are threatened by human disturbance and, particularly, the collection of eggs and chicks by local communities, who either consume them or sell them to middle men in the wildlife trade. The bird nest protection programme was initiated in 2002 to locate, monitor and protect the remaining nesting sites of key species. Local people are offered a monetary reward for reporting nests, or are employed to monitor and protect the nest sites until the chicks fledge. All reported sarus crane nests are protected. It is very likely that the great majority of cranes breeding in the Northern Plains are detected, because large numbers of local community members are present in the forest and the incentive to report nests is

high. The protection teams are visited every one-to-two weeks by village rangers and WCS monitoring staff to check the status of the nests. Nests are checked using binoculars from a distance if possible and extreme care is taken not to disturb nests excessively, which might cause abandonment.

Clutch size was recorded for 171 of the 254 nests. Twenty-two nests (12.9%) contained one egg and 147 nests (86%) contained two eggs. In two

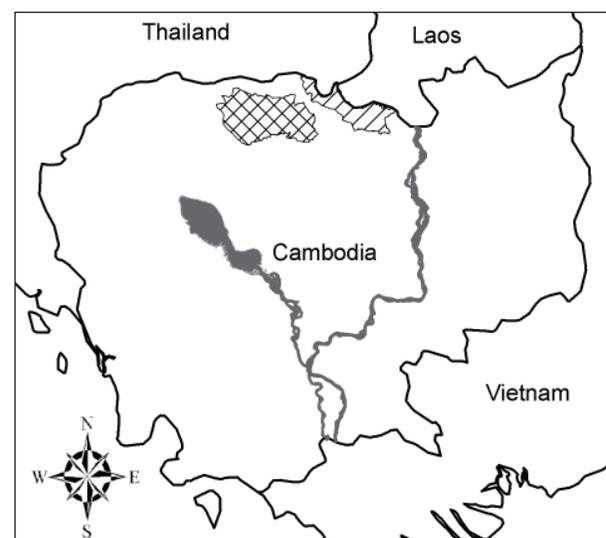


Fig. 1 Map showing the location of Kulen Promtep Wildlife Sanctuary (cross-hatching) and Preah Vihear Protected Forest (simple hatching).

nests (1.2%), both in KPWS in 2009, there were three eggs. It is possible that clutch size may have been under-recorded in some cases, particularly for nests with one egg, which may have been partially predated prior to checking, or another egg may have been laid after checking. It is unlikely that the third egg was laid by an additional female because sarus cranes are highly territorial during the breeding season, and nest parasitism has never been confirmed in any crane species (Kathju, 2007).

Sarus cranes, like most cranes of the genus *Grus*, normally have a clutch size of two eggs and rarely one (e.g. Johnsgard, 1983; Meine & Archibald, 1996; Ellis *et al.*, 1996; see also Table 1). A clutch size of three eggs is extremely rare (Table 1). There is only one record of a nest with four eggs from India (Sundar & Choudhury, 2003). The clutch sizes in the Northern Plains of Cambodia were broadly comparable to other populations of this species. The percentage of nests with three eggs ranges from 0.0% to 2.7% in different studies, and if all nests in Table 1 are combined, three-egg clutches account for 0.8% (five out of 647 nests).

In both nests in the present study, all three eggs hatched and the chicks survived for at least 12 and 16 days respectively. By this time the monitoring ended, because the chicks were mobile and thus more difficult to monitor and less susceptible to poaching. This successful hatching of all three chicks in a three-egg clutch is rare, as breeding pairs of sarus cranes characteristically raise only one or two chicks each year (e.g. Borad *et al.*, 2002). It is suspected that the second egg is laid as an insurance in case of the loss of the first one (Meine & Archibald, 1996), and clutches of more than two eggs may be suboptimal for cranes to incubate (Sundar & Choudhury, 2005). In two clutches of three eggs in India, the adults abandoned the third egg after two chicks hatched, even when it was fertile (Sundar & Choudhury, 2003; Kathju, 2007).

There are only very few cases where the successful raising of three chicks in sarus crane has been reported. Sundar (2006) described two pairs encountered with three fledged chicks of the same age. Pairs with three chicks of apparently similar age have also been observed in migrating flocks

Table 1 Unusual clutch sizes of sarus cranes recorded in various studies. For the Northern Plains of Cambodia (this study), the combined percentage of three-egg clutches was 1.2% (two out of 171 nests).

Location	No. of nests examined	No. of nests containing one egg (%)	No. of nests containing three eggs (%)	Source
Kulen Promtep Wildlife Sanctuary, northern Cambodia	75	14 (18.7)	2 (2.7)	This study.
Preah Vihear Protected Forest, northern Cambodia	96	8 (8.3)	0 (0.0)	This study.
Kheda District, Gujarat State, India	70	1 (1.4)	0 (0.0)	Mukherjee <i>et al.</i> (2002).
Gujarat State, India	73	no data	1 (1.4)	Kathju (2007).
Keoladeo National Park, Rajasthan, India	132	4 (3.0)	2 (1.5)	Walkinshaw (1973; cited in Sundar & Choudhury, 2005).
Keoladeo National Park, Rajasthan, India	11	2 (18.2)	0 (0.0)	Ramachandran & Vijayan (1994; cited in BirdLife International, 2001).
Southeast Rajasthan, India	33	10 (30.3)	0 (0.0)	Vyas (1999; cited in BirdLife International, 2001).
Etawah and Mainpuri districts, Uttar Pradesh, India	157*	40 (25.5)	0 (0.0)	Sundar (in litt. 2010).

*One nest (0.64%) in this sample contained four eggs (Sundar & Choudhury, 2003).



Fig. 2 Sarus crane nesting habitat and nest with two eggs in grassland in open deciduous dipterocarp forest in the Kulen Promtep Wildlife Sanctuary, Preah Vihear Province, northern Cambodia, June 2007 (© M. Handschuh/ACCB).

in Cambodia (G.W. Archibald verbally, cited by Sundar, 2006). In none of these cases had the actual nests been seen, but the families were encountered after the chicks had fledged. Thus, it is possible that one or two chicks had been adopted by a different pair, or joined a different family after being separated from their own parents. Unfortunately, it was not possible to determine whether the chicks in the two cases from Cambodia, reported here, survived until fledging.

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Introduction to the pitcher plants (*Nepenthes*) of Cambodia

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សេចក្តីសង្ខេប

រុក្ខជាតិបំពង់ស្រមោច (pitcher plants) នៃពួក *Nepenthes* (អំបូរ Nepenthaceae) នៅប្រទេសកម្ពុជាគឺមានការយល់ដឹងតិចតួចណាស់។ អត្ថបទនេះពិពណ៌នាពីការស្រាវជ្រាវថ្មីៗទាំងអស់នៃរុក្ខជាតិនៅក្នុងពួកនេះនៃប្រទេសកម្ពុជា។ វាពិពណ៌នាសង្ខេបលើប្រវត្តិរុក្ខជាតិនៃពួកនេះប្រទេសកម្ពុជានៅប្រទេសកម្ពុជា និងបង្ហាញការសង្ខេបចំណាត់ថ្នាក់ប្រភេទតាមលក្ខណៈវិទ្យាសាស្ត្រ ដែលរួមបញ្ចូលនូវការធ្វើចំណាត់ថ្នាក់ថ្មីៗមួយដើម្បីស្គាល់ប្រភេទនោះ។ អត្ថបទនេះផ្តល់ឱ្យនូវការយល់ច្បាស់ទៅលើលក្ខណៈអេកូឡូស៊ីនៃពួកទាំងនេះ របាយ និងការអភិរក្សរបស់ពួកវានៅក្នុងប្រទេសកម្ពុជា។ ថ្វីបើមានការបោះពុម្ពផ្សាយថ្មីៗមួយចំនួនក៏ដោយ ភាពចម្រុះ និងភាពផ្សេងៗគ្នានៃពួក *Nepenthes* ប្រទេសកម្ពុជានៅមានការយល់ដឹងតិចតួច និងជាសំខាន់ទាមទារឱ្យមានការសិក្សាស្រាវជ្រាវបន្ថែមទៀត។

Abstract

The pitcher plants of the genus *Nepenthes* (Nepenthaceae) in Cambodia are poorly known. This article discusses all of the recent research on this genus in Cambodia. It outlines the botanical history of the Cambodian taxa and presents a taxonomic summary that includes a key to the currently recognised taxa. The paper also provides insights into the ecology of the genus, its distribution, and its conservation status on Cambodian territory. Despite a number of recent publications, the diversity and variability of the genus *Nepenthes* in Cambodia remain poorly understood and require significant further research.

Keywords

Cambodia, carnivorous plants, conservation, Indochina, *Nepenthes*, taxonomy.

Introduction

As a result of past internal and international conflicts, Cambodia's borders have long been closed to researchers. It was only in the late 1990s that scientists were able to begin investigating Cambodia's biological diversity in earnest. Now, thanks to the increased efforts of local and international scientists, Cambodia is revealing its diverse flora and fauna. Even so, the documentation of biodiversity in Cambodia is still in its infancy (Daltry, 2008) and, without doubt, many species remain to be described (Ashwell, 1997). Data on the flora of Cambodia are particularly scant. The number of plant collections has risen steadily in the past decade, but owing to a lack of research and literature, hundreds of specimens remain unidentified (Daltry, 2008).

Cambodia is the home of several species of carnivorous plants. These attract, capture, kill and digest prey using modified leaves that act as traps (Lloyd, 1942). This group of plants, which is currently composed of approximately 720 known species divided among 11 families and 19 genera (McPherson, 2010), is represented in Cambodia by three genera in three different families: the sundews *Drosera* L. (Droseraceae), the pitcher plants *Nepenthes* L. (Nepenthaceae) and the bladderworts *Utricularia* L. (Lentibulariaceae). Carnivorous plants from the countries of the Indochinese Peninsula - namely Cambodia, Laos, Thailand and Vietnam - have received little attention from researchers in comparison to those from other parts of the world, such as Australia, the Malesian region, South Africa

and the Americas, where many species have been studied and described (McPherson, 2010). The literature on Cambodian carnivorous plants is particularly scarce and has not been updated in recent times. Most records date back to colonial times, from the end of the 19th Century to the early 20th Century (Mey, 2009).

Although the spectacular genus *Nepenthes* (commonly known as the ‘tropical pitcher plants’, ‘Asian pitcher plants’, ‘monkey cups’, or ‘Ampueng Sramoch’ and ‘Ampueng Kralôm’ in the Khmer language) has been the subject of several papers in recent years (Cheek & Jebb, 2009; Mey, 2009; Holden, 2010; Mey *et al.*, 2010), only a relatively small part of Cambodian territory has been prospected. Significantly more surveillance work is needed to develop a full understanding of the diversity and the distribution of *Nepenthes* in Cambodia. In the same fashion, though to a greater extent, the relatively inconspicuous carnivorous plant genera *Drosera* and *Utricularia* also require further in-depth study.

Most of Cambodia’s carnivorous plants are adapted to the strongly seasonal Indochinese climate, which is roughly divided into wet and dry seasons. Indochina is subject to the influence of monsoons with seasonal rainfall patterns: the dry season begins in November or December and lasts until April or May (Anon., 2006). While most carnivorous plants worldwide occur in relatively wet habitats, species of the Indochinese Peninsula have adapted to the seasonal droughts. Four of the five known Cambodian species of *Nepenthes* are regarded as pyrophytes: these taxa have the ability to survive in seasonally dry savannahs or semi-deciduous monsoon forests, which are prone to dry season fires, due to their development of water storage organs in the form of a fleshy rootstock (Mey *et al.*, 2010).

The carnivorous plants in the other two genera have developed their own ways to survive the Indochinese climate. One of the sundews, *Drosera peltata* Thunb., produces a tuber typical of the tuberous *Drosera* species within the section *Ergaleium*. This allows the plant to survive the dry season in a

dormant state. The other two Cambodian sundews, *D. indica* L. and *D. burmanni* Vahl, are annual species that endure the drought as seeds (McPherson, 2008). Several of the bladderworts, including *U. caerulea* L. and *U. bifida* L., are also annual (Taylor, 1989).

The genus *Nepenthes* currently includes 129 known species worldwide, with the islands of Borneo, Sumatra and the southern Philippine archipelago considered to be the *Nepenthes* centres of diversity (Danser, 1928; McPherson, 2009). They host 36, 37 and 24 species respectively (McPherson, 2009; 2010). In comparison, only five species are known from Cambodia and 14 from the four countries of the Indochinese Peninsula. Of these, nine species are thought to be so closely related that they have been ascribed to a single group, the *Nepenthes thorelii* aggregate (Mey *et al.*, 2010).

Botanical history of the Cambodian species

In 1909, botanist Paul Henri Lecomte published an account on the species of French Indochina – Cambodia, Laos and Vietnam – in which he described three taxa: *Nepenthes thorelii* Lecomte, from Vietnam, and *N. kamptoniana* Lecomte and *N. geoffrayi* Lecomte from Kampot Province in Cambodia (Lecomte, 1909). For a long time, Lecomte’s publication and its successor - the *Flore Générale de l’Indo-Chine* (Lecomte, 1946) - were the only substantial literature on the *Nepenthes* of this area.

There has since been a striking lack of research on the Indochinese Nepenthaceae, which is explained by several factors. Most significant is the great internal and international conflicts that have affected many of these countries, leading them to close their borders for long periods. Furthermore, most of the type specimens for this region are comprised of fragmented material that is difficult to study and, given the superficial similarity of some species to one another, a great deal of confusion has developed. It has, for instance, recently been revealed that one of the Vietnamese taxa, *N. thorelii*, was described from mixed material belonging to

a number of different Indochinese taxa, including one Cambodian taxon (Mey, 2009, 2010).

The *Nepenthes* of Indochina have recently received significantly more attention, making up for a century of critically lacking research. This has included an account about the enigmatic *N. thorelii* (Mey, 2010), a Vietnamese taxon which may also occur in Cambodia (see below) and the description of several new taxa, namely *N. bokorensis* Mey, *N. holdenii* Mey (Mey, 2009, Mey *et al.*, 2010) from Cambodia; and *N. thai* Cheek (Cheek & Jebb, 2009), *N. andamana* M. Catal., *N. chang* M. Catal., *N. suratensis* M. Catal., *N. mirabilis* (Lour.) Druce *var. globosa* M. Catal. and *N. kerrii* M. Catal. & T. Kruetr. from Thailand (Catalano, 2010).

Identifying the Cambodian species

Nepenthes are long lianas that usually climb among neighbouring shrubs or trees, but can also scramble along the ground. They produce highly specialized leaves: at the end of the leaf blade (the normal-looking leaf) arises the pitcher, which is connected to the leaf blade by a thin tendril. The pitchers are seasonal in some species. In Cambodia, pitcher production is low during the dry season, making it difficult for the untrained eye to recognise a *Nepenthes* plant.

The pitcher has an oblique mouth which is overhung by a lid. The edge of the pitcher 'mouth' bears a ridge of hardened tissue: a finely ribbed structure commonly called the peristome. There are many nectar glands on the underside of the lid and their size, nature and distribution are of some taxonomic importance. Some appendages can also be found on the lower surface of the lid, either at the base of the midline or at the apex. The pitcher cup, which sometimes has a pronounced hip, is divided into two distinct zones. The upper part is called the "waxy zone" because its surface is covered with wax plates, while the "digestive zone", in the lower part of the pitcher, is covered with digestive glands and contains fluid.

When collecting and studying *Nepenthes*, it is crucial to take into account the dimorphism of the pitchers. Like most of their counterparts from other countries, Cambodian *Nepenthes* produce two different types of pitchers. These are commonly referred to as lower (or terrestrial) and upper (or aerial) pitchers. The lower pitchers lie on the ground and are usually squat and colourful. Most Cambodian *Nepenthes* produce reddish lower pitchers. There are two fringed wings on the front of this type of pitcher. The upper pitchers usually lack wings (they are reduced to two thin ribs), and are more elongated and infundibular (Clarke, 2001; Jebb & Cheek, 2001). The size and shape of the peristome, the nature of its inner margin, the gland size and their distribution on the lower surface of the pitcher lid provide important diagnostic characters. Botanists are strongly advised to press specimens so that the leaf petiole insertion, which provides important diagnostic characters, is clearly visible. The leaf shape, the number of longitudinal veins and the indumentum are also helpful.

Because *Nepenthes* is an entirely dioecious genus, it is also advisable to collect both male and female plants, or at least inflorescences from the same locality, although in the vast majority of Indochinese taxa, both sexes develop very similar inflorescences (Jebb, 1991; Jebb & Cheek, 1997, 2001).

Cambodia's *Nepenthes* flora can be divided into two informal groups. The first group consists of *N. mirabilis* only, a species which can be easily identified thanks to its petiolate leaves. The other group consists of the four species that comprise the *N. thorelii* aggregate. The species of this aggregate are similar in overall appearance and share many features: inflorescences that take the form of long thyrsoid panicles which are 1- or 2-pedicellate, flower production during the rosette stage, seed with reduced filiform appendages, coriaceous narrow leaves, decurrent leaf attachment, and pyrophytic habit, with the production of a thickened rootstock. A key to this aggregate was proposed in Mey *et al.* (2010).



Fig. 1 *Nepenthes bokorensis*, Mount Bokor (© F. Mey).



Fig. 2 *Nepenthes holdenii*, Cardamom Mountains (© F. Mey).



Fig. 3 *Nepenthes kampotiana* from Trat, Thailand (© M. Catalano).



Fig. 4 *Nepenthes mirabilis*, Kbal Chay (© F. Mey).



Fig. 5 *Nepenthes smilesii*, Kampot area (© F. Mey).



Fig. 6 *Nepenthes smilesii* x *mirabilis*, Kampot area (© F. Mey).



Fig. 7 Unidentified taxon, Cardamom Mountains (© J. Holden).

Key to the *Nepenthes* of Cambodia

- 1a. Leaves petiolate, margins of lower leaves fimbriate..... *N. mirabilis*
- 1b. Leaves sub-petiolate to sessile, slightly to strongly decurrent leaf attachment 2
- 2a. Leaves lanceolate to oblong, inflorescences with scattered 2-flowered partial peduncles, wholly infundibular upper pitchers, vaulted lid, striped bulbous peristome..... *N. bokorensis*
- 2b. Leaves linear to linear-lanceolate, 1-flowered or 2-flowered pedicellate inflorescences.....3
- 3a. Short hairs on all vegetative parts, tendril as long as or shorter than pitcher..... *N. smilesii*
- 3b. Stem and leaves glabrous (pitcher and tendril excluded), tendril longer than pitcher.....4
- 4a. 1-flowered pedicels on both male and female inflorescences, cylindrical peristome.....
..... *N. kampfotiana*
- 4b. 2-flowered partial peduncles on both male and female inflorescences, slightly sinuate peristome..... *N. holdenii*

Systematic accounts

Nepenthes bokorensis Mey (Fig. 1)

Nepenthes bokorensis Mey, in *Carniflora Australis - Journal of the Australasian Carnivorous Plants Society*, 7(1), 6–15 (2009).

N. bokor Cheek in *Kew Bulletin* 64, 319-325 (2009).

Type: Marie Martin 1231 bis (holo P!), southern Cambodia, province of Kampot, Phnom Bokor, 800 m, 07 XII 1968.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, subpetiolate;

lamina oblongue to lanceolate; long tendril. Upper pitchers wholly infundibular; peristome cylindrical and bulbous, often striped, lid orbicular with a cordate base, vaulted. Inflorescence with flowers borne solitary on pedicels, occasionally on 2-flowered partial peduncles, usually without bracts. Indumentum variable.

Material examined: M. Martin 1231 bis (holo P!), Bokor Hill, 800 m, province of Kampot, Cambodia. Chevalier 36411, 36429, Damrei Mountains (P!). Geoffray 324, 325, 326, 327, 328 (P!), Popokvil Falls, Bokor Hill, 960 m, province of Kampot, Cambodia. Mey 3 (RUPP!), Phnom Bokor (Bokor Hill), 992 m. Middleton & Monyrak 589 (P!), Bokor Hill, 944 m. Poilane 206, 14728 (P!).

Distribution: Endemic to Phnom Bokor (Bokor National Park). This species has been collected from the road leading to the summit plateau and from the Popokvil Falls. Whether or not the species grows elsewhere in the extensive Bokor massif or in the Phnom Damrei (Elephant Mountains) range remains to be answered. Additional surveys are required.

Ecology: Pyrophyte. 800-1,000 metres above sea level. Inhabits clearings in lower montane forest and the edge of forests. Seasonally wet habitats.

Nepenthes holdenii Mey (Fig. 2)

Nepenthes holdenii Mey, in S.R. McPherson (ed.) *Carnivorous Plants and their Habitats: Volume 2*, pp. 1,306-1,331 (2010).

Type: Mey 1A (holo, RUPP!), western Cambodia, Cardamom Mountains, province of Pursat, 653 m, 1 VIII 2009.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, sub-petiolate; lamina linear to linear lanceolate; long tendril.

[Editor's note: In this paper, the herbaria acronyms are: P = Muséum National d'Histoire Naturelle, Paris, France; and RUPP = Royal University of Phnom Penh, Cambodia. Specimen acronyms are: holo = holotype; synt = syntype; iso = isotype. An exclamation mark (!) indicates that the author has examined that specimen, while an absence of an exclamation mark means the author did not examine the specimen or saw only its photograph].

Upper pitchers infundibular; slightly sinuated peristome. Lid elliptic with a cordate base, not vaulted. Inflorescences male and female with 2-flowered partial peduncles, usually with bracts. Indumentum glabrous except on leaf axils, tendril and pitchers.

Material examined: Mey 1A (holo, RUPP!), Cardamom Mountains, 650 m, province of Pursat, Cambodia, 1 VIII 2009. Mey 1B, 1C, 1D (iso RUPP!), *ibid.* Mey 7A, 7B, 7C (RUPP!), Cardamom Mountains, 760 m, province of Pursat, Cambodia, 12 VIII 2009. Neang & Holden 1, 2, 3, 4, 5, 6 (RUPP photo), Cardamom Mountains, between 600-750 m, province of Pursat, Cambodia, VII 2008.

Distribution: 600-800 m above sea level. Known only from two peaks in the western Cardamom Mountains in Pursat Province. Further study may reveal the presence of this species on other peaks in the extensive Cardamom Mountains range.

Ecology: Pyrophyte. Inhabits the transitional zone between lowland evergreen forest and low montane evergreen forest. *Nepenthes holdenii* grows on steep ridges in peaty soil, in bright to fully sun-exposed areas.

Nepenthes kampoiana Lecomte (Fig. 3)

Nepenthes kampoiana Lecomte, in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, pp. 62-63 (1909).

N. geoffrayi Lecomte, in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, p. 62 (1909).

Types: Geoffray 89, 90, 191, 362 (all P!), Cambodia, Kampot.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, sub-petiolate; lamina linear to lanceolate; long tendril. Lower pitchers ovate in the lower third, narrowing above. Upper pitchers cylindrical with a bulbous base, to obovate. Peristome narrow, usually without stripes. Lid orbicular with a cordate base, not vaulted. Inflorescence with solitary male and female flowers

borne on pedicels. Indumentum absent except on leaf axils, tendril and pitchers.

Material examined: Geoffray 89, 90, 191, 362 (synt P!), Kampot, Cambodia.

Distribution: Kampot Province. *Nepenthes kampoiana* has not been reported in Cambodia since its description in 1909. Unfortunately, Geoffray, the original collector, did not specify the exact location: "Kampot" could mean either the province or its main city. The author of the present paper has tried to search for *N. kampoiana* near Kampot city several times in vain. *Nepenthes kampoiana* has been found in Thailand (Catalano, 2010), in Trat Province near the south western border of Cambodia. Additional investigations are required to locate *N. kampoiana* on the Cambodian side, including the extreme western part of Phnom Samkos Wildlife Sanctuary.

Ecology: Pyrophyte. Inhabits seasonally inundated open savannahs and grasslands.

Nepenthes mirabilis (Loureiro) Druce (Fig. 4)

Nepenthes mirabilis (Loureiro) Druce, in *Report of the Botanical Society and Exchange Club of the British Isles, 1916*, p. 601 (1917).

Phyllamphora mirabilis Loureiro, *De Flora Cochinchinensis*, 2, p. 606 (1790).

Nepenthes phyllamphora Willdenow, *Caroli Linnaei Species Plantarum*, 4, p. 874 (1805).

N. phyllamphora Willdenow var. *pediculata* Lecomte in *Les Nepenthes d'Indo-Chine. Notulae Systematicae*, p. 65 (1909).

Type: Loureiro s. n. Vietnam, near Hue.

Distinguishing characteristics: This taxon does not produce a thickened rootstock. Leaves chartaceous, petiolate; lamina oblong to lanceolate. Lower pitchers bulbous at the base with a distinct hip at the lower third; lid orbicular to ovate. Upper pitchers wholly cylindrical, sometimes with a swollen base. Inflorescence with male and female flowers borne solitary on pedicels, without bracts. Indumentum,

young parts with short hairs; mature plants glabrous; margins of lower leaves fimbriate.

Material examined: Kbal Chay, *vide* Mey 2007, 2009. Kep, *vide* Mey 2009. Sihanoukville, *vide* Mey 2009. Kampot city, *vide* Mey 2009, 2010.

Distribution: This is the most widespread species of this genus. *Nepenthes mirabilis* occurs in the four countries of the Indochinese Peninsula and throughout the Malesian region (Indonesia, Malaysia, Brunei, Singapore, the Philippines, Papua New Guinea and northern Australia). This species was collected in Cambodia in the 19th Century, in small copses near Kep city (Lecomte, 1909). Nowadays, it still grows around Kep (pers. obs.) and it has also been found in two localities near Kampot city: one in wet grassland and another near a paddy field. Given the simple growing conditions demanded by this species, it is likely it grows in many similar habitats along the southern coast of Cambodia. This species has also been found growing in small numbers along roadside ditches around Sihanoukville, and there is an established population in Kbal Chay nearby.

Ecology: Inhabits wet localities along roads or paddy fields.

Nepenthes smilesii Hemsley (Fig. 5)

Nepenthes smilesii Hemsley, in *Kew Bulletin*, p. 116 (1895).

N. anamensis Macfarlane, in *Nepenthaceae*, A. Engler, *Das Pflanzenreich*, pp. 39-40 (1908).

Type: Smiles F.S. (K), northern Siam, Baw Saw, Nam Kawng, 22 V 1893.

Distinguishing characteristics: A member of the *N. thorelii* aggregate. Leaves coriaceous, subpetiolate; lamina narrowly linear to lanceolate, short tendril. Lower pitchers often cylindrical with a swollen base; peristome narrow, usually without stripes. Upper pitchers, cylindrical with a swollen base, to infundibular. Lid usually elliptic with a cordate base, not vaulted. Inflorescence with male and

female flowers borne solitary on pedicels. Indumentum, the whole plant is covered with hairs.

Material examined: Mey 2 (RUPP!), Kirirom National Park, 712 m, province of Kampong Speu, Cambodia. Mey 4 (RUPP!), Kampot city, 16 m, province of Kampot, Cambodia. Poilane 17457 (P!), south of Chambok, province of Kampong Speu, Cambodia. Kampot city, *vide* Mey, 2010.

Distribution: Apart from *N. mirabilis*, this is the most widespread species in the Indochinese Peninsula, known from Cambodia, Laos, Thailand and Vietnam. It has been found at sea level in Kampot and between 600-720 m in Kirirom National Park. The low altitudinal range around Kampot city is unusual because *N. smilesii* is usually found between 500 and 1,000 m in the other countries of Indochina.

Ecology: Pyrophyte. Usually found in seasonally wet habitats such as open sandy savannahs and grasslands. In Kirirom National Park, *Nepenthes smilesii* grows in clearings among pine trees.

Nepenthes smilesii x *mirabilis* (Fig. 6)

Type: None. This natural hybrid has not been formally described as a taxon.

Distinguishing characteristics: The following short description is based on a single specimen. Leaves chartaceous, sub-petiolate; lamina lanceolate. Lower pitchers wholly cylindrical with a distinct hip at the lower third; lid orbicular. Upper pitchers completely green, infundibular; peristome cylindrical and bulbous, without stripes. Inflorescence unknown. Indumentum, plants lined with short hairs. The presence of hairs on the whole plant discards the possibility of the glabrous *N. kampfotiana*, which has been collected in the same area, to be one of the parents.

Material examined: Mey 6 (RUPP!), near Kampot city, 14 m, Kampot Province, Cambodia.

Distribution: A single large specimen, with multiple offshoots, of this natural hybrid has been recorded

from Kampot city (exact locality withheld for conservation purposes).

Ecology: *Nepenthes smilesii* x *mirabilis* has been found in a large, open, inundated area, close to a stream, with populations of *Utricularia caerulea* and *Drosera indica*. Populations of the pyrophytic *N. smilesii* and *N. mirabilis* were found within a few kilometres of the site. It is not known whether this hybrid produces a tuberous stem or a thickened root system like the species of the *N. thorelii* aggregate.

Other taxa that may occur in Cambodia

Populations of unknown *Nepenthes* have been observed in Botum Sakor National Park, Koh Rong, and several parts of the Cardamom Mountains (J. Holden and V. Ly, pers. comm.). For the moment, they are known to the author of the present paper only from photographs (e.g. Fig. 7).

Of the other Indochinese pitcher plants, *Nepenthes thorelii* Lecomte is a Vietnamese species that has been collected near the Cambodian border in the former Vietnamese province of Song Bé (now Binh Duong and Binh Phuoc Provinces). This species has not been officially recorded since its description in 1909 and is therefore believed to be on the brink of extinction in Vietnam (Mey, 2010). It is conceivable that it also occurs on the other side of the border in Cambodia, and a survey of this area is required.

Nepenthes chang M. Catal., a close Thai relative of *N. holdenii* which grows in Khao Kuap in the Bantad Mountains, could also be found in the neighbouring Cardamom Mountains of Cambodia.

Ethnobotany and conservation

Pitcher plants have long been used in Cambodia for traditional medicine. *Nepenthes mirabilis* is used in the countryside around Kampot city to make medicines (pers. obs.). Villagers who live near the type locality of *Nepenthes holdenii* report using the leaves and roots of this plant to make a decoction

to cure fever and pain (pers. comm.). People from Kampot used to boil the roots of *N. bokorensis* and give them to pregnant women to ease their pains (Marie Martin, herbarium label on Marie Martin 1231 bis).

As is the case in most parts of the world, *Nepenthes* are greatly threatened by human activities. Cambodia's biodiversity is under pressure from various threats such as logging, poaching, land speculation and encroachment in protected areas and other forests, invasive alien species, and transformation of natural habitats by roads, agricultural concessions, mines and hydroelectric dams (Daltry, 2008). The lowland *Nepenthes* species especially have been wiped out from most of the fields, grasslands and wastelands where they used to grow. According to Cambodian people the author met on various expeditions, pitcher plants were once much more common, especially before the Khmer Rouge regime. The Cambodian lowland species (*N. kam-potiana*, *N. mirabilis*, *N. smilesii*) are the most accessible and hence the most vulnerable. Any remnant specimens that survive development are also likely to be collected for traditional uses.

All *Nepenthes* species are on Appendix II of CITES (www.cites.org), but this regulates only their international trade. It is important to locate, study and name *Nepenthes* populations in Cambodia to assign them with their correct category of threat on the IUCN Red List (see IUCN, 2001), ensure they are adequately protected under national law, and guide and develop in situ or ex-situ conservation programmes. The following paragraphs summarise the threats that face each of the currently known Cambodian pitcher plants.

Nepenthes bokorensis: This species, endemic to a ridge of Phnom Bokor and the Popokvil Falls, is at risk because its habitat has been leased for private development. Monitoring is needed and further explorations of the plateau, the National Park and the Phnom Damrei range are required to locate any additional populations of this species. *Nepenthes bokorensis* has been assessed as Vulnerable accord-

ing to IUCN criteria by Mey (2009), while Cheek & Jebb (2009) assessed it as Endangered B2ab(iii).

Nepenthes holdenii: This recently described species is known only from a couple of peaks of the Cardamom Mountains. It has been assessed as Near Threatened (Mey *et al.*, 2010). The known populations are scattered, highly localised and composed of only a few dozen specimens. In the short term, the main threat is likely to come from over-collection. In the long term, the species could be affected by habitat loss, logging and land speculation.

Nepenthes kampotiana: This species has not been reported since it was first described by Lecomte in 1909. This taxon was collected somewhere in Kampot Province in the late 19th Century and must now be very rare or even extinct. Attempts to rediscover it in the Kampot area were unsuccessful. Isolated populations, believed to belong to this species, were observed by Catalano (2010) in the Thai province of Trat, near the south-western Cambodian border. It is important to locate this species, named after a Cambodian locality, to develop an appropriate conservation programme.

Nepenthes mirabilis: This is the least threatened of the Cambodian species. It is known from several localities in the southern coast and it is possible many other small populations will be found in the future. The Kbal Chay roadside populations consist of several dozen individuals, which could be easily wiped out by development. The other known populations consist of small numbers of specimens persisting on wastelands or paddy fields. *Nepenthes mirabilis* seems to have a patchy distribution in southern Cambodia and was once fairly common. It may still grow in good numbers in protected areas, such as Botum Sakor National Park. It is also known from the Vietnamese island of Phu Quoc, south of Kampot city. This taxon may be classified as Least Concern.

Nepenthes smilesii: Cambodian populations of this widespread Indochinese species (also known from Thailand, Laos and Vietnam) have been studied on the Kirirom plateau at intermediate altitudes (600-700 m above sea level), and around

Kampot city, close to sea level. The population on the Kirirom plateau seems to be well established in an eco-tourism site where there appears to be no immediate threat. The lowland populations are highly endangered. Only two isolated populations around Kampot city have been documented, each of which consists of a small number of plants near crop plantations and paddy fields. However, there are insufficient data to assess the status of this species, and it probably ought to be classed as Data Deficient (IUCN, 2001).

Nepenthes smilesii x mirabilis: During numerous expeditions in Cambodia, only one plant of this natural hybrid has been documented. This is a very old, large specimen that grows in isolation near Kampot city. Further research might reveal more such hybrids, but given the increasing rarity of *Nepenthes*, the loss of their habitats in the Cambodian lowlands, and the natural rarity of *Nepenthes* hybrids, their number is likely to be very low.

Conclusions

Studies of the genus *Nepenthes* in Cambodia have only recently begun, with surveys having covered only a very small part of this territory. Many areas in Cambodia that have suitable *Nepenthes* habitat have yet to be prospected. The Cardamom Mountains range, parts of the Damrei (Elephant) Mountains, the islands of the southern coast and the numerous southern provinces along the Vietnam border, are especially likely to reveal more *Nepenthes* populations.

Moreover, several populations of unidentified pitcher plants have been observed. Additional botanical survey work is certainly warranted and is likely to result in new discoveries that will help to reveal the extent of the diversity of *Nepenthes* in Cambodia.

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About the Author

FRANÇOIS MEY was born in Ha-Tien, Vietnam, after his Cambodian parents fled the Khmer Rouge regime. He arrived in France at the age of three, and now teaches French literature in high school. He became seriously interested in carnivorous plants in 2004, and has since intensively studied their systematic and ecology, with a particular focus on the Indochinese Nepenthaceae. François has undertaken extensive field research across Cambodia and Vietnam, and his observations led to the publications of *N. bokorensis* and *N. holdenii*. He has produced botanical diagrams and illustrations for several carnivorous plants books and is now, with biologist Jeremy Holden, working on a book devoted to the carnivorous plants of Cambodia.

Ecology and natural history of banteng in eastern Cambodia: evidence from camera trapping in Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary

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សេចក្តីសង្ខេប

ទិន្នន័យដែលទាក់ទងទៅនឹងប្រវត្តិចម្នាតិការកំរាមកំរែហែងទៅលើប្រភេទនិមួយៗ គឺមានសារៈសំខាន់ណាស់ សំរាប់ធ្វើការអភិរក្សប្រកបដោយប្រសិទ្ធភាព។ ប៉ុន្តែមានទិន្នន័យទាំងនេះមានចំនួនតិចតួចដែលត្រូវបានបោះពុម្ពស្តីពីប្រវត្តិ និងអេកូឡូជីនៃប្រភេទសត្វទន្សោងដែលជាប្រភេទទទួលរងគ្រោះជាសកលនៅគ្រប់ទីកន្លែងដែលជាទីជំរកដើមនៃប្រភេទនេះមានវត្តមាន។ យើងបង្ហាញពីលទ្ធផលដែលបានមកការសិក្សាដោយម៉ាស៊ីនថតស្វ័យប្រវត្តិ ដែលត្រូវបានសិក្សានៅក្នុងតំបន់ស្នូលនៃព្រៃការពារ ខេត្តមណ្ឌលគិរី និងដែនជំរកសត្វព្រៃភ្នំព្រៃចេដែលស្ថិតខ្លះរាបភាគខាងកើតនៃប្រទេសកម្ពុជា រវាងខែមករា រហូតដល់ខែធ្នូ ឆ្នាំ២០០៩។ មួយរយបីម៉ាស៊ីនថតស្វ័យប្រវត្តិទីតាំងត្រូវដាក់ ហើយច្រើនជាង ៧០០០អន្ទាក់យប់ប្រើដោយម៉ាស៊ីនថតស្វ័យប្រវត្តិដែលថតរូបទន្សោងបាន ១៦០ដង ពី៤៥ទីតាំង នៃម៉ាស៊ីនថតស្វ័យប្រវត្តិដែលដាក់។ រូបថតដែលទទួលបានទាំងនោះរួមមានទន្សោងមេជាមួយកូន ដែលបង្ហាញការរដាគឺជីវិតនៃការបន្តជំរកសំប្រភេទនេះ។ អត្រារូបថតទន្សោងត្រូវបានថតប្រហាក់ប្រហែលគ្នារវាងព្រៃបោះ និងព្រៃពាក់កណ្តាលស្រោង រីឯព្រៃបោះចំរុះ ដែលប្រភេទព្រៃទាំងនេះមានសារៈសំខាន់សំរាប់ពពួកគោសាទិស។ ចំនួនមធ្យមទំហំក្រុមនិមួយគឺ ២.៦ក្បាល (ចន្លោះពី១ ទៅ១៣ក្បាល មេដ្យានគីស្ទើ ១) ដែលជាចំនួនទំហំក្រុមនេះមានតិចជាងគេ បើប្រៀបធៀបចំនួនទំហំក្រុមទន្សោងនៅអាស៊ីអាគ្នេយ៍។ ទន្សោងជាប្រភេទសត្វដែលមានសកម្មភាពនៅពេលយប់ច្រើនជាង ៨០ភាគរយ នៃអត្រាដែលត្រូវបានថតដោយម៉ាស៊ីនថតស្វ័យប្រវត្តិរវាងម៉ោង ១៨:០០ និងម៉ោង ៦:០០។ សកម្មភាពមានភាពនេះផ្ទុយគ្នាទៅនឹងសកម្មភាពទន្សោង ដែលត្រូវបានបោះពុម្ពដោយ ទិន្នន័យនូវមានកំរិតនៃការកោះ Java ដែលទន្សោងនៅទីនោះមានសកម្មភាពនៅថ្ងៃច្រើនជាងពេលយប់។ យើងយល់ថា សកម្មភាពទន្សោងដែលចំណាយពេលវេលាច្រើននៅពេលយប់នៅក្នុងប្រទេសកម្ពុជា គឺមានបណ្តាលមកពីការវិនាសដោយសកម្មភាពរបស់មនុស្ស និងការបាញ់ ហើយការពង្រឹងច្បាប់ជាការងារចាំបាច់ដើម្បីកាត់បន្ថយការកំរាមកំរែហែងតាមរយៈការបាញ់ទៅលើប្រភេទនេះ។

Abstract

Information on the natural history of threatened species is essential for their effective conservation. However there are few published data on the natural history and ecology of the globally Endangered banteng *Bos javanicus* in Indochina. We present results from a camera trapping study conducted within the core areas of Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, eastern Cambodia, between January and December 2009. One hundred and three camera trap locations were trapped for >7,000 camera trap-nights producing 160 photographic encounters of banteng from 45 locations. A number of photographs contained females with calves, suggesting successful reproduction. Banteng were photographed at similar rates in both deciduous dipterocarp and semi-evergreen/ mixed deciduous forest, highlighting the importance of this habitat mosaic for wild cattle. Mean banteng group size was 2.6 (range 1-13; median 1), which is smaller than reported from elsewhere in Southeast Asia. Banteng showed a distinctly nocturnal activity pattern with >80% of encounters between 1800h and 0600h. This contrasts with the limited published information on the activity patterns of banteng in Java, which are predominantly diurnal. We suggest that the nocturnal activity of banteng in Cambodia is a response to human disturbance and hunting, and stress the importance of improved law enforcement to reduce the hunting threats to this charismatic species.

Keywords

Banteng, camera trap, Eastern Plains Landscape, habitat mosaic, Mondulkiri, wild cattle.

Introduction

Automatic camera traps have, over the past 20 years, become a mainstream tool in conservation and ecology. Rowcliffe & Carbone (2008) documented a 50% annual increase in the number of published papers using camera trapping since the early 1990s. Uses for camera trapping in ecology and conservation include inventorying protected areas, discovering new species, estimating relative and absolute abundance, and studying population dynamics and forest ecology (Karanth & Nichols, 1998; Zetra *et al.*, 2002; Weckel *et al.*, 2006; Gimán *et al.*, 2007; Sharma *et al.*, 2009). Given the difficulty of obtaining direct observations of rare, large vertebrates in tropical forests, camera traps may also be very valuable for obtaining basic ecological and natural history information on some of Asia's rarest species.

The banteng *Bos javanicus* is a species of wild cattle that historically inhabited deciduous and semi-evergreen forests from Northeast India and southern Yunnan through mainland Southeast Asia and Peninsular Malaysia to Borneo and Java (Timmins *et al.*, 2008). Banteng populations have declined dramatically throughout Southeast Asia due to hunting and habitat loss as well as possible competition and disease transmission from domestic livestock (Timmins *et al.*, 2008; Pedrono *et al.*, 2009). Consequently, banteng are listed by IUCN as Endangered. This species has been extirpated from India, Bangladesh, Brunei and Peninsular Malaysia, and only small, scattered populations remain in Myanmar, Thailand, Cambodia, Indonesian Borneo and Java and, to a much lesser extent, Laos and Vietnam (Timmins *et al.*, 2008).

In Cambodia, three main regions - the Southwest (Cardamom Mountains), the Northern Plains (Preah Vihear Province) and Eastern Plains (Ratanakiri/Mondulkiri Provinces) - still support banteng populations. The Eastern Plains Landscape, comprising the protected areas of Seima, O' Yadao and Mondulkiri Protected Forests and Phnom Prich and Lumphat Wildlife Sanctuaries, may support the largest population in Cambodia. This landscape

is dominated by deciduous dipterocarp and mixed deciduous forest with smaller patches of semi-evergreen and evergreen forest along watercourses and at slightly higher elevations. The deciduous dipterocarp forest experiences a high-frequency burning regime, with widespread fires between December and March (*pers. obs.*). This encourages the regeneration of grass and herbaceous bamboo (*Arundinaria* spp.), providing abundant forage for large herbivores (*pers. obs.*).

Although banteng have been studied in Java (Halder, 1973; Pudyatmoko & Djuwantoko, 2006) and in northern Australia (Choquenot, 1993), where a feral population exists, the ecology and natural history of banteng in mainland Southeast Asia is extremely poorly known. There have been few published studies since Charles Wharton's groundbreaking work on Cambodian wild cattle in the 1950s (Wharton, 1957). The aims of the present study were to use camera trap data to obtain basic information on the ecology and natural history of banteng from two protected areas - Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary - in the lowland deciduous forest mosaic of the Eastern Plains Landscape.

Methods

Study Area

Phnom Prich Wildlife Sanctuary (PPWS; 2,225 km²) is located in the west of Mondulkiri Province (approximate location 12°08'N, 106°05'E; Fig. 1). The protected area is contiguous with Mondulkiri Protected Forest (to the east) and Seima Protected Forest (to the south). It is characterized by higher elevation and relief (maximum 640 metres above sea level) in the southeastern section near the Mondulkiri Plateau, with gently undulating lowlands, elevation *circa* 80-200 metres above sea level, over the majority of the protected area. Mondulkiri Forest Protected (MPF; 3,350 km²; approximate location 12°40'N, 107°00'E) is in the north of Mondulkiri Province and is bordered by Yok Don National Park, Vietnam to the east, PPWS

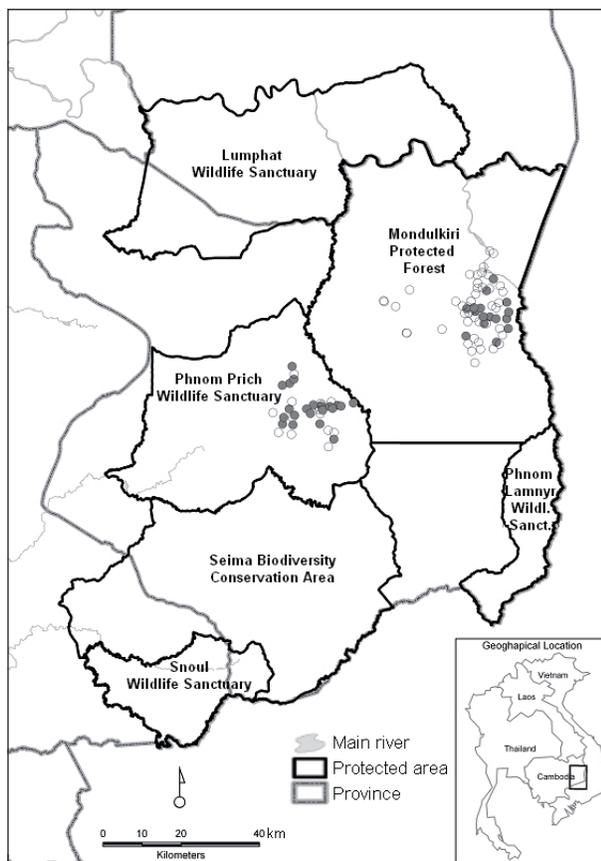


Fig. 1 Map showing the locations of Monduliri Protected Forest and Phnom Prich Wildlife Sanctuary in the Eastern Plains Landscape, Cambodia. Locations of camera traps, with presence (closed circles) and absence (open circles) of banteng, are also shown.

to the west and Lumphat Wildlife Sanctuary and O'Yadao Protected Forest, Ratanakiri Province, to the north (Fig. 1). In comparison to PPWS, this protected area is flatter with fewer areas of dense semi-evergreen and evergreen forest. The Srepok River, a major tributary of the Mekong, flows through the protected area.

Camera trapping

Between January and December 2009, commercially available infrared, remote-trip digital camera units (Reconyx RapidFire Professional PC90; Wisconsin, USA) were used to survey terrestrial mammals within the core areas of PPWS and MPF. Cameras

were set to be operational for 24 hours and all photographs were digitally stamped with the date and time. Camera traps were deployed in 103 locations (63 in MPF; 40 in PPWS; Fig. 1) selected to maximize the chances of encountering terrestrial mammals. Forty camera trap locations were along motorbike trails and footpaths, 27 along dry-stream and river beds, 22 alongside animal trails and 14 at other locations including ridge-lines, seasonal water-holes and natural springs. A total of 7,245 camera trap nights were conducted: 3,521 in MPF and 3,724 in PPWS. All cameras were placed on trees between 20 and 150 cm above the ground (mean = 0.57 cm). No two cameras were placed closer than one kilometre from each other. Eighty camera traps were placed in deciduous dipterocarp forest (51 in MPF; 29 in PPWS) and 23 camera traps were placed in mixed deciduous and semi-evergreen forest (12 in MPF; 11 in PPWS). The habitats at camera trap locations were defined post-hoc in ArcGIS using a remotely-sensed forest cover data set (JICA, 2003) and ground-truthed by WWF fieldworkers.

Data Analysis

All independent encounters with banteng - defined when successive photographs of the species were separated by more than 20 minutes - were extracted from camera trap data and the date, time and camera trap location were recorded. Minimum group size (number of individuals) for each encounter was estimated from the photographs (see Discussion for limitations of this approach). Activity patterns of banteng were calculated based upon the time imprinted on each photograph with the time of encounters with camera traps assumed to correlate with activity levels. Time periods were pooled to one-hour intervals and encounters classified as nocturnal (1800h-0600h) or diurnal (0600h-1800h) although, due to approximately one hour variation in sunrise and sunset times throughout the year, these periods do not correspond exactly to night and day.

At each camera trap location, a banteng Relative Abundance Index (RAI) *sensu* O'Brien *et al.* (2003) was calculated as the number of independ-

ent encounters per 100 trap-nights. Differences in mean RAI between camera traps located in MPF and PPWS, and between those in deciduous dipterocarp forest and mixed deciduous/semi-evergreen forest, were tested for using independent sample *t*-tests or, when data were not normally distributed, Mann-Whitney *U* tests using SPSS v13.0 statistical software.

Results

Banteng were photographed from 45 (43%) camera trap locations - 20 in MPF and 25 in PPWS (Fig. 1) - with a total of 160 independent encounters. Relative

Abundance Index (RAI) was significantly higher at camera trap locations in PPWS (mean RAI = 3.24, \pm SEM 0.9) than in MPF (mean RAI 1.6 \pm SEM 0.5; $z = 3.3$, $p < 0.01$). Banteng were encountered more frequently by camera traps in semi-evergreen and mixed deciduous forest (mean RAI = 3.0 \pm SEM 1.5) than those in deciduous dipterocarp forest (mean RAI = 1.98 \pm SEM 0.5). However, this difference was not statistically significant ($z = 0.2$, $p = 0.8$).

Banteng herd size - estimated from the number of individuals recorded in photographs at each encounter - was between one and 13 (median = 1; mean = 2.6 \pm SEM 0.4). There was no significant difference in mean group size of banteng between

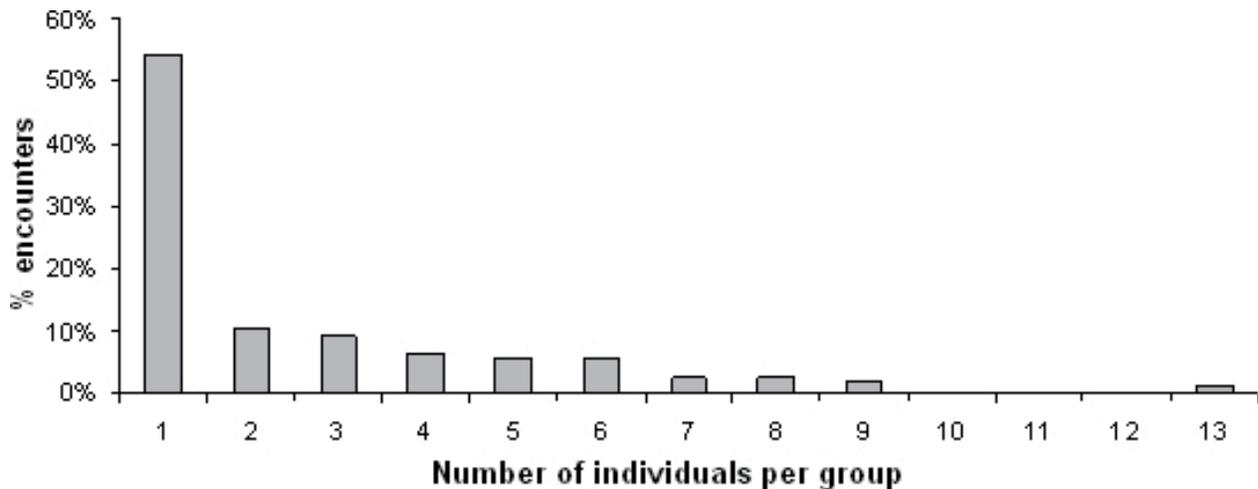


Fig. 2 Number of individual banteng per photographic encounter from camera trap data from Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, eastern Cambodia.

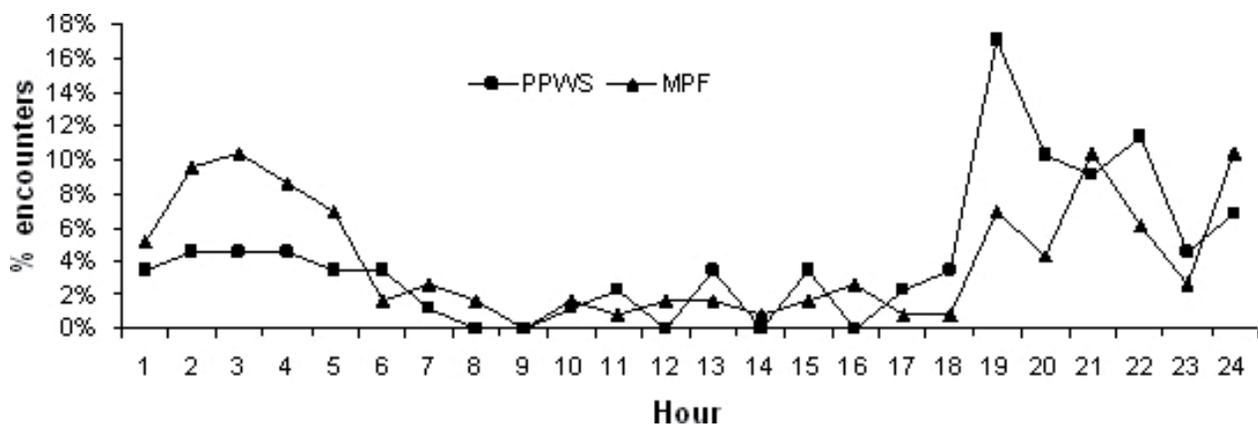


Fig. 3 Activity patterns (percentage of encounters per hour) for banteng, taken from camera trap data from Mondulkiri Protected Forest and Phnom Prich Wildlife Sanctuary, eastern Cambodia.

MPF (mean = $2.5 \pm \text{SEM } 0.3$) and PPWS (mean = $2.7 \pm \text{SEM } 0.6$; $z = 1.4$, $p = 0.9$). The majority of encounters (54%) were of single individuals (Fig. 2). Where these could be identified to sex ($n = 38$), all were males. Thirty-two encounters (20%) were of two or three individuals and 28 (18%) encounters comprised from four-to-six individuals. Only two encounters were of groups estimated to comprise more than 10 individuals (Fig. 2).

In both MPF and PPWS, banteng showed a distinctly nocturnal activity pattern with 83% of encounters between 1800h and 0600h. However, activity patterns differed slightly between the two protected areas (Fig. 3). In PPWS there was a distinct peak in activity after dusk (c. 1900h) and prior to midnight (0000h) whilst in MPF activity peaked in the early morning (0200h-0400h).

Discussion

Basic understanding of the natural history of threatened species is essential for their effective conservation (Sutherland, 2000). However there are little published data on the natural history and ecology of banteng in Indochina. Our camera traps in MPF and PPWS regularly photographed banteng, suggesting the presence of relatively healthy and potentially substantial populations of this globally Endangered species. A number of photographic encounters of banteng comprised groups or individuals accompanied by juveniles (approximately 50-75% smaller than adult females; Pudyatmoko & Djuwantoko, 2006) indicating successful reproduction (Fig. 4). However, it was difficult to quantify the proportion of groups accompanied by calves due to the poor quality of some images, particular-



Fig. 4 Camera trap photograph of juvenile banteng, accompanied by mother, from Phnom Prich Wildlife Sanctuary.

ly at night, and it was difficult to detect small calves in tall bamboo.

Further evidence for the importance of the banteng population within the study region comes from observations during distance-based line transects in which banteng were recorded 34 times from 520 km of randomly distributed line transects throughout the core areas of both protected areas during the 2009/10 dry season (WWF unpublished data). Line transects will continue to be used in the 2010/11 dry season to generate sufficient data to produce a robust density estimate.

The use of a simple Relative Abundance Index (*sensu* O'Brien *et al.*, 2003) based on camera trap encounter rates for ecological studies is controversial because a large number of variables (e.g. body size, average group-size, behaviour, and habitat type) are likely to affect trapping rates and confound the relationship with actual abundance (Carbone *et al.*, 2001; Jennelle *et al.*, 2002; Treves *et al.*, 2010). Although banteng encounter rates were higher in PPWS than in MPF, it is unclear whether this reflects genuine patterns of abundance. We suggest that this difference may in fact be an artefact of camera trap placement, which in each protected area was performed by different teams of rangers with slightly different objectives. In PPWS a higher proportion of cameras (43%) were set on animal trails than in MPF (7%), whilst in the latter site more cameras were placed on man-made roads (42% vs 19% in PPWS). Given that banteng, unlike large carnivores such as leopards *Panthera pardus* and tigers *P. tigris*, are unlikely to actively follow man-made trails (pers. obs.), this may explain the higher encounter rate in PPWS. In contrast, encounter rates of banteng on the line transects, which were randomly distributed across the core areas of MPF and PPWS, were very similar in the two protected areas (WWF unpublished data). This highlights the fact that great care is required when comparing raw camera trap encounter rates (i.e. Relative Abundance Indices) between sites.

Banteng were photographed from camera traps in both deciduous dipterocarp and mixed decidu-

ous/ semi-evergreen forest with encounter rates higher in the latter habitats, though not significantly so. Whilst it is possible that camera trap detection probabilities may vary between forest types, it seems unlikely that banteng would have lower probability of detection in open deciduous dipterocarp forest. Analysis of banteng camera trap encounter histories from MPF in an occupancy framework (*sensu* Linkie *et al.*, 2007) - thereby accounting for imperfect detection at camera trap locations - indicates similar probabilities of detecting banteng presence using camera traps in both deciduous dipterocarp and mixed deciduous/ semi-evergreen forests (Gray, unpublished manuscript). Although the banteng is generally regarded, particularly in Indochina, as a specialist of deciduous dipterocarp forests (Steinmetz, 2004; Timmins *et al.*, 2008), the regular use of mixed deciduous forest, particularly in the dry season, was noted by Wharton (1957).

Wharton (1957) also suggested banteng were less restricted, year-round, to open deciduous dipterocarp forest than the formerly sympatric kouprey *Bos sauveli* and wild water buffalo *Bubalus arnee*. A richer array of food types, including forage, browse and fruits in mixed deciduous forest, is likely to make the habitat particularly attractive to banteng and gaur *Bos gaurus* (Steinmetz, 2004). The movements and habitat selection of banteng in the Eastern Plains Landscape are likely to be affected by water availability and dry season fires in the deciduous dipterocarp forest, leading to regular utilisation of denser forest types. Year-round radio or satellite telemetry of banteng would generate much valuable information on their movements, home ranges and habitat preferences.

Banteng herd size, estimated by counting the number of individuals photographed during each encounter, was low (mean 2.6 individuals per encounter) with only 22 (14%) encounters of groups estimated to comprise more than five individuals. Whilst this maybe an artefact of camera trap photographs, which are likely to under-estimate group size (e.g. due to poor quality of images at night, not all individuals in a group being photographed, difficulties in detecting all calves), data

from line transect observations are similar. During 34 encounters mean herd size was three individuals (range 1-12; median 2) with six groups (18%) of five or more individuals (WWF unpublished data).

These figures are considerably lower than those quoted from remnant banteng populations elsewhere in mainland Southeast Asia and Indonesia. In Yok Don National Park, Vietnam, Nguyen (2009) reported a mean herd size of seven individuals, whilst in Thailand, the average recorded banteng herd size is reportedly between six and 10 (Prayurasiddhi, 1997, cited in Nguyen, 2009). Nguyen (2009) also suggested that herd sizes in Yok Don had declined since the early 1990s when "average herds" were comprised of 20 to 30 individuals. This decline in herd size was attributed to declining habitat availability and fragmentation, high illegal hunting pressure, and competition with domestic livestock. In Balarun National Park, Java, median banteng herd size, from 736 observations, was five with 29% of observations consisting of herds larger than 10 individuals (Pudyatmoko & Djuwantoko, 2006). However, these data were obtained from observations at an open grassland feeding area with artificial water sources, which may have encouraged congregation.

Indeed, Timmins *et al.* (2008) suggest that the basic social group in banteng, as in the other large Asian Bovini, is the female-juvenile unit with larger groups tending to be more or less temporary assemblages. If group size is therefore highly fluid, possibly even varying daily (Hoogerwerf, 1970 in Timmins *et al.*, 2008), our low estimation of herd size could simply reflect the fact that few camera traps were at locations (e.g. seasonal waterholes and saltlicks) where aggregations are more likely to form. During the late dry season 2010, when water availability was highly restricted, camera trapping at two waterholes in the core area of MPF produced 37 banteng encounters with a mean group size of 4.5 individuals and three encounters of herds of more than 15 individuals (WWF unpublished data).

In both MPF and PPWS, the banteng appear to be highly nocturnal. Whether this is in response

to hunting pressure and human disturbance or is a natural pattern is unclear. Halder (1976, cited by Timmins *et al.*, 2008) suggested that banteng in Java "display a more or less fixed diurnal pattern of behavior" but "in areas which are subject to frequent human disturbance... become rather nocturnal and generally enter open areas only at night, although in especially attractive localities it will tolerate human presence to a certain extent." Hoogerwerf (1970, cited by Timmins *et al.*, 2008) also suggested that whilst banteng in Java "do not differentiate much in their activities between day and night... really large assemblages on open plains occur almost exclusively by day."

The strong nocturnal patterns of activity documented from our camera trap data differ markedly from this. Given that both protected areas experienced extensive hunting from the 1970s until the mid-1990s and banteng meat remains available in Mondulkiri, with regular confiscations by law enforcement staff (WWF unpublished data), it seems likely that the nocturnal patterns of activity we have noted are at least in part a response to human activity. A similar tendency towards nocturnal behaviour in response to human activity has been detected through camera trapping studies in a number of other hunted species (Griffiths & van Schaik, 1993; Bitetti *et al.*, 2008). It will be fascinating to note whether, with continued conservation investment in MPF and PPWS, banteng activity becomes increasingly diurnal. Given that the Eastern Plains Landscape is likely to support one of, if not the, largest global populations of banteng, it is imperative to improve law enforcement to eliminate the impacts of hunting on this charismatic species of the deciduous forests of Cambodia.

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First report on the herpetofauna of Dalai Mountain in Phnom Samkos Wildlife Sanctuary, southwestern Cardamom Mountains, Cambodia

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សេចក្តីសង្ខេប

ការសិក្សាស្រាវជ្រាវថ្នាក់ជាតិ និងឧបត្ថម្ភនៃភ្នំដាឡៃ នៅក្នុងតំបន់ដែនជម្រកសត្វព្រៃភ្នំសំកុសជាលើកដំបូង បានរកឃើញសត្វចំនួន ២៤ (៩ ប្រភេទ ជាថ្មីសត្វ និង ១៥ ប្រភេទទៀតជាឧបត្ថម្ភ) ហើយដែល ១៨ ប្រភេទត្រូវបានគេស្គាល់ថាមានវត្តមានតែនៅក្នុងតំបន់ភ្នំក្រវាញ។ ក្នុងចំណោមទាំង ២៤ ប្រភេទដែលបានរកឃើញ មាន ៤ ប្រភេទ តំណាងអោយប្រភេទដែលទើបតែបានធ្វើកំណត់ត្រាជាលើកដំបូង សំរាប់តំបន់ដែនជម្រកសត្វព្រៃភ្នំសំកុស (*Megophrys auralensis*, *Theloderma asperum*, *Philautus parvulus* និង *Dasia olivacea*) ហើយ ៣ ប្រភេទផ្សេងទៀត ត្រូវបានគេជឿថា ជាប្រភេទថ្មីសំរាប់វិទ្យាសាស្ត្រ (សិស្សស្បែក *Ichthyophis* sp. ថ្លែនឥតជើង *Dibamus* sp. និងថ្លែនជើងខ្លី *Lygosoma* sp.) ។ កំណត់ត្រា និងប្រភេទថ្មីទាំងនេះ បង្ហាញពីកំណើនយ៉ាងលឿន នៃចំនួនថ្មីសត្វ និងឧបត្ថម្ភរកឃើញពីតំបន់ភ្នំក្រវាញ ដែលទើបតែមានការស្រាវជ្រាវតិចតួចនៅឡើយ ហើយដែលមានតម្លៃបន្ថែមទៀតយ៉ាងសំខាន់ សំរាប់ការអភិរក្ស។

ពាក្យគន្លឹះ: ថ្មីសត្វ កម្ពុជា ភ្នំក្រវាញ ភ្នំដាឡៃ ឧបត្ថម្ភ ការស្រាវជ្រាវ។

Abstract

The first herpetological survey of Dalai Mountain in Phnom Samkos Wildlife Sanctuary revealed 24 species (nine amphibians and 15 reptiles), 18 of which are presently known only from the Cardamom Mountains. Of these, four represent first records for Phnom Samkos Wildlife Sanctuary (*Megophrys auralensis*, *Theloderma asperum*, *Philautus parvulus* and *Dasia olivacea*) and a further three are believed to be new to science (a caecilian *Ichthyophis* sp. and two lizards *Dibamus* sp. and *Lygosoma* sp.). These new records and taxa highlight the rapidly growing number of amphibian and reptile species known from this little-explored region of the Cardamom Mountains, and represent a significant additional value worthy of conservation attention.

Keywords

Amphibians, Cambodia, Cardamom Mountains, Dalai, reptiles, survey.

Introduction

Compared with mammals and birds, the amphibians and reptiles of Cambodia have received little attention. The earliest herpetological collections were made by Henri Mouhot in mountainous areas of eastern and southwestern Cambodia during the mid-1800s. Mouhot's collections were described by Gray (1861a, b) and Günther (1861, 1864). Subsequent collections were made by Malcolm A. Smith (1922, 1928), Bourret (1936, 1941, 1942), and Saint Girons (1972) in the Cardamom Mountains and other parts of Cambodia. Until recently, these works represented the only significant sources of information for herpetological explorations in Cambodia.

Shortly after the political reconciliation and integration in the late 1990s, field surveys were initiated at the request of the Cambodian government to assess the biodiversity of priority areas in a drive to conserve Cambodian natural resources (e.g. Daltry & Momberg, 2000). This resurgence in herpetological field investigations targeted three distinct biogeographical areas: (1) mountainous areas in northeastern Cambodia (Long *et al.*, 2000; Stuart *et al.*, 2006; Rowley *et al.*, 2010; Stuart *et al.*, 2010); (2) low lying floodplains around the Tonle Sap Lake (Touch *et al.*, 2000; Lehr & Holloway, 2000; Stuart *et al.*, 2000), augmented by collections in Siem Reap (Hartmann *et al.*, 2009, 2010) and along the Mekong River (Bezuijen *et al.*, 2009); and (3) the Cardamom Mountains (Daltry & Chheang, 2000; Swan & Daltry, 2000; Swan & Daltry, 2002; Daltry & Wüster, 2002; Long *et al.*, 2002; Ohler *et al.*, 2002; Daltry & Traeholt, 2003; Stuart & Platt, 2004; Stuart & Emmett, 2006; Grismer *et al.*, 2007a, b; 2008a, b; Grismer *et al.*, 2010; Wood *et al.*, 2010; Neang *et al.* (in review).

To date, herpetological investigations in Cambodia's Cardamom Mountains, which cover an area of approximately two million hectares (Fig. 1), have documented 138 species of amphibians and reptiles (Grismer *et al.*, 2008b). Of these, 32 amphibian and 75 reptile species are confirmed to occur in Phnom Samkos Wildlife Sanctuary, in the northwest of the range. Although the number of species

has grown rapidly with additional fieldwork, these figures likely underestimate the true diversity of amphibian and reptiles within the area because only approximately 10% of the sanctuary's landscape has been surveyed thus far. Additional fieldwork in as-yet unexplored areas of the sanctuary is required to complete the inventory and evaluate the distribution and conservation status of the species present. In this paper, we report the findings of the first study of the herpetofauna of Dalai Mountain, which lies in the northern part of Phnom Samkos Wildlife Sanctuary.

Methods

The field survey was carried out from 4–10 July 2009, during the middle of the wet season, on Dalai Mountain (Fig. 1), with additional material collected during 16–22 November 2009 and 9–23 January 2010. One of many mountain peaks within the Phnom Samkos Wildlife Sanctuary, the Dalai Mountain (elevation 1,043 metres) lies adjacent to Tumpor Mountain, but is isolated from it by the Tumpor River which flows into the Pursat River. These mountains are separated by the low-lying Samkos Basin from Mount Samkos (1,717 metres), Cambodia's second highest peak, which lies approximately 30 km to the south. Dalai Mountain is covered with semi-evergreen forest on its lower hill slopes and primary evergreen forest on the upper hills and ridges. Parts of this mountain were selectively logged, and a significant number of commercial tree species removed, while this area was under Khmer Rouge control during the early 1990s. Selective logging continues to degrade the regenerating forests at lower altitudes, and newly created logging roads were observed during the present study.

The field survey focussed on hillside habitats between rocky streams and mountain ridges in two main areas as follows:

Camp I was located approximately 20 metres from a pond at the base of a large waterfall on the Dalai stream (12°25'233"N, 103°04'072"E, 556

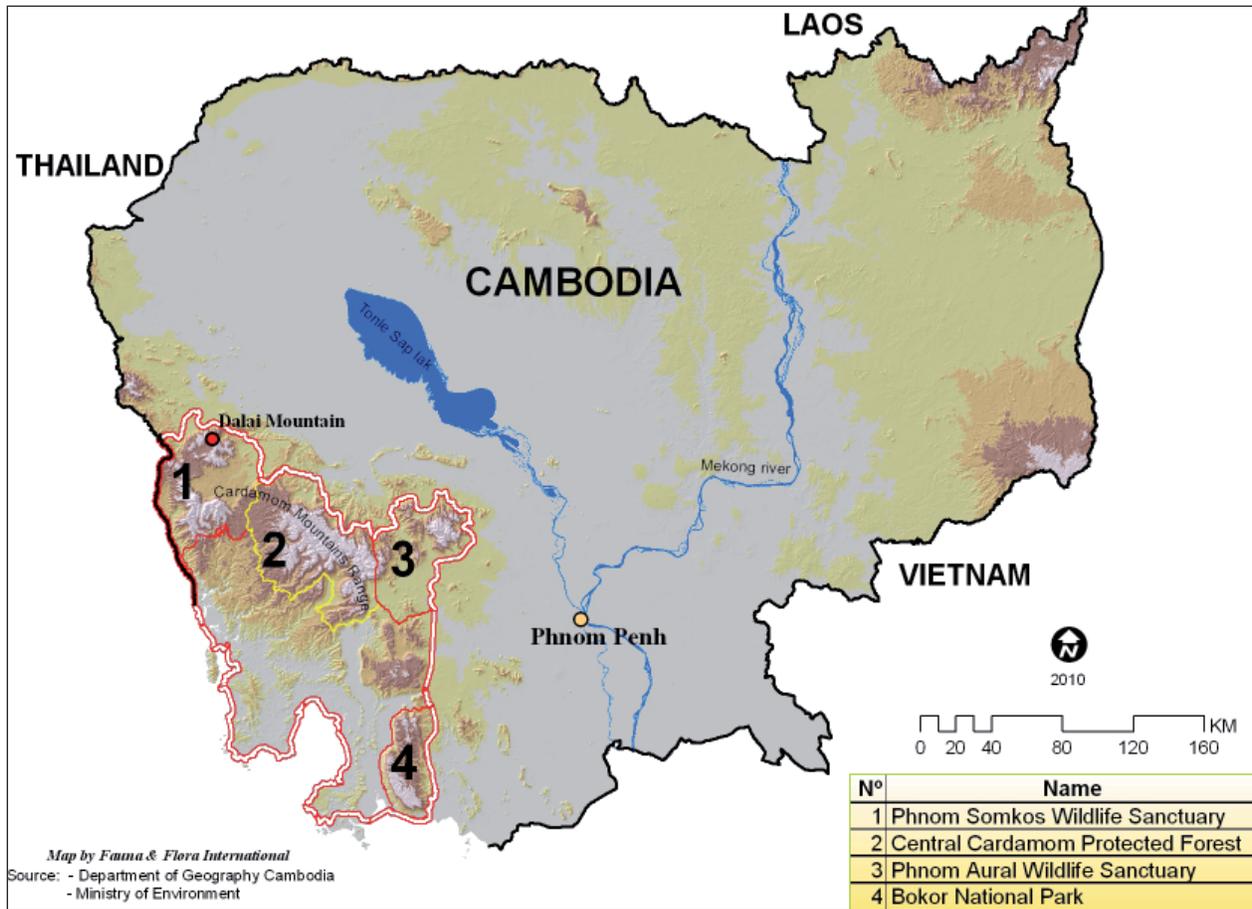


Fig. 1 Map showing the location of Dalai Mountain in the Cardamom Mountains of Southwest Cambodia.



Fig. 2 *Ichthyophis* sp. (LSUHC 9335) from Camp II on Dalai Mountain (© Neang T.).



Fig. 3 *Quasipaa fasciculispina* from Camp II on Dalai Mountain (© Neang T.).



Fig. 4 *Hylarana mortenseni* from Camp I on Dalai Mountain (© Neang T.).



Fig. 5 *Cnemaspis chanthaburiensis* from Camp II on Dalai Mountain (© Neang T.).



Fig. 6 *Ahaetulla prasina* from Camp I on Dalai Mountain (© Neang T.).

metres elevation) in an area of disturbed evergreen hill forest. Night-time searches focussed on a rocky, fast-moving and shallow stream and adjacent forests, while searches during the day were undertaken throughout the surrounding forest area.

Camp II was located beside a small, rocky and fast-moving stream ($12^{\circ}26'134''N$, $103^{\circ}03'217''E$, 968 metres elevation) in undisturbed tall evergreen hill forest. Daytime and night-time searches for amphibians and reptiles were undertaken along the stream and throughout the surrounding forest area.

Camp III was in primary tall evergreen forest ($12^{\circ}26'26.091''N$, $103^{\circ}4'39.708''E$, 1,009 metres elevation). Search activities were carried out both by day and by night along a slow-flowing stream and in the forest.

Camp IV was in lowland disturbed evergreen forest beside O'Peam ($12^{\circ}12'15.079''N$, $103^{\circ}4'12.330''E$, 293 metres elevation). Survey efforts were made in the forest during the daytime and along the slow-moving stream at night.

Specimens were located through visual searches and captured by hand, sometimes with the aid of blowpipes for arboreal reptiles. Following euthanasia, liver tissue was taken and stored in 97% ethanol. All specimens were tagged and fixed in 10% formalin for a minimum of 24 hours, then transferred to 70% ethanol. All specimens were deposited in the herpetological laboratory of La Sierra University, California, USA (LSUHC). Species identifications were undertaken through comparison with museum material and species descriptions in the literature.

Morphological characters were measured to the nearest 0.1 mm using a dial calliper under a Nikon SMZ645 dissecting microscope. Characters measured included: snout to vent length (SVL); tympanum to eye distance (TYE) from the posterior margin of the eye to the anterior margin of the tympanum; head depth (HD) from the posterior margin of the eyelid to the throat; interorbital distance (ID), the shortest distance between the medial

base of the eyelids; the number of scale rows anterior to head; the number of mid-body scale rows (excluding the ventral scale for snakes); the number of scale rows anterior to the vent; the number of ventral scale rows from the mental scale to the last scale at the vent; and subdigital scales on the third, fourth and fifth toes, counted from the base of the proximal interphalangeal joint to the tip of toe. In the following accounts, left (L) and right (R) refer to scale counts on the left and right sides of snakes.

Results

A total of 24 species, comprising nine amphibian species (eight genera in five families) and 15 reptile species (10 lizards and five snakes, in 14 genera in six families) were found on Dalai Mountain in Phnom Samkos Wildlife Sanctuary (Table 2). Accounts of all species are presented below.

Amphibians

Ichthyophiidae

Ichthyophis sp. (Fig 2)

Material examined: LSUHC 9335: Camp II, 7 July.

A single specimen (SVL 177.6 mm) is in accord with Taylor's (1968) diagnostic characters of this genus in having a distinct tail (length 3 mm); four series of teeth (two rows in the upper jaw and another two in the lower jaw); longitudinal vent; and primary and secondary annuli forming a medial, posteriorly directed ventral angle. The specimen was uniform dark brown in life, and in preservative it is dark grey on the dorsum and paler on the ventral surface, with cream-white on the anal region.

This specimen was found during the day in damp soil beneath a fallen log on a hillside. Two specimens from the Central Cardamom Mountains ascribed to the genus *Ichthyophis* were previously listed by Grismer *et al.* (2007a), although their specific identify remains unknown. The specimen from Dalai Mountain is presently being described as a new species.

Dicroglossidae

Limnonectes gyldenstolpei (Anderson, 1916)

Material examined: LSUHC 9313– 9315: Camp I, 6 July.

One adult female (SVL 51.7 mm) and two juvenile females (SVL 36.5–37.8 mm) match the diagnosis of this species by Taylor (1962) and Ohler *et al.* (2002) in lacking a fang-like process in the lower jaw; not having a prominent flap on the head (but a flattened vestigial flap is visible), the head is not swollen and the jaw not widened; and the diameter of tympanum is four-fifths the diameter of the eye. All specimens have small tubercles on the eyelids and numerous tubercles on the dorsum and limbs. In life, they had a pale, interorbital bar and the body was dark brown above and white below.

The specimens were collected at night from muddy, gravelly substrate at the edge of a slow-moving rocky stream. This species was reported by Daltry & Chheang (2000), Ohler *et al.* (2002) and Swan & Daltry (2002) from Phnom Samkos Wildlife Sanctuary, the Central Cardamoms Protected Forest and Phnom Aural Wildlife Sanctuary.

Quasipaa fasciculispina (Inger, 1970) (Fig. 3)

Material examined: LSUHC 9316–17: Camp I, 6 July; LSUHC 9322: Camp II, 7 July.

Three adult females (SVL 86.8–97.7mm) closely agree with the expanded descriptions of this species by Stuart & Emmett (2006) from Knorng Louk in the Central Cardamoms Protected Forest and Grismer *et al.* (2007a) from Phnom Aural Wildlife Sanctuary, in having expanded toe discs; proximal subarticular tubercles on the fingers that are twice as long as the distal, subarticular tubercles; small black spots on the tubercles of the dorsum, head, limbs and anal region; and small, black, keratinized tubercles on the upper parts of the throat and chest that do not form groups as in males. In life, the head, dorsum, flanks, and surface of limbs were brownish green and the belly was whitish except for the chest, which had faint dark blotches.

Specimens LSUHC 9316–17 were found at night sitting half-submerged in shallow, slow-moving water in the cascade sections of streams. LSUHC 9322 was collected from soil substrate on the bank

1.3 metres from the slow-flowing water of a rocky stream. Ohler *et al.* (2002) reported this species from the Cardamom Mountains.

Megophryidae

Megophrys (Xenophrys) auralensis Ohler, Swan & Daltry, 2002

Material examined: LSUHC 9346: Camp II, 8 July.

A single adult female (SVL 31.1 mm) with a remnant short pointed tail (0.9 mm) agrees with diagnosis of this species by Ohler *et al.* (2002) and Grismer *et al.* (2007a) for Phnom Aural Wildlife Sanctuary, and Stuart & Emmett (2006) for Knorng Louk in the Central Cardamoms Protected Forest, in having a vomerine ridge lacking vomerine teeth; large head; visible tympanum; no white band on the upper lip; and relatively long tibia. In preservative, the specimen is dark-brown dorsally with a darker, triangular marking on the head, and has a greyish belly with black spots.

This specimen was collected at night after a light rain, in leaf litter on the forest floor, 20 metres from a rocky, fast-flowing stream. This is the first report of this species in Phnom Samkos Wildlife Sanctuary. This record, together with previous records by Ohler *et al.* (2002), Stuart & Emmett (2006) and Grismer *et al.* (2007a), suggest *M. auralensis* may be widely distributed in suitable habitats throughout the Cardamom Mountains.

Ranidae

Hylarana faber (Ohler, Swan & Daltry, 2002)

Material examined: LSUHC 9323: Camp II, 7 July; LSUHC 9347: Camp II, 8 July.

An adult male (SVL 58.1 mm) and adult female (SVL 68.7 mm) agree with the original diagnosis by Ohler *et al.* (2002) and with Stuart & Emmett's (2006) description of this species from the Cardamom Mountains in having an indistinct humeral gland; distinct nuptial pad on finger I reaching the distal subarticular tubercle; no vocal pouch in males; males smaller than females; and distinct thin dorsolateral folds in both sexes.

This species is often confused with *Hylarana mortenseni* (Fig. 4) so we examined six adult males

Table 1 Selected measurements in millimetres for *Hylarana mortenseni* and *H. faber*. Values given are: mean, standard deviation, (minimum-maximum). See text for an explanation of the measurements.

Sex	<i>Hylarana mortenseni</i>		<i>Hylarana faber</i>	
	Male (n = 6)	Female (n = 3)	Male (n = 1)	Female (n = 1)
SVL	63.1 ± 4.87 (56.0-68.3)	62.0 ± 5.90 (56.8-68.4)	58.1	68.7
TYW	3.7 ± 0.62 (2.8-4.9)	3.1 ± 0.77 (2.4-3.8)	1.8	3.0
HD	10.7 ± 0.80 (9.2-11.5)	9.9 ± 0.78 (9.1-11.0)	9.1	10.0

(LSUHC 7923, 7926, 7927, 8754-8756) and two adult females (LSUHC 8757, 8758) of *H. mortenseni* collected in the lowland areas of the Cardamom Mountains for comparison. We found that the distance from the posterior margin of eye to anterior margin of tympanum (TYE) in both sexes was much longer in *H. mortenseni* than in *H. faber* from Dalai Mountain (Table 1). Additionally, *H. faber* has flat, elongated rectal glands as opposed to the triangular rectal glands in *H. mortenseni*. The two species may be further separated by the greater head depth (HD) in both sexes in *H. mortenseni* than in *H. faber* (Table 1). For the latter character, however, these preliminary data only slightly separated the females of each species and were based on a very small sample size.

In preservative, the specimens have a light greyish brown colour on the dorsum; small yellowish spots on the flanks in females; and cream-white blotches on an immaculate ventral surface.

LSUHC 9323 was collected at night on a twig, 50 cm above the water near the bank of a rocky section of a fast-moving stream. LSUHC 9347 was found at night in leaf litter on the forest floor away from any stream.

Hylarana mortenseni Boulenger, 1903 (Fig. 4)

Material examined: LSUHC 9311: Camp I, 6 July.

A single adult female (SVL 60.7 mm) matches a series of six males and two females (SVL 56.8–68.4 mm) from the Cardamom Mountains (see above).

Our specimen agrees with the diagnostic characters listed by Ohler *et al.* (2002) and Stuart & Emmett (2006) for Cardamom Mountains specimens in having males and females with nearly equal SVL (Table 1); an enlarged, short head; distinct thick dorsolateral folds; triangular rectal gland; brown dorsum; cream-white venter; and a dark brown chest and throat bearing darker blotches (in preservative).

This specimen was collected at night on a rocky bank, one metre from the edge of a slow-moving rocky stream.

Rhacophoridae

Philautus parvulus (Boulenger, 1893)

Material examined: LSUHC 9342–9345: Camp II, 8 July.

Four adult males (SVL 13.5–20.4 mm) match Taylor's (1962) original diagnosis of this species, Boulenger's (1893) description of specimens from Chiang Mai Province in Thailand, Stuart & Emmett's (2006) description of specimens from Kampot Province in the southeastern Cardamom Mountains, and the description by Grismer *et al.* (2007a) from Phnom Aural Wildlife Sanctuary, in having a pointed snout; invisible tympanum; inter-orbital distance wider than width of upper eyelid; lacking vomerine teeth; having a large vocal sac; slight webbing between fingers III and IV; webbing of the third and fifth toe reaching the distal subarticular tubercle; toes with relatively large discs; and a granular venter.

All four specimens were found at night while calling from the leaves of saplings 1.0–1.5 m above the ground. In most cases, this species can be located only while calling owing to its cryptic colouration and small size. Ohler *et al.* (2002) reported *Philautus parvulus* from Phnom Aural Wildlife Sanctuary. Our record may represent the first account of this species in Phnom Samkos Wildlife Sanctuary.

Rhacophorus bisacculus Taylor, 1962

Material examined: LSUHC 9312: Camp I, 6 July; LSUHC 9340: Camp II, 8 July.

Two adult females (SVL 34.8 and 40.5 mm) correspond to Taylor's (1962) diagnosis of this species

from Phu Kading, Loei Province, Thailand, and Stuart & Emmett's (2006) description of specimens from Kampot and Knorng Louk, Central Cardamom Mountains, in having a short pointed snout, all fingers with slight webbing, a row of granular tubercles on outer edge of arm and tarsus; and the venter bearing rounded granulate tubercles. In life, the dorsum was brown to dark brown, there were numerous black spots on the flanks, throat and chin; and the anal region and undersides of the thighs were orange.

LSUHC 9312 was found at 1330h resting on a large, long leaf of a tree, 1.2 m above the ground near a pond along the stream. LSUHC 9340 was collected on the leaf of a tree, 80 cm above ground. This species was also reported by Ohler *et al.* (2002) and Stuart & Emmett (2006) from the Cardamom Mountains.

Theلودerma asperum Boulenger, 1886

Material examined: LSUHC 9341: Camp II, 8 July.

A single adult male (SVL 33.2 mm) agrees with the original diagnosis of this species by Taylor (1962) and description of this species by Stuart *et al.* (2006) from Keo Seima, Mondulhiri Province, northeastern Cambodia, in having scattered white asperities on the dorsum, head and limbs, but not the flanks; larger white tubercles in the anal region; fingers slightly webbed at their base; and the inter-orbital distance wider than the width of the upper eyelid. In preservative, the specimen is dark grey above; has a dark interorbital bar; an indistinct creamy, rust-coloured marking on the occiput that bifurcates into distinct lines continuing down the flanks; a dark grey throat; a dark ventral surface; and white reticulations at the base of the underside of the thigh.

The specimen was collected at night after a light rain from the mossy base of tree, 50 cm above ground, among small bushes. Ohler *et al.* (2002) and Swan & Daltry (2002) reported this species from the eastern Cardamom Mountains, and Stuart *et al.* (2006) reported it from northeastern Cambodia.

Reptiles

Agamidae

Acanthosaura cardamomensis Wood, Grismer, Grismer, Neang, Chav & Holden, 2010

Material examined: LSUHC 9328: Camp I, 6 July; LSUHC 9324, 9329: Camp II, 7 July; LSUHC 9330, 9348, 9351–9355: Camp II, 8 July.

Five adult males (SVL 97.5–138 mm), two adult females (SVL 98.3–143.8 mm) and three juvenile males (48.5–54.5 mm) match the diagnosis of this species by Wood *et al.* (2010) in having a maximum SVL of 143.8 mm in females and 138 mm in males; a large long cylindrical spine above posterior edge of eye; a long large spine on the nape between tympanum and nuchal crest; a naked, round tympanum; a large rectangular rostral scale; small dewlap in both sexes; scattered groups of larger keeled scales on flanks; high flattened nuchal crest; 6–16 scales in nuchal diastema except for the juvenile (LSUHC 9330) which had 24 nuchal scales; vertebral crest with flattened, enlarged, pointed scales extending from above shoulder region to the base of the tail; tail length 124–157% of SVL; the area around eye black; large dark bands alternating with smaller light bands on the tail; greenish yellow above; and females being darker green than males.

The majority of specimens were collected at night sleeping on tree trunks, one-to-two metres above the ground. Others, especially juveniles, were found during the day on the forest floor. A juvenile was also found deep in the centre of a rotting tree base. Hatchlings were found in a tree hole. Wood *et al.* (2010) reported *Acanthosaura cardamomensis* ranging from Bokor National Park (Kampot Province), Phnom Aural Wildlife Sanctuary (Kampong Speu Province), Thmar Baing District (Koh Kong Province) in the Central Cardamom Mountains, to Phnom Samkos Wildlife Sanctuary in the western Cardamom Mountains and extending northward along the Cardamom Mountains in Thailand to Nakhon Ratchasima Province.

Calotes emma Gray, 1845

Material examined: LSUHC 9306: On road near Camp I; LSUHC 9308: Camp I, 6 July.

An adult female LSUHC 9306 (SVL 100.1 mm), a male LSUHC 9307 (SVL 71.3 mm) and a juvenile agree with the descriptions of this species by Taylor (1963) for Thailand; by Stuart *et al.* (2006) from Ta Veng (Ratanakiri Province), northeastern Cambodia; and Stuart & Emmett (2006) from Thmar Baing (Koh Kong Province) in the Central Cardamoms Protected Forest, in having a spine on the posterior end of supraciliary edge; a spine above the tympanum; a spine in the occiput region midway between the tympanum and nuchal crest; and an oblique skin fold anterior to the shoulder bearing black and pinkish scales. The male specimen from Dalai Mountain has distinct large cream-coloured paravertebral stripes on the upper flanks extending from the posterior margin of the tympanum to two-thirds of the body length between the front and hind limb insertion. A similar, but less distinct, line occurs in the female.

All specimens were found during the day sitting on tree trunks and branches of saplings approximately one metre above the ground near a rocky stream. As *Calotes emma* has been found in both the Cardamom Mountains and northeastern Cambodia, it is likely to occur in suitable habitat throughout the country.

Draco maculatus (Gray, 1845)

Material examined: LSUHC 9304: Camp I, 6 July.

One adult female (SVL 62.4 mm) matches the description of this species by Gray (1845) and by Grismer *et al.* (2007a) from Phnom Aural Wildlife Sanctuary in the southeastern Cardamom Mountains in having outwardly directed nostrils; two enlarged, medial, maxillary teeth; nine supralabials; tympanum covered by scales; enlarged scales on lateral pouches; nuchal crest absent; five ribs in the patagia; and strongly keeled caudal scales. The single specimen from Dalai Mountain has enlarged, dorsolateral body tubercles. In preservative, the dorsum is bluish grey; has a dark interorbital bar with a large black spot on middle top of head; a patagium with alternative rows of creamy, pale

grey coloured dark lines; and white dorsolateral body tubercles.

The specimen was found during the day on a tree trunk, 5 m above the ground. *Draco maculatus* was also reported by Stuart & Emmett (2006) from Phnom Srouch (Kampong Speu Province) and Thmar Baing (Koh Kong Province) in the Central Cardamom Mountains.

Draco taeniopterus Günther, 1861

Material examined: LSUHC 9305, 9309: Camp I, 6 July; LSUHC 9331–9333 between Camp I & II, 8 July.

Four adult males (SVL 64.5–73.5 mm) and one adult female (SVL 69.1 mm) correspond to Stuart & Emmett's (2006) description of specimens from Thmar Baing District, Koh Kong Province, in the Central Cardamom Mountains, and the description of this species by Grismer *et al.* (2007a) from Phnom Aural Wildlife Sanctuary, in having upwardly directed nostrils; a row of keeled scales on rostrum; two enlarged, maxillary teeth; 7–10 keeled supralabials; tympanum naked; five ribs in patagium; enlarged scales on lateral pouches, hind limb length equalling the distance between limbs; and caudal scales strongly keeled. The specimens from Dalai Mountain have few, enlarged dorsolateral scales on the posterior body. In life, the gums (soft tissue around the teeth) were blue; the upper part of dewlap was yellowish, the base of dewlap was red in males; there was a black spot on the head; and black transverse bands on the upper surface of the patagium.

All specimens were found during the day resting on tree trunks from 4–6 m above the ground. This species is known to occur throughout the Cardamom Mountains (Daltry & Chheang, 2000; Swan & Daltry, 2002; Stuart & Emmett, 2006; Grismer *et al.*, 2007a).

Dibamidae

Dibamus sp.

Material examined: CBC 00559–560, LSUHC 9779–80: Camp III, 20 November 2009.

One male (SVL 123.8 mm) and three females (SVL 116.8–127.6 mm) have the following charac-

ters: nasal sutures complete; rostral suture present and incomplete; rostral pad divided into two equal parts; a single postocular; three scales bordering posterior edge of first infralabial; 20 midbody scale rows; 22 transverse scale rows just posterior to head; 20 scale rows anterior to vent; 185–209 ventral scales; 50 subcaudal scales in males and 48–52 in females; possessing an enlarged, medial, sublabial scale. In life, dorsum and flanks are light brown; the ventral surface lighter brown; and the tail darker brown. Some individuals have nuchal and body scales bearing a cream-coloured band and small cream-coloured markings.

All specimens were found at midday on the soil surface beneath a rotten log in primary evergreen forest. This new species is currently being described by Neang *et al.* (in review).

Gekkonidae

Cnemaspis chanthaburiensis Bauer & Das, 1998 (Fig. 5)

Material examined: LSUHC 9337–38: Camp II, 8 July.

Two adult males (SVL 32.2–42.4 mm) correspond to the description of this species by Bauer & Das (1998) from southeastern Thailand and Grismer *et al.* (2008a) from Phnom Samkos Wildlife Sanctuary in having an extra phalange in the second digit of manus and pes (2–4–4–5–4); 7–8 preanal pores; lacking femoral pores; fifth digit of manus slightly shorter than fourth; ventral and subcaudal scales smooth; 23 subdigital scales on the third toe; 20 on the fourth toe; 12 on the fifth toe; dorsal pattern with white paravertebral blotches and scattered black granular tubercles.

One specimen was found on the ground underneath a rotten log and another was collected from loose bark on the forest floor. *Cnemaspis chanthaburiensis* probably occurs throughout the Cardamom Mountains and may overlap with the distribution of the rock-dwelling *C. neangthyi* (Grismer *et al.*, 2010) to the east. *Cnemaspis chanthaburiensis* ranges as far west as the Cardamom Mountains of southeastern Thailand (Bauer & Das, 1998).

***Cyrtodactylus intermedius* (Smith, 1917)**

Material examined: LSUHC 9318–19: Camp I, 6 July; LSUHC 9325–26, LSUHC 9336: Camp II, 7 July; LSUHC 9349: Camp II, 8 July.

Two adult males (SVL 70–74.5mm), one adult female (SVL 76.3 mm) and three juveniles (SVL 46.3–52.8 mm) agree with Taylor's (1963) expanded description of Thai specimens, Stuart & Emmett's (2006) description of the Central Cardamom specimens and the description by Grismer *et al.* (2007a) of specimens from the Phnom Aural Wildlife Sanctuary in possessing 7–9 preanal pores in males; enlarged preanal scales; 7–11 enlarged femoral scales; a distinct ventrolateral body fold; ear opening less than half the diameter of eye; a dark brown band extending from the eye across the neck, edged in white to yellow; four brown bands on body; and a dark and light banded tail.

All specimens were collected at night at the base of trees and on leaves and branches 1–1.5 m above the ground. This species was most commonly seen around Camp II. *Cyrtodactylus intermedius* has been reported from throughout the Cardamom Mountains from 300–1,100 metres in elevation (e.g. Daltry & Chheang, 2000; Stuart & Emmett, 2006; Grismer *et al.*, 2007a).

Scincidae***Dasia olivacea* Gray, 1838**

Material examined: LSUHC 9303: Camp I, 6 July.

A single female (SVL 100.5 mm) agrees with the diagnosis of this species by Taylor (1963), and with Stuart & Emmett's (2006) description of specimens from the Central Cardamom Mountains, in having a pair of supranasals separated by the contact of the rostral and frontal scales; prefrontals touching; four supraoculars; preanal scales slightly enlarged; a pair of transversely enlarged and elongate nuchal scales, 30 midbody scale rows; and 57 ventral scales. In preservative, the specimen is greenish brown and the body scales are darkly edged, forming corrugate pattern of dark lines; the belly is bluish grey; a light cream dorsolateral stripe beginning from the lumbar region and extending to one third of the way down the tail.

The specimen was found during the day on the trunk of a strangler fig tree, one metre above the ground along the bank of a rocky stream. Stuart & Emmett (2006) reported this species from Chum Noab Commune, Koh Kong Province, in the Central Cardamom Mountains.

***Lygosoma* sp.**

Material examined: LSUHC 9321: Camp I, 6 July.

Adult male (SVL 159.2 mm) with its original tail (TL 157 mm); body elongate, robust, limbs stout, greatly reduced, do not overlap when adpressed against body; eyelids well developed, lower eyelid scaly; nostril in nasal scale; supranasals present; large frontonasal followed by widely separated prefrontals; frontoparietals paired; interparietal bounded posteriorly by parietals; digits short, robust; 15 keeled subdigital lamellae on fourth toe; overall dorsal colouration brown, slightly lighter ventral colouration.

The specimen was collected in the early morning from a hole inside a large log laid on the ground. It was first seen near the log, but ran into the hole when approached. This species is now being described as new species.

***Scincella reevesii* (Gray, 1838)**

Material examined: LSUHC 9781–82: Camp III, 17 and 18 November; LSUHC 9783–86: Camp IV, 13, 14, 15 and 16 January 2010.

One adult male (SVL 43.7 mm), three adult females (SVL 42.9–44.1 mm) and two juveniles (SVL 26.5–33.5 mm) agree with the expanded description by Ouboter (1986) in lacking supranasal scales; having a central transparent disc in the lower eyelid surrounded by tiny scales, a broad suture formed by the prefrontals; the fifth and sixth supralabials separated from small granular scales of lower eyelids by a scale row; 31–33 body scale rows; mean SVL/ head width ratio of 7.8; mean SVL/ head length ratio of 5.3. In life, all specimens had a light brown dorsum; dark irregular vertebral spots; a reddish tail; dark lateral stripe extending from the nostrils through the eyes and onto the upper flanks, fading at the base of tail; and a white belly and subcaudal region.

LSUHC 9782 was caught at night on the trunk of a tree 45 cm above the ground in evergreen forest. LSUHC 9783 was found at night beneath the bark of a partly fallen dead tree, 50 cm above ground and 40 m from stream. LSUHC 9784 was found at night on and beneath the leaf litter of the forest floor, and LSUHC 9786 was collected during the day on the ground near the base of a tree at O'Peam campsite. This species was reported by Daltry & Chheang (2000) and Swan & Daltry (2002) in Phnom Samkos and Phnom Aural Wildlife Sanctuaries respectively.

Colubridae

Ahaetulla prasina (Lacépède, 1789) (Fig. 6)

Material examined: LSUHC 9320: Camp I, 6 July.

A single male (SVL 780.4 mm) agrees with the descriptions of this species by Stuart *et al.* (2006) from Mondulkiri Province, northeastern Cambodia, Stuart & Emmett (2006) from the Central Cardamom Mountains, and Taylor (1965) from Thailand, in having an elongate head distinct from the neck; pointed snout, the length being approximately two times of the diameter of eye; rostral scale directed upwards with a free edge above, but not bearing a distal nasal appendage; the orbit bordered below by three labials; and the anal scale divided. In preservative, there are two distinct black streaks along the side of neck; the anterior region of the dorsum is grey brown above with interstitial black and white markings (Fig. 6). Our specimen has distinct black dorsolateral spots on the posterior four-fifths of the right side of the tail and indistinct spots on the left side of the tail.

The specimen was found at night sleeping on branches 1.5 m above the ground. This species was previously recorded in Cambodia by Saint Girons (1972), Stuart & Emmett (2006) from the Central Cardamom Mountains, Grismer *et al.* (2008b) from Bokor, and Stuart *et al.* (2006) from Mondulkiri Province, eastern Cambodia, suggesting *Ahaetulla prasina* occurs in suitable habitat throughout Cambodia.

Amphiesma boulengeri, Gressitt, 1937

Material examined: LSUHC 9339: Camp II, 7 July.

A single adult male (SVL 493.4 mm) matches a series of six specimens from Phnom Aural Wildlife Sanctuary in the southeastern Cardamom Mountains that were reported as *A. cf. khasiensis* by Grismer *et al.* (2007a). Our specimen agrees with the diagnosis of David *et al.* (2007) in having a distinct white narrow streak beginning from the posterior lower margin of the eye and running along the posterior three supralabials to the nuchal region and not forming a distinct chevron; a light dorsolateral stripe with distinct lighter spots; light coloured stripe running across the darkened margin of the ventral scales forming distinct dark brown square blotches ventrolaterally; two light elongated spots on parietal scales, which are distinct in all juveniles from Phnom Aural, but absent in adult specimens from Dalai; two preoculars; three postoculars; nine supralabials; and 19 longitudinal scale rows at midbody. LSUHC 9339 has 165 ventral scales compared to 163–176 reported by Grismer *et al.* (2007a) and 139–156 reported by David *et al.* (2007). The tail had 36 subcaudal scales, but was broken.

The specimen was found at night on the edge of a boulder beside a slow, rocky stream. When approached, it retreated into the shallow water beneath the boulder.

Boiga cyanea (Duméril, Bibron & Duméril, 1854)

Material examined: LSUHC 9327: Camp I, 6 July; LSUHC 9334: Camp II, 7 July.

One juvenile female (SVL 537.1 mm) and a juvenile male (SVL 666.8 mm) agree with the diagnosis of this species by Taylor (1965) and descriptions by Stuart *et al.* (2006) from Keo Seima in Mondulkiri Province, Stuart & Emmett (2006) from the Central Cardamom Mountains, and Grismer *et al.* (2008a) from Phnom Samkos Wildlife Sanctuary, in possessing eight supralabials; 11–12 infralabials; one preocular; two postoculars; 21 scale rows at midbody; enlarged ventral scales; 244–250 ventral scales; and 132–140 paired subcaudal scales. The juvenile female LSUHC 9327 is light brown above and the male LSUHC 9334 is grey to blue brown anteriorly and light brown posteriorly.

Table 2 Checklist of herpetofauna known from Dalai Mountain in Phnom Samkos Wildlife Sanctuary (PSWS). Asterisks (*) indicate species new to science. Status follows IUCN (2010) for species that have been evaluated: LC = Least Concern; NT = Near Threatened; DD = Data Deficient; VU = Vulnerable.

	New record for PSWS	In Cambodia, restricted to Cardamom Mts	Status
APODA (CAECILIANS)			
Ichthyopidae			
* <i>Ichthyophis</i> sp.	Yes	Yes	-
ANURA (FROGS)			
Dicroglossidae			
<i>Limnonectes gyldestolpei</i> (Anderson, 1916)	No	Yes	LC
<i>Quasipaa fasciculispina</i> (Inger, 1970)	No	Yes	VU
Megophryidae			
<i>Megophrys auralensis</i> Ohler, Swan & Daltry, 2002	Yes	Yes	DD
Ranidae			
<i>Hylarana faber</i> (Ohler, Swan & Daltry, 2002)	No	Yes	LC
<i>Hylarana mortenseni</i> (Boulenger, 1903)	No	Yes	NT
Rhacophoridae			
<i>Theloderma asperum</i> (Boulenger, 1886)	Yes	No	LC
<i>Rhacophorus bisacculus</i> Taylor, 1962	No	Yes	LC
<i>Philautus parvulus</i> (Boulenger, 1893)	Yes	Yes	LC
SQUAMATA (LIZARDS AND SNAKES)			
Agamidae			
<i>Acanthosaura cardamomensis</i> Wood, Grismer, Grismer, Neang, Chav & Holden, 2010	No	Yes	-
<i>Calotes emma</i> Gray, 1845	No	No	-
<i>Draco maculatus</i> (Gray, 1845)	No	Yes	LC
<i>Draco taeniopterus</i> Günther, 1861	No	Yes	LC
Dibamidae			
* <i>Dibamus</i> sp.	Yes	Yes	-
Gekkonidae			
<i>Cnemaspis chanthaburiensis</i> Bauer & Das, 1996	No	Yes	-
<i>Cyrtodactylus intermedius</i> (Smith, 1917)	No	Yes	-
Scincidae			
<i>Dasia olivacea</i> (Gray, 1838)	Yes	Yes	LC
<i>Scincella reevesii</i> (Gray, 1838)	No	Yes	-
* <i>Lygosoma</i> sp.	Yes	Yes	-
Colubridae			
<i>Ahaetulla prasina</i> (Reinwart in Boie, 1827)	No	No	LC
<i>Amphiesma boulengeri</i> (Gressitt, 1937)	No	Yes	-
<i>Boiga cyanea</i> (Duméril, Bibron & Duméril, 1854)	No	No	-
<i>Rhabdophis chrysargos</i> (Schlegel, 1837)	No	No	-
Viperidae			
<i>Viridovipera</i> cf. <i>vogeli</i> (David, Vidal & Pauwels, 2001)	No	No	-

The female was collected at night in bushes 3 m above the ground, and the male was found at night crawling on tree branches 5 m above the ground. This is a common species that occurs from North-east Cambodia (Stuart *et al.*, 2006; Bezuijen *et al.*, 2009) and extends to the Southwest as well (Stuart & Emmett, 2006; Grismer *et al.*, 2008a), suggests *Boiga cyanea* occurs in similar habitats throughout Cambodia.

Rhabdophis chrysargos Schlegel, 1837

Material examined: LSUHC 9310: Camp I, 6 July.

A single juvenile male (SVL 163.7 mm) matches the diagnosis by Taylor (1965) of Thai specimens, the descriptions by Stuart *et al.* (2006) of specimens from Monduliri Province in northeastern Cambodia; Stuart & Emmett (2006) of material from the Central Cardamom Mountains, and the description of this species by Grismer *et al.*, (2007a) from Phnom Aural Wildlife Sanctuary, in having nine supralabials, the fourth, fifth and six touching the orbits; three postoculars (but four were recorded by Grismer *et al.*, 2007a); 18 keeled dorsal scale rows at midbody; two anterior temporals; 154 ventral scales; and 93 subcaudal scales. In preservative, the specimen has a pair of light spots on parietal scales; white nuchal V-shaped band connected to the corners of the mouth; olive–brown dorsum with short white transverse bars on upper flanks; white supralabials and infralabial and white venter with small black lateral spots.

This specimen was found during the day crossing a logging road 4 m from a fast-moving stream. One specimen was seen crawling across the forest floor near the peak of the mountain, but escaped capture. *Rhabdophis chrysargos* has been reported to occur from northeastern Cambodia (Stuart *et al.*, 2006) to the Cardamom Mountains (e.g. Saint Girons, 1972; Stuart & Emmett, 2006; Grismer *et al.*, 2007a), suggesting that *R. chrysargos* is found in suitable habitat throughout Cambodia.

Viperidae

Vividovipera cf. *vogeli* (David, Vidal & Pauwels, 2001)

Material examined: LSUHC 9356: Camp II, 8 July.

A single adult female (SVL 640 mm) has two (L) and three (R) preoculars; two postoculars; enlarged internasals separated by one scale; 10L/11R supralabials, the first separated completely from the nasal scale, the third in contact with subocular, the fourth separated from subocular by one scale; 13L/12R infralabials; 21 dorsal scale rows, strongly keeled; 22 scale rows posterior to head; 13 scale rows anterior to vent; 172 ventral scales; and a white ventrolateral stripe running along the lower part of the first dorsal scale row. This specimen had 42 pairs of subcaudal scales, but the tail was broken. These characters agree with both *Vividovipera stejnegeri* and *V. vogeli*, which are morphologically similar except for colouration (see David *et al.*, 2001; Malhotra & Thorpe, 2004), which could not be assessed in the preserved female. Swan & Daltry (2002), Stuart & Emmett (2006) and Grismer *et al.* (2007a) reported *V. vogeli* from the Eastern and Central Cardamom Mountains, and David *et al.* (2001) reported this species from Chanthaburi and Trat Provinces in southeastern Thailand, which are relatively close and in the same mountain range. *Vividovipera stejnegeri*, on the other hand, occurs in northeastern Thailand and northeastern Vietnam. Thus we refer the Dalai Mountain specimen to *V. cf. vogeli*.

This specimen was collected at night on branch of tree near the stream bank, 3 m above the ground.

Discussion

Our results include four new records (*Megophrys auralensis*, *Philautus parvulus*, *Theloderma asperum*, and *Dasia olivacea*) for Phnom Samkos Wildlife Sanctuary plus three previously undescribed taxa (*Ichthyophis* sp., *Lygosoma* sp. and *Dibamus* sp.). This study has increased the sanctuary's known species richness to 36 amphibian and 78 reptile species.

The three taxa new to science are currently being described and may prove to be endemic to Cambodia's Cardamom Mountains. If so, this

would increase the number of endemic herpetofaunal species in the Cardamom Mountains to nine: the other six being *Lycodon cardamomensis* (Daltry & Wüster, 2002), *Megophrys auralensis*, *Hylarana faber*, *Philautus cardamonus* (Ohler et al., 2002), *Chirromantis samkosensis* (Grismer et al., 2007b) and *Cnemaspis neangthyi* (Grismer et al., 2010). The new species would also increase the number of Cambodian endemics to twelve; including *Ophryophryne synoria*, *Leptobrachium mouhoti* (Stuart et al., 2006) and *Leptolalax melicus* (Rowley et al., 2010), which have not been found outside of the country.

The reports of *Megophrys auralensis* by Ohler et al. (2002) and Grismer et al. (2007a) from Phnom Aural Wildlife Sanctuary and by Stuart & Emmett (2006) from the Central Cardamom Mountains and the present report suggest this amphibian occurs in similar habitats throughout the mountain range. The same may be true of *Dasia olivacea* (first reported from the Central Cardamom Mountains by Stuart & Emmett, 2006), but this lizard is difficult to detect due to its cryptic, arboreal lifestyle.

Table 2 shows that out of the 24 species known to inhabit the Dalai Mountain, 18 species (eight species of frogs and ten species of reptiles) have, within Cambodia, been found only in the Cardamom Mountains (Grismer et al., 2008b; Wood et al., 2010; Neang et al., in review). The other six species (one frog: *Theloderma asperum* and five reptiles: *Calotes emma*, *Ahaetulla prasina*, *Boiga cyanea*, *Rhabdophis chrysargos*, *Vividovipera cf. vogeli*) have a broader distribution and are known from both the Cardamom Mountains and northeastern Cambodia (Stuart et al., 2006; Grismer et al., 2008b; Bezuijen et al., 2009).

The growing number of new taxa and records and the presence of species listed by IUCN as Data Deficient (*Megophrys auralensis*), Vulnerable (*Quasipaa fasciculispina*) and Near Threatened (*Hylarana mortenseni*) from the Cardamom Mountains, underscore the importance of continuing research in the area. The fact that many of the recently recorded species appear to have restricted distribution ranges suggests that these should be accorded priority.

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[Editor's note:- Ratana Che and Sam Han kindly assisted with translating the abstract of this paper into Khmer].

Recent theses

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

Impacts of ecotourism in the Tonle Sap Biosphere Reserve: a case study in Prek Toal Core Area, Battambang Province

Long Kheng

Many definitions have been developed for ecotourism, and requirements for sustainable development generally dictate that this should create environmental benefits and support the well-being of local communities. Ecotourism is believed to be the fastest growing segment of the world tourism market, with travellers willing to pay 8.5% more for related travel services and products.

The Prek Toal Core Area in the Tonle Sap Biosphere Reserve has high ecotourism potential due to a variety of attractions, which include colonies of globally threatened water birds and pristine areas of flooded forest. Although ecotourism activities began at the site in 1999, little is known about their success in changing attitudes to wildlife conservation and improving local livelihoods. Understanding such issues is crucial to improving ecotourism management at Prek Toal. As a result, the aim of my study was to assess the impacts of ecotourism at the site and explore how future ecotourism activities might be improved through a review of stakeholder perceptions, which included extensive interviews with local communities, management authorities, foreign visitors and ecotourism operators.

The majority of respondent groups ranked ecotourism services and facilities at Prek Toal as

being “fair” to “good” and supported their expansion in the core area and to other sites in the Tonle Sap region. Most respondents agreed that ecotourism activities had directly or indirectly benefitted local communities and conservation at the site. At present, 38 villagers are employed as rangers at Prek Toal and over 100 families have benefited from ecotourism activities. Most respondents (76-87%) also believed that ecotourism had led to reduced hunting and bird egg-collection because local people wanted to retain wildlife to attract visitors and tourists. According to interviews, the number of visitors to the site increased annually up to 2009, and declined thereafter due to the global economic crisis. Notwithstanding this, an increase to 600-1,000 foreign visitors per year was considered possible.

Although ecotourism management at Prek Toal was considered “fair” to “good”, certain facilities and services at the site require improvement to reach international standards. Appropriate strategies and mechanisms need to be developed to involve more local people in ecotourism services such as transportation and accommodation. In addition, a long-term plan is needed to minimize negative ecotourism impacts and maximize revenues available for conservation and improving the wellbeing of local communities.

Monitoring of law enforcement, illegal activity and large mammals in Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, Southwest Cambodia

Seng Rathea

Phnom Samkos Wildlife Sanctuary is in Southwest Cambodia and supports exceptionally rich biodiversity with many endemic animals and plants of global conservation importance. In common with many protected areas in Cambodia, ranger teams have been established to combat illegal activities

at the site. Although the rangers have routinely recorded data on natural resource offences at the sanctuary for a number of years, longer term trends at the site have remained unclear due to lack of analysis.

As a consequence, my research aimed to (i) evaluate law enforcement activities undertaken by rangers at Phnom Samkos; (ii) ascertain changes in the scale and scope of illegal activities occurring at the site; and (iii) analyse changes in the abundance of large mammals in selected areas. Ranger data from 2005 to 2009 and large mammal monitoring data from 2007 to 2009 provided the main source of information. A variety of statistical tests were employed in this analysis, including regression models, chi-squared tests, Pearson product-moment correlations and chi-square analysis of contingency tables.

The study found that ranger patrols had increased significantly over time, with a mean of 34 additional patrols per year over the five-year period. Four main kinds of illegal activity were apparent: logging of luxury timber, land encroachment, wildlife poaching and sassafras oil extraction. Each year, the number of chainsaws and volume of

luxury timber confiscated decreased, while quantities of sassafras oil and wildlife traps confiscated and the numbers of offenders arrested increased. First offenders were typically required to sign a contract pledging to stop their illegal activities, or, in cases of serious crime, were sent to court for sentencing. Results also suggest that the abundance of Asian elephant *Elephas maximus*, banteng *Bos javanicus*, gaur *Bos gaurus*, red muntjac *Muntiacus muntjak* and sambar *Cervus unicolor* declined at monitoring sites between 2007 and 2009.

I conclude that existing law enforcement efforts are not fully effective in combating illegal activities in Phnom Samkos Wildlife Sanctuary because (i) current ranger numbers are insufficient to properly police the site; (ii) the human population is increasing rapidly in the area and placing ever greater demands on natural resources; and, (iii) increased ranger patrols do not appear to have led to a major decrease in illegal activities. However, there seems little doubt that ranger activities have significantly reduced local rates of natural resource degradation and loss. Without their protection, the biodiversity of Phnom Samkos Wildlife Sanctuary would be declining much faster.

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. The 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 or report that you wish to be listed in the next issue, please send an electronic copy, summary or Internet link to: Editor.CJNH@gmail.com

New species and taxonomic reviews

Deng, M., Zhou, Z.K. & Coombes, A. (2010) Lectotypification and new synonymy in *Quercus* subg. *Cyclobalanopsis* (Fagaceae). *Novon - a Journal for Botanical Nomenclature*, **20**, 400-405.

The Cambodian oak *Quercus cambodiensis* Hickel & A. Camus, described from the Elephant Mountains, is not a valid species, but is instead a junior synonym of *Q. langbianensis* Hickel & A. Camus. *Quercus langbianensis* is widely distributed in Indochina and is one of the dominant species in broad-leaved evergreen forests. Author: zhouzk@mail.kib.ac.cn; Online: <http://hua.huh.harvard.edu/china/novon/novo-20-4-400.pdf>

Francis, C.M., Borisenko, A.V., Ivanova, N.V., Eger, J.L., Lim, B.K., Guillén-Servent, A., Kruskop, S.V., Mackie, I. & Hebert, P.D.N. (2010) The role of DNA barcodes in understanding and conservation of mammal diversity in Southeast Asia. *PLoS ONE* **5**, e12575. doi:10.1371/journal.pone.0012575.

DNA barcodes were obtained from bats throughout Southeast Asia, including Cambodia, representing 165 recognized species. Many of the currently recognized species were found to contain a number of distinct genetic lineages, suggesting the presence of unrecognised taxa. The authors concludes that the number of mammal species in the region may have been underestimated by at least 50%, with higher levels of endemism than previously recognized. Author: charles.francis@ec.gc.ca;

Online: http://www.ecbol.org/docs/Publications/francis_et_al_2010.pdf

Gephart, N., Blate, G., McQuistan, C. & Thompson, C. (2009) *New Blood: Greater Mekong New Species Discoveries 2009*. WWF Greater Mekong, Vientiane, Lao PDR.

This report contains a checklist of 147 new species discovered in the Greater Mekong Region in 2009, adding to the 1,200 identified since 1999. Of these, three were described in Cambodia: the plants *Aeschynanthus cambodiensis* Middleton, *Dasymaschalon acuminatum* Wang & Saunders, and *Nepenthes bokorensis* Mey. Online: http://assets.panda.org/downloads/greater_mekong_species_report_web_version_report_1_oct_2010.pdf [*Editor's note:- These statistics do not include invertebrates, and at least one new insect was described in Cambodia in 2009: the cicada Qurana ggoma (cited in the Cambodian Journal of Natural History volume 2010, issue 1)*].

Hartmann, T., Hun C., Handschuh, M., Nguyen Q.T. & Böhme, W. (2009) First record of *Tropidophorus cocincinensis* Duméril and Bibron, 1839, from Cambodia. *Herpetology Notes*, **2**, 87-89.

The first record of the water skink *Tropidophorus cocincinensis* from Cambodia (Phnom Kulen National Park, Siem Reap Province). This lizard was previously known from Vietnam, Laos and Thailand. This discovery increases the number of known water skink species in Cambodia to two: the other being *T. microlepis*. Author: t.hartmann.zfmk@uni-bonn.de

Hartmann, T., Nguyen Q.T., Ohler, A., Hun C., Handschuh, M. & Böhme, W. (2010) Rediscovery of the rare Thai scincid lizard *Sphenomorphus lineopunctulatus* Taylor, 1962: new country records from Cambodia and Laos and a redescription. *Russian Journal of Herpetology*, **17**, 105-109.

The first report of the line-spotted forest skink in Cambodia (Phnom Kulen National Park, Siem Reap Province) and Laos. This lizard was previously known only from Thailand. This paper provides a fuller description of this species and new observations on its natural history. Author: t.hartmann.zfmk@uni-bonn.de

Hinsley, A. (2010) Two new *Dendrobium* records in Cambodia. *The Orchid Review*, **118**, 96-97.

The first records of the orchids *Dendrobium berco glossum* and *D. friedricksianum* from Cambodia. Both species were discovered in the Central Cardamoms Protected Forest and are occasionally kept as ornamental house plants by local people. Author: amy.hinsley@fauna-flora.org

Kosterin, O.E. (2010) *A Glance at the Odonata of the Cambodian Coastal Mountainous Regions: End of Dry Season in 2010*. Report No 29, International Dragonfly Fund, UK.

This 75-page report describes a rapid survey of the coastal provinces of Koh Kong, Kampong Saom, Kampot and Kep. Fifty-one species of dragonflies and damselflies were identified, including 14 new national records: *Neurobasis chinensis*, *Dysphaea gloriosa*, *Euphaea masoni*, *Onychargia atrocyana*, *Copera marginipes*, *C. vittata*, *Prodasineura autumnalis* *P. verticalis sensu* Asahina, 1983, *Lathrecista asiatica*, *Orthetrum chrysis*, *Rhyothemis obsolescens*, *Tramea transmarina euryale*, *Zygonyx iris malayana*, and *Zyxomma petiolatum*. The author also collected two species that may be new to science, in the genera *Burmagomphus* and *Microgomphus*. Author: kosterin@bionet.nsc.ru

Mabberley, D.J. (2010) The species of *Citrus* (Rutaceae) with pinnate leaves. *Blumea*, **55**, 73-74

The plant genus *Feroniella* is formally transferred to *Citrus*, and Cambodia's *Feroniella oblata* Swingle

(1913) should henceforth be known as *Citrus lucida*. This species also occurs in Laos, Thailand, Java and possibly Vietnam. Author: d.mabberley@kew.org; Online: <http://docserver.ingentaconnect.com/deliver/connect/nhn/00065196/v55n1/s9.pdf?expires=1294004348&id=60492636&titleid=75002419&accname=Guest+User&checksum=2ADF2E8B59B92D59160D80B4B6DCF300>

Malley, R. & Nuss, M. (2010) Phylogeny and nomenclature of the box tree moth, *Cydalima perspectalis* (Walker, 1859) comb. n., which was recently introduced into Europe (Lepidoptera: Pyraloidea: Crambidae: Spilomelinae). *European Journal of Entomology*, **107**, 393-400.

This paper notably includes new records of the following moths in Cambodia (Phnom Samkos Wildlife Sanctuary, Cardamom Mountains): *Agrioglypta eurytusalis*, *Cydalima laticostalis*, *Glyphodes onychinalis* and *Sisyrophora pfeifferae*. Author: richard.mally@senckenberg.de; Online: <http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.167.6025&rep=rep1&type=pdf>

Maxwell, J.F. (2009) Vegetation and vascular flora of the Mekong River, Kratie and Steung Treng Provinces, Cambodia. *Maejo International Journal of Science and Technology*, **3**, 143-211.

During a botanical survey of the islands in the Mekong River between Kratie and Stung Treng, 690 species (683 vascular plants and seven bryophytes) were collected, including one species new to science (provisionally named *Amorphophallus hemicyptus* Hettterscheid) and 23 new country records: *Acacia leucophloea*, *Desmodium flexuosum*, *Indigofera zollingeriana*, *Rhodamnia cinerea*, *Brachystelma kerrii*, *Diospyros oblonga*, *Ardisia attenuata*, *Calcareoboa bonii*, *Kaempferia siamensis*, *Typhonium laoticum*, *Brachycorythis helferi*, *Habenaria viridiflora*, *Liparis rheedii*, *Liparia siamensis*, *Nervilia punctata*, *Nervilia calcicola*, *Vandopsis gigantea*, *Fimbristylis brunneooides*, *F. jucunda*, *Murdannia discreta*, *Amorphophallus koratensis*, *Cryptocoryne crispitula* and *Hemisorghum mekongense*. In addition, "some of the unidentified species collected may perhaps be new". The vegetation was classified into six river-

ine zones and four terrestrial classes (facies). Riparian habitats were found to be mostly intact, but the terrestrial vegetation was often destroyed or degraded, potentially endangering the livelihoods of local people. Detailed descriptions of all vegetation types, a database, and photographs are contained in this report. Author: scopplrn@chiangmai.ac.th; Online: <http://www.mijst.mju.ac.th/vol3/143-211.pdf>

McLeod, D.S. (2010) Of Least Concern? Systematics of a cryptic species complex: *Limnodynastes kuhlii* (Amphibia: Anura: Dicroglossidae). *Molecular Phylogenetics and Evolution*, **56**, 991-1000.

A mitochondrial DNA study of "*Limnodynastes kuhlii*", which occurs throughout Southeast Asia including Cambodia, suggests that this common frog is actually a species complex that contains a number of new, undescribed species. However, this paper does not attempt to name or describe the new taxa. (The title refers to *Limnodynastes kuhlii* being classed as Least Concern on the IUCN Red List). Author: dsmcleod@ku.edu

Mey, E. (2010) The *Pedicinus* species (Insecta, Phthiraptera, Anoplura, Pedicinidae) on douc langurs (*Pygathrix* spp.). *Vietnamese Journal of Primatology*, **4**, 57-68.

All three species of Southeast Asian douc langur monkeys harbour unique parasitic lice. In Cambodia, *Pedicinus tongkinensis* parasitises the red-shanked douc *Pygathrix nemaeus*, while the black-shanked douc *P. nigripes* is host to the louse *Pedicinus atratulus*, described in this paper as a new species. Author: mey-rudolstadt@t-online.de; Online: http://zgf.de/download/1229/Vietnamese+Journal+of+Primatology+4_low.pdf#page=3

Mey, F.S., Catalano, M., Clarke, C., Robinson, A., Fleischmann, A. & McPherson, S. (2010) *Nepenthes holdenii* (Nepenthaceae), a new species of pyrophytic pitcher plant from the Cardamom Mountains of Cambodia. In *Carnivorous Plants and Their Habitats: Volume 2* (ed. S.R. McPherson), pp. 1306-1331. Redfern Natural History Productions, Poole, UK.

Describes and illustrates a new species of pitcher plant. *Nepenthes holdenii* was named after Cambodia-based biologist and photographer Jeremy Holden, who first observed the plant in Phnom Samkos Wildlife Sanctuary, and it may be endemic to Cambodia's Cardamom Mountains. This paper also presents a key to the nine known species of the "*Nepenthes thorelii* aggregate" in Indochina. Author: meyrfr@yahoo.fr; Online: <http://www.carnivorous-plants.it/desc.holdenii.pdf> [*Photographs and descriptions of all known pitcher plants in Cambodia are presented by Mey in the current issue of the Cambodian Journal of Natural History*].

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

Describes a new megophryid frog, *Leptolalax melicus*, from the Kon Tum Plateau in Northeast Cambodia. All specimens of the new species were found near rocky streams in evergreen forest between 650 and 850 metres above sea level. The authors suggest the new species should be classified as Data Deficient. Author: Jodi.Rowley@austmus.gov.au

Tarasov, S., Krikken, J. & Huijbregts, J. (2010) The Indochinese members of the *Onthophagus* (*Parascatonomus*) *aurifex* species group (Coleoptera: Scarabaeidae), with the description of a new species. *Zootaxa*, **2490**, 63-68.

This paper reviews the dung beetles within the *Onthophagus* (*Parascatonomus*) *aurifex* species group in Indochina, and describes a new species, *Onthophagus alexeevi*, from southern Cambodia (Sihanoukeville) and western Thailand. The Cambodian specimens were collected in disturbed forest using pitfall traps baited with dead fish. Author: sergxf@yandex.ru; Online: <http://www.mapress.com/zootaxa/2010/f/zt02490p068.pdf>

Telepova-Texier, M. (2009) *Acampe hulae* Telepova (Orchidaceae), une nouvelle espèce du Cambodge et du Laos. *Adansonia*, **31**, 267-272. [In French].

Describes *Acampe hulae* Telepova, a new species of orchid from Cambodia and Laos. Author: telepova@

mnhn.fr; Online: http://www.mnhn.fr/museum/front/medias/publication/22731_a09n2a3.pdf

The Plant List (2010) *The Plant List, Version 1*. [Http://www.theplantlist.org/](http://www.theplantlist.org/) [Accessed 30 December 2010].

Developed by the Royal Botanic Gardens, Kew and Missouri Botanical Garden, *The Plant List* is a new working compendium of the world's plants. Version 1 is intended to contain all known species of vascular plants (flowering plants, conifers, ferns and their allies) and bryophytes (mosses and liverworts). The online searchable checklist provides the accepted scientific names for most species, with links to their synonyms. Remarkably, by the end of 2010, the compilers had rejected 477,601 plant species names as synonyms, thereby slashing the total number of recognized plant species worldwide. To date, only 298,900 plant species have been accepted as valid. [*This ongoing review is bound to significantly affect the names and total number of plant species recognized in Cambodia - Ed.*].

Tippery, N.P., Les, D.H., Regalado Jr, J.C., Averyanov, L.V., Vu N.L. & Raven, P.H. (2009) Transfer of *Villarsia cambodiana* to *Nymphoides* (Menyanthaceae). *Systematic Botany*, **34**, 818-823.

Villarsia cambodiana is formally renamed *Nymphoides cambodiana*. This semi-aquatic flowering plant is considered rare, putatively due to loss of natural wetlands, but has been reported to occur with rice crops in Cambodia. Author: nicholas.tippery@uconn.edu; Online: http://www.eeb.uconn.edu/people/les/Manuscript_Files/Syst_Bot_34%28818%29%5B2009%5D.pdf

Van N.T., Mootnick, A.R., Vu N.T., Nadler, T. & Roos, C. (2010) A new species of crested gibbon, from the central Annamite mountain range. *Vietnamese Journal of Primatology*, **4**, 1-12.

The southern white-cheeked gibbon *Nomascus siki* is split into two taxa based on genetic, acoustic and morphological differences, and the second form is described as a new species, *N. annamensis*. This discovery brings the total number of crested gibbon species to seven, all endemic to Indochina. Cambodia therefore has two crested gibbon species: the

northern buff-cheeked gibbon *N. annamensis* in the Northeast, and the buff-cheeked gibbon *N. gabrielae* in the East, separated by the Srepok River. Adult females of both species look almost identical, while adult males may be distinguished by the darker cheek patches of *N. annamensis*. The calls of the two species also differ. Author: vanthinhngoc@yahoo.com; Online: http://zgf.de/download/1229/Vietnamese+Journal+of+Primatology+4_low.pdf#page=3

Wang, J., Chalermglin, P. & Saunders, R.M.K. (2009) The genus *Dasymaschalon* (Annonaceae) in Thailand. *Systematic Botany*, **34**, 252-265.

As part of a taxonomic revision of this plant genus in Thailand, a new species has been described from Thailand and Cambodia: *Dasymaschalon acuminatum* Wang & Saunders. The Annonaceae is commonly called the custard apple family. Author: saunders@hkucc.hku.hk

Guides and monographs

Das, I. (2010) *A Field Guide to the Reptiles of South-East Asia: Myanmar, Thailand, Laos, Cambodia, Vietnam, Peninsular Malaysia, Singapore, Sumatra, Borneo, Java, Bali*. New Holland Publishers, London, UK.

For the first time, descriptions and natural history notes are given to all the >1,000 reptile species that have been recorded from this region, together with colour illustrations of 700 species. This 376-page book is now widely on sale for around US\$50. Author: hamadryad2004@hotmail.com

Biodiversity inventories

Beunen, R. & Louwsma, M. (2010) *Vietnam & Cambodia, 15 January–12 February 2010*. Unpublished report, AVG-W, The Netherlands.

Illustrated report containing a checklist of 127 species of birds identified during a private tour to Kampong Thom, Siem Reap, Sihanoukeville, Kratie and Phnom Penh. Author: raoulbeunen@gmail.com; Online: http://www.travellingbirdier.com/tripreports/reports/100801171050_birding_trip_report.pdf

van Bochove, J.H., Vitlin, N., Bush, V. & Raines P. (2010) Initial results from scientific surveys conducted on Cambodia's fringing reefs. *Scientific poster attributed to Coral Cay Conservation [no conference details provided]*.

Baseline surveys of the coral reef resources around various offshore islands in Preah Sihanouk Province found hard coral cover was approximately 24%. Coral cover were dominated by massive *Porites* sp. (50% cover) and *Diploastrea heliopora*, followed by *Pavona decussata*, *Favia* spp., *Galaxea* spp., *Favites* spp., *Pocillopora* spp., *Goniopora* or *Alveopora* spp., *Lobophyllia* spp., *Podabocia* spp., *Echinopora* spp., *Turbinaria* spp., *Montipora foliose*, *Porites rus* and *Plerogyra* spp. Anthropogenic impacts were generally low, but the populations of certain economically-valuable fish appeared to have been suppressed and high levels of sedimentation were recorded at all survey sites. In May 2010, water temperatures exceeded 34 °C, causing significant bleaching (from 31-45% in shallow-water sites). The authors recommend developing a management plan to address the significant threats of coastal development to Cambodia's coral reefs. Online: http://www.coral-cay.org/component/option,com_docman/task,doc_download/gid,363/Itemid,393/

Dreyer, N.P. (2010) *Cambodia, January 2010*. Unpublished report, Fuglebjerg, Denmark.

Illustrated report containing records of over 200 species of birds, plus mammals, identified during a private tour to Siem Reap, Prek Toal, Ang Trapeang Thmor, Tmatboey, Preah Vihear Protected Forest, Kampong Thom, Kratie and the Seima Biodiversity Conservation Area. Author: npd@dreyerfoto.dk; Online: <http://dreyerfoto.dk/index/wp-content/uploads/cambodia1.pdf>

Grindley, M.E. (2009) *Rapid Field Survey Report 2009: Preah Kieu, Lomphat Wildlife Sanctuary*. General Department of Administration for Nature Conservation and Protection, Phnom Penh, Cambodia, People Resources and Conservation Foundation, Amherst, USA, and BirdLife International, Hanoi, Vietnam.

A brief survey concluded that Preah Kieu still supports "an abundance of" banteng, Annamese silvered langur, bears and other globally threatened species. A possible tiger footprint was also found. This evergreen forest is an important source of forest products for local villagers, and signs of hunting and logging were observed. Author: mark.grindley@prcfunion.org; Online http://www.prcf-alliance.org/cambodia/cambodia_pdf/PD09002_Rapid_Biodiversity_Survey_Preah_Kieu_March_2009_EN.pdf

Kang, B., Perrett, L., Li, Y. & Daming, H.E. (2010) Are the fish of the upper and lower Mekong interconnected? *Chinese Journal of Oceanology and Limnology*, **27**, 400-407.

Of the 162 fish species in the Upper Mekong and the 869 species in the Lower Mekong, 61 species are common to both groups. Eight cascade dams are currently planned or under construction on this river, of which the Mengsong Dam (on the border of China and Laos) poses the greatest threat to migratory species from the Lower Mekong. Author: binkang@ynu.edu.cn; Online: <http://www.springerlink.com/content/p726754u7rjl44g1/fulltext.pdf>

Lan, W., Li, H., Wang, W.-D., Katayama, Y. & Gu, J.-D. (2010) Microbial community analysis of fresh and old microbial biofilms on Bayon Temple sandstone of Angkor Thom, Cambodia. *Microbial Ecology*, **60**, 105-115.

Using genetics to identify the taxa, this study investigated the microbial diversity of the fresh and old biofilms on the sandstone surfaces of the Bayon Temple. Organisms were clustered into 11 bacterial, 11 eukaryotic and two archaeal divisions (Acidobacteria, Actinobacteria, Bacteroidetes, Cyanobacteria, Proteobacteria; Alveolata, Fungi, Metazoa, Viridiplantae; Crenarchaeote, and Euyarchaeota). The old biofilm was very similar to the newly formed biofilm in terms of its bacterial composition, but differed in its eukaryotes. This study has implications for understanding microbial colonisation and succession on exposed sandstone. Author: jdgu@hkucc.hku.hk; Online: <http://www.springerlink.com/content/f4921722v722m15q/fulltext.pdf>

Lithner, S. (2010) *Birds, mammals, amphibians and reptiles seen in Thailand and Cambodia Jan 23 – Feb 11 2010*. Unpublished report, Karlshamn, Sweden.

Illustrated report containing 170 species of birds, plus a smaller number of mammals and reptiles identified in Cambodia during a private tour to Siem Reap, Kampong Thom grasslands, Kulen Promtep Wildlife Sanctuary, Ang Trapeang Thmor, and Prek Toal. Author: slit@lithner.se; Online: <http://www.club300.se/Files/TravelReports/Thailand%20and%20Cambodia%202010.pdf>

Marsh, S.T., Brummitt, N.A., de Kok, R.P.J. & Utteridge, T.M.A. (2009) Large-scale patterns of plant diversity and conservation priorities in South East Asia. *Blumea*, **54**, 103-108.

Distribution data for all plant genera in Indochina, Malesia and the Pacific were compiled from regional floras and herbarium specimens at the Royal Botanic Gardens, Kew. Over this wide geographical area, Cambodia was identified among the *lowest* plant conservation priority areas due to its relatively low plant diversity (679 genera, none endemic) and relatively low threat from human activities. In terms of its plant genera, Cambodia is most similar to Laos. Author: R.Brummitt@rbgkew.org.uk

Ohtaka, A., Narita, T., Kamiya, T., Katakura, H., Araki, Y., Im S., Chhay R. & Tsukawaki, S. (2010) Composition of aquatic invertebrates associated with macrophytes in Lake Tonle Sap, Cambodia. *Limnology*, doi: 10.1007/s10201-010-0330-4.

Aquatic invertebrates that live on submerged plants are an important prey for fish and other higher predators. Invertebrate communities were studied in different parts of the Tonle Sap Lake, with particular attention to the root systems of the free-floating, alien water hyacinth *Eichhornia crassipes*. Nine invertebrate phyla were collected, of which oligochaetes, shrimps, *Limnoperna* mussels and meiobenthic crustaceans were the most abundant. The Tonle Sap might be unique in its abundance of sessile animals, such as sponges, bryozoans and mussels, in its macrophyte-associated fauna. Water movement controls the dispersal of larvae and is therefore an important factor determining the dis-

tribution and abundance of the sessile animals. Author: ohtaka@cc.hirosaki-u.ac.jp

Sorongon, P.M.E. & Palomares, M.L.D. (2010) Non-fish vertebrates of the South China Sea. In *Marine Biodiversity of Southeast Asian and Adjacent Seas* (eds M.L.D. Palomares & D. Pauly), pp. 32-42. Fisheries Centre Research Report No. 18. Fisheries Centre, University of British Columbia, Vancouver, Canada.

The South China Sea has 102 non-fish vertebrates, according to data held on SeaLifeBase (www.sealifebase.org) and other sources. More than half of these (11 sea birds, 30 marine mammals and 20 marine reptiles) have been reported in Cambodian waters. Approximately 35% of the marine mammals, 8% seabirds and 78% reptiles in the South China Sea are either Data Deficient or have not yet been evaluated against IUCN categories of threat. The authors propose a strategy to fill in these information gaps and enlarge the SeaLifeBase database. Author: p.sorongon@cgiar.org; Online: <ftp://ftp.fisheries.ubc.ca/FCRR/18-3.pdf#page=36>

Sriphairoj, K., Klinbu-nga, S., Kamonrat, W. & Nanakorn, U. (2010) Species identification of four economically important Pangasiid catfishes and closely related species using SSCP markers. *Aquaculture*, **308**, S47-S50.

Single Stranded Conformation Polymorphism (SSCP) approaches were used to develop species-specific genetic markers for Pangasiidae fish, including specimens from Cambodia. A new marker, *PL8*, was shown to be effective at identifying most species, including *Pangasianodon gigas*, *P. hypophthalmus*, *Pangasius bocourti* and *P. larnaudii*. This could be a useful tool for identifying fish larvae or species in food products. Author: ssriphairoj@hotmail.com

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

Sixty species of freshwater cladocerans (commonly called water fleas) were recorded from the Great Lake and its adjacent waters. Four species - *Ceriodaphnia laticaudata*, *Bunops cf. tuberculatus*, *Ley-*

digia australis and *Chydorus cf. dentifer* - were new records for Southeast Asia. Cladocerans are especially diverse in shallow and heavily vegetated areas. Author: ohtaka@cc.hirosaki-u.ac.jp

Thi M.H.D, Lebbe, R.V., Nguyen H.P. & Nguyen Thi B.L. (2010) Indochinese bamboos: biodiversity informatics to assist the identification of "vernacular taxa". In *Tools for Identifying Biodiversity: Progress and Problems* (eds P.L. Nimis & R. Vignes Lebbe), pp. 207-211. EUT - Edizioni Universita di Trieste, Trieste, Italy.

This is a preliminary report from the Sud Expert Plantes project 'Indochina Bamboos' (2008-2010), which aims to update the bamboo flora of this region and publish free access keys, digital images and information on their traditional and economic use. Specimens have been collected in Vietnam, Laos and Cambodia and the software programme *Xper²* has been applied to compare and identify taxa based on morphological characteristics. Three new species have been detected so far (localities not given) and will be published separately. Online: <http://www.openstarts.units.it/dspace/bitstream/10077/3825/1/My%20Hanh%20Diep%20Thi%20et%20al,%20bioidentify.pdf>

Species ecology and status

Adamson, E.A.S., Hurwood, D.A., Baker, A.M. & Mather, P.B. (2009) Population subdivision in Siamese mud carp *Henicorhynchus siamensis* in the Mekong River basin: implications for management. *Journal of Fish Biology*, **75**, 1371-1392.

Spatial analysis of mitochondrial DNA fragment (*ATPase 6* and *8*) identified five distinct stocks: one in the Khlong River, Thailand, and four in the Mekong River. Populations in northern Laos and northern Thailand represent two independent stocks, while Thai tributaries and adjacent Mekong sites above the Khone Falls form a third stock. All sites below the Khone Falls constitute a single vast stock that includes Cambodia and the Mekong Delta. These results suggest *H. siamensis* is not as mobile as previously assumed and populations

need to be managed at finer spatial scales. Author: eas.adamson@gmail.com

Anonymous (2010) Increase in Cambodia's vultures gives hope to imperilled scavengers. *The Babbler*, **35**, 34.

Record numbers of vultures were counted in Cambodia's annual vulture census by the Cambodia Vulture Conservation Project in 2010, with nearly 300 individuals of three Critically Endangered species (white-rumped vulture *Gyps bengalensis*, slender-billed vulture *G. tenuirostris*, and Indian vulture *G. indicus*) counted at multiple sites across the Northern and Eastern Plains. Cambodia is therefore considered to be the only place where these species are increasing. Vulture populations have crashed elsewhere in Asia, primarily due to the use of the veterinary drug diclofenac in cattle, which poisons the birds when they scavenge on carcasses. Online: <http://birdlifeindochina.org/sites/default/files/Babbler%2035.pdf> [This article was taken from a press release by the Wildlife Conservation Society - Ed.].

Anonymous (2010) Largest ever white-shouldered Ibis count. *The Babbler*, **35**, 35.

A record count of 429 white-shouldered ibises *Pseudibis davisoni* was obtained in Cambodia in the 2010 census, suggesting the global population of this Critically Endangered species could exceed 500; larger than previously thought. Lomphat Wildlife Sanctuary, Ratanakiri Province, is especially significant, with up to 40% of the known population. White-shouldered ibises declined during the past century due to habitat loss and hunting, and the species is now extinct from Thailand, Myanmar, Vietnam, Malaysia and China. Online: <http://birdlifeindochina.org/sites/default/files/Babbler%2035.pdf> [This article, published in *The Babbler*, was originally taken from a public press release by the University of East Anglia].

Duong V, Blassdell, K., May, T.T., Sreyrath L., Gavotte, L., Morand, S., Frutos, R. & Buchy, P. (2010) Diversity of *Orientia tsutsugamushi* clinical isolates in Cambodia reveals active selection and recombination process. *Infection, Genetics and Evo-*

lution, 18 September 2010 [E-pub ahead of print].

Orientia tsutsugamushi is an obligate intracellular bacterium that commonly parasitises rodents and causes scrub typhus in humans, an often fatal disease. This pathogen is transmitted through the bites of infected larvae of trombiculid mites (genus *Leptotrombidium*). A genetics study of Cambodian *O. tsutsugamushi* found them to be highly clonal, probably because their transmission mode via mites generates repeated bottlenecks. Consequences for the epidemiology of scrub typhus are discussed. Author: dveasna@pasteur-kh.org

Lynam, A.J. (2010) Securing a future for wild Indochinese tigers: transforming tiger vacuums into tiger source sites. *Integrative Zoology*, **5**, 324-334.

Habitat loss and fragmentation, market-driven poaching and loss of prey have led to the disappearance of tigers *Panthera tigris* across most their former range. Decisions on where to focus conservation effort should consider both the vulnerability (likelihood of extinction) and irreplaceability (likelihood that the area contributes to regional conservation) of tiger sub-populations. This paper attempts to identify priority sites in Thailand, Laos, Peninsular Malaysia, Myanmar and Cambodia. Even though tigers are possibly extinct in Cambodia's Eastern Plains, this site is considered irreplaceable because it represents the region's largest (>10,000 km²) block of dry forest habitat. The author recommends re-introduction as the only option to enable tigers to recover here. Author: tlynam@wcs.org

Neilson, E. (2010) *The use of singing behaviour to model the occupancy of pileated gibbons (Hylobates pileatus) in the Cardamom Mountains, Cambodia*. MSc thesis, Oxford Brookes University, Oxford, UK.

A high density of pileated gibbons was found in the evergreen hill forests of Phnom Samkos Wildlife Sanctuary, and detection rates increased at higher elevations (>700 m). The gibbons tended to be less vocal (making fewer "great calls") in lower areas where there was increased human presence. The authors advise on how to mitigate the effects of

human activities on these Endangered primates. Author: ewneilson@googlemail.com

Nekaris, K.A.I., Shepard, C.R., Starr, C.R. & Nijman, V. (2010) Exploring cultural drivers for wildlife trade via an ethnoprimate approach: a case study of slender and slow lorises (*Loris* and *Nycticebus*) in South and Southeast Asia. *American Journal of Primatology*, **72**, 877-886.

Analysis of international records from the last 30 years reveals that the trade in live lorises exceeds the trade in their body parts, with Laos, Cambodia and Thailand being the main exporters. In Cambodia, there is widespread domestic trade in northern slow lorises *N. bengalensis* and pygmy lorises *N. pygmaeus* for traditional medicines. Attitudes towards wildlife trade vary among different ethnic groups, even within a country. Author: anekaris@brookes.ac.uk; Online: <http://onlinelibrary.wiley.com/doi/10.1002/ajp.20842/pdf>

Phan C. & Gray T.N.E. (2010) Status and habitat of yellow-cheeked gibbons (*Nomascus gabriellae*) in Phnom Prich Wildlife Sanctuary, Mondulkiri, Cambodia. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 79-89. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

Using acoustic survey methods, Phnom Prich Wildlife Sanctuary was estimated to contain approximately 195 family groups - the second largest population after the Seima Biodiversity Conservation Area (with >800 groups). The gibbons are at risk from habitat loss and degradation, but the authors consider these threats to be manageable. Author: phanchanna1@yahoo.com

Rawson, B. (2010) The status of Cambodia primates. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 17-25. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

Cambodia contains 11 species of primates, some of which occur in greater numbers than in neighbouring countries. The kingdom's populations of black-

shanked douc, yellow-cheeked crested gibbon and pileated gibbon are particularly significant. Most species are globally threatened and, in Cambodia, are at risk from hunting and habitat loss. Author: b.rawson@conservation.org

Rowley, J., Brown, R., Bain, R., Kusriani, M., Inger, R., Stuart, B., Wogan, G., Neang T., Chan-ard, T., Cao T.T., Diesmos, A., Iskandar, D.T., Lau, M., Ming, L.Z., Makchai, S., Nguyen Q.T. & Phimmachak, S. (2010) Impending conservation crisis for Southeast Asian amphibians. *Biology Letters*, **6**, 336-338.

The amphibians of Southeast Asia, including Cambodia, are severely threatened by high deforestation rates and harvesting. There is a clear need to identify and protect habitats that have high species diversity and/or are regionally distinctive. Long-term population monitoring, enhanced survey efforts, biological, ecological and taxonomic research, and evaluation of the impact of commercial trade are also needed. Author: jodi.rowley@austmus.gov.au; Online: <http://rsbl.royalsocietypublishing.org/content/6/3/336.full>

So T., Theilade, I. & Dell, B. (2010) Conservation and utilization of threatened hardwood species through reforestation: an example of *Azelia xylocarpa* (Kruz.) Craib and *Dalbergia cochinchinensis* Pierre in Cambodia. *Pacific Conservation Biology*, **16**, 101-116.

Throughout their ranges, the leguminaceous rosewoods, *Azelia xylocarpa* (Caesalpinioideae) and *Dalbergia cochinchinensis* (Fabaceae) are threatened by habitat loss and over-exploitation for their extremely valuable timber. This paper considers how both species could be used in planting programmes to alleviate the pressure on the wild stocks and generate revenue. This will require testing and improving silvicultural practices, and increasing the supply of genetically superior seeds from seed production areas and/or seed orchards. A network of *in situ* gene banks has already been established in natural forests in Cambodia. The participation of a wide range of stakeholders is considered necessary to address socio-economic development and

reduce poverty. This is in line with the National Forest Programme of Cambodia. Author: B.Dell@murdoch.edu.au

Starr, C.R. (2010) *The use, distribution and ecology of two species of loris (Nycticebus bengalensis and N. pygmaeus) in Cambodia: implications for conservation*. PhD thesis, The University of Queensland, Brisbane, Australia.

Thesis not seen. Author: carlystarrcbc@gmail.com

Starr, C., Rogers, L., Nekaris, K.A.I. & Streicher, U. (2010) Surveys and preliminary field observations of the northern slow loris (*Nycticebus bengalensis*) in Cambodia. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 43-52. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

Seven protected areas were surveyed, but lorises were observed in only two: Phnom Samkos Wildlife Sanctuary and Phnom Kulen National Park. The authors suggest that northern slow lorises occur only West of the Mekong, and present new data on their status, behavioural ecology and threats. Author: carlystarrcbc@gmail.com

Starr, A., Sam H. & Daltry, J. (2010) 2010 monitoring and nest surveys reveal status and threats of community-protected *Crocodylus siamensis* subpopulations in Cambodia. *Crocodile Specialist Group Newsletter*, **29**, 7-9.

Analysis of monitoring data since 2001 suggest that populations of the Critically Endangered Siamese crocodile have stabilized and may even be increasing in community-managed crocodile sanctuaries in the Areng River and Veal Veng Marsh (estimated to hold 40 and 50 adults respectively), both in the Cardamom Mountains. Numbers at a third important site, Chay Reap, appear to be decline, however, putatively due to hunting, electro-fishing and other increasing human activities in this area. The authors present evidence that Cambodia's wild Siamese crocodiles continue to be subjected to poaching, and warn of the even greater impending threats from proposed hydrodams in Cambodia. Author: adamstarr.ffi@gmail.com

Takagi, A.P., Ishikawa, S., Nao T., Song, S.L., Sitha H., Thammavong, K., Saphakdy, B., Phomsouvanhm, A., Nishida, M. & Kurokura, H. (2010) Genetic differentiation and distribution routes of the bronze featherback *Notopterus notopterus* (Osteoglossiformes: Notopteridae) in Indochina. *Biological Journal of the Linnean Society*, **101**, 575-582.

The mitochondrial DNA of bronze featherback fish from 11 localities in Indochina was analysed, revealing three genetically distinct groups from: 1) Chao Phraya River; 2) Middle Mekong River; and 3) Lower Mekong River. The third group was most closely related to populations on the Malay Peninsula. Even though they inhabit the same river basin, molecular clock calculations indicate groups 2 and 3 separated approximately 1.2 million years ago. Author: akirapt@mail.ecc.u-tokyo.ac.jp

Tateishi, M., Miyazawa, Y., Tomo'omi, K., Ma V., Sokh H. & Mizoue, N. (2010) Interspecies comparison of transpiration in Cambodia for the prediction of water use under the tropical monsoon climate. *Geophysical Research Abstracts*, **12**, EGU2010-7900. Paper presented to European Geosciences Union (EGU) General Assembly, 2-7 May, Vienna, Austria.

Exotic, fast-growing trees are generally assumed to consume more water than native species. Water flow was monitored in four tree species: two native (*Dipterocarpus obtusifolius* and *Shorea roxburghii*) and two exotic (*Acacia auriculiformis* and *Eucalyptus camaldulensis*). All demonstrated similar transpiration rates under the same conditions during the rainy season. In the dry season, however, the water uptake of *A. auriculiformis* decreased while the transpiration rate of the native *S. roxburghii* remained high. This suggests *S. roxburghii* has deep roots to access groundwater. Author: tmakiko@forest.kyushu-u.ac.jp

Thaenkham, U., Nuamtanong, S., Sa-nguankiat, S., Yoonuan, T., Touch S., Manivong, K., Vonghachack, Y., Sato, M. & Waikagul, J. (2010) Monophyly of *Opisthorchis viverrini* populations in the lower Mekong Basin, using mitochondrial DNA *nad1*

gene as the marker. *Parasitology International*, **59**, 242-247.

The liver fluke *Opisthorchis viverrini* causes serious public-health problems in the Lower Mekong Basin. Genetic analysis of six fluke populations in Cambodia, Laos and Thailand revealed no significant geographic variation. The authors therefore reject the notion of an *O. viverrini* species complex. Author: tmjwk@mahidol.ac.th

Tingay, R.E., Nicoll, M.A.C., Whitfield, D.P., Sun V. & McLeod, D.R.A. (2010) Nesting ecology of the grey-headed fish-eagle at Prek Toal, Tonle Sap Lake, Cambodia. *Journal of Raptor Research*, **44**, 165-174.

Prek Toal supports a globally significant population of grey-headed fish-eagles *Ichthyophaga ichthyaetus*, a Near Threatened species. This paper presents the first quantitative information on this species' nesting ecology, in seasonally flooded swamp forest. Nesting fish-eagles were found to select trees that had an open crown structure and were relatively tall, and close to permanent water. Fewer active nests were found in areas with more people, which may reflect indirect effects of human exploitation of the fish-eagles' prey (which include aquatic snakes). This may be exacerbated in the future by changes to the Tonle Sap ecosystem caused by dams upstream. Author: dimlylit100@hotmail.com

Thompson, C. (2010) *River of Giants: Giant Fish of the Mekong*. WWF Greater Mekong Programme, Vientiane, Lao PDR.

This report profiles four fish in the Mekong River that rank among the world's 10 largest freshwater fish: the giant freshwater stingray *Himantura chaophraya*, Mekong giant catfish *Pangasianodon gigas*, giant pangasius (dog-eating catfish) *Pangasius san-itwongsei* and giant barb *Catlocarpio siamensis*. The primary threat to these fish is the construction of large-scale hydropower dams in the Lower Mekong River and large tributaries, which will block their migration routes to spawning grounds. Plans for 11 hydropower dams are currently in various stages of development, and of particular concern is the dam

proposed in Sayabouly Province, northern Laos. At least 50 migratory species are highly vulnerable to mainstream dam development, comprising 40-70% of the catch of fish in the Mekong. The report warns that such dams will also reduce sediment flowing downstream to the Mekong Delta, increasing the vulnerability of millions of people to the effects of climate change such as sea level rise. Author: christian-thompson@hotmail.co.uk; Online: http://assets.panda.org/downloads/new_river_of_giants_report_14_may_2010_web_version.pdf

Walston, J., Robinson, J., Bennett, E., Breitenmoser, U., da Fonseca, G., Goodrich, J., Gumal, M., Hunter, L., Johnson, A., Karanth, K., Leader-Williams, N., MacKinnon, K., Miquelle, D., Pattanavibool, A., Poole, C., Rabinowitz, A., Smith, J., Stokes, E., Stuart, S., Vongkhamheng, C. & Wibisono, H. (2010) Bringing the tiger back from the brink—the six percent solution. *PLoS Biology*, **8**, doi: 10.1371/journal.pbio.1000485.

Numbers of tigers *Panthera tigris* have plummeted due to hunting and habitat destruction, and fewer than 3,500 animals remain in the wild, within less than 7% of their historical range. This paper proposes that by focusing conservation efforts on 42 “source sites”, representing 6% of the tiger’s range, this species could be saved at the annual cost of \$82 million. In selecting sites, the team looked for areas with potential to maintain at least 25 breeding females, and surrounding habitats that could support at least 50 females. The analysis also favoured nations with existing conservation infrastructure and tiger protection laws. Most of the 42 proposed sites are in India, Sumatra and the Russian Far East. No sites were identified in Cambodia, China, North Korea or Vietnam because these countries are considered to have no breeding populations left. Author: jwalston@wcs.org; Online: <http://www.plosbiology.org/article/info%3Adoi%2F10.1371%2Fjournal.pbio.1000485>

Coasts, wetlands and aquatic resources

van Bochove, J.-W., Sandström, M. & Raines P. (2010) *Cambodia Reef Conservation Project: Pilot Project Report, August–October 2009*. Fisheries Administration, Phnom Penh, Cambodia, and Coral Cay Conservation, London, UK.

Illustrated report on a three-month assessment of the coral reef resources around Koh Rong and Koh Rong Semleon Islands, Preah Sihanouk Province in 2009. A low abundance of snappers (Lutjanidae), groupers (Serranidae) and parrotfishes (Labridae: Scarinae) was interpreted as evidence of overfishing, while a high abundance of long-spine sea urchins (*Diadema* sp.) points towards instability in the reef ecosystem. Comparisons with similar surveys in 2003 revealed that coral cover had remained the same, at around 23%, but the density of snappers and groupers had fallen. Based on the survey findings, the authors recommend developing a network of no-take zones to protect important reef sites and allow fish stocks to recover, underpinned with community capacity building and educational programmes. Measures should also be taken to minimise land run-off and pollution. Author: jvb@coralcay.org; Online: http://www.coralcay.org/component/option,com_docman/task,doc_download/gid,340/Itemid,393/

van Brake, M.L. & Ross, L.G. (2010) Aquaculture development and scenarios of change in fish trade and market access for the poor in Cambodia. *Aquaculture Research*, doi: 10.1111/j.1365-2109.2010.02661.x.

Poor fishers in Cambodia have very little opportunity to access urban markets, but there is greater, unrealised potential for them to trade with rural markets. With the aid of a Geographic Information System-based model, the authors predict that improving rural market access would benefit up to one million poor aquatic resource users in Cambodia. Author: m.vanbrakel@cgiar.org

Brooks, S.E., Kebede, B., Allison, E.H. & Reynolds, J.D. (2010) The balance of power in rural marketing networks: a case study of snake trading

in Cambodia. *Journal of Development Studies*, **46**, 1003-1025.

This study used a combination of price analysis and interview data to assess the status of snake hunters in the trade of aquatic snakes from the Tonle Sap Lake. In spite of their dependency on intermediate traders for market access and credit, the hunters are not powerless participants. They can command relatively high prices from the traders, who operate under high competition due to the decreasing availability of snakes. Author: sharonelizabethbrooks@googlemail.com

Chea E., Va D. & Irvine, K. (2010) Levels of Cr, Cu and Zn in food stuffs from a wastewater treatment wetland, Phnom Penh: a preliminary assessment of health risks. *Asian Journal of Water, Environment and Pollution*, **7**, 23-30.

The natural wetlands of Phnom Penh support a peri-urban community that actively harvests vegetables, snails and fish. Field sampling and social surveys revealed lower toxic metal concentrations in edible aquatic plants, such as the morning glory *Ipomoea aquatica*, than in fishes and snails. None of the foods posed a severe health risk, however, with the exception of fish at one site whose chromium levels could be hazardous to children. Author: chea.eliyan@rupp.edu.kh

Day, M.B., Hodell, D.A., Brenner, M., Curtis, J.H., Kamenov, G.D., Guilderson, T.P., Peterson, L.C., Kenney, W.F. & Kolata, A.L. (2010) Middle to late Holocene initiation of the annual flood pulse in Tonle Sap Lake, Cambodia. *Journal of Paleolimnology*, doi: 10.1007/s10933-010-9482-9.

The Tonle Sap Lake possesses one of world's most productive inland fisheries because the flow of the Tonle Sap River reverses seasonally, driving the lake's biological productivity. Based on radiocarbon dating, the authors estimate this annual flood pulse first began between 4,450 and 3,910 years ago. Author: mbd33@cam.ac.uk

Dok D. & Yakupitiyage, A. (2010) A policy alternative for lagoon management: case study of Sre Ambel coastal marine fisheries, Cambodia. *Journal of Coastal Conservation*, **15**, doi: 10.1007/

s11852-010-0117-0.

Sre Ambel is Cambodia's most productive coastal area for marine fisheries. The ability of local fishers to apply laws and regulations was measured using the weight average index method. While the fishers' education levels were found to be good enough to apply regulations, their understanding of existing fisheries laws and guidelines was poor. The authors recommend developing stronger collaboration among the various stakeholders in the area and converting the current open-access system to a common property resource use regime. Author: dokdoma@gmail.com

Dugan, P.J., Barlow, C., Agostinho, A.A., Baran, E., Cada, G.F., Chen, D., Cowx, I.G., Ferguson, J.W., Jutagate, T., Mallen-Cooper, M., Marmulla, G., Nestler, J., Petrere, M., Welcomme, R.L. & Wine-miller, K.O. (2010) Fish migration, dams, and loss of ecosystem services in the Mekong Basin. *Ambio - A Journal of the Human Environment*, **39**, 344-348.

Dams on the Mekong River and its major tributaries will have major impacts on the Mekong Basin's fisheries and the people who depend upon them. This study found no evidence that current strides towards dam construction will stop, and considers two scenarios for the future of the basin's fisheries and its ecosystem. The authors conclude that major investment in innovative technology is needed to reduce the loss of ecosystem services, plus alternative livelihood strategies to cope with losses that do occur. Author: p.dugan@cgiar.org

Irvine, K. & Koottatep, T. (2010) Natural wetlands treatment of sewage discharges from Phnom Penh, Cambodia: successes and future challenges. *Asian Journal of Water, Environment and Pollution*, **7**, 1-2.

Recent studies have found Boeung Cheung Ek to be remarkably effective in treating the waste discharge from central and south Phnom Penh. The wetland also receives stormwater discharges when it rains and thereby helps to reduce flooding in the city. Parts of Boeung Cheung Ek are being filled in to create land for urban growth, however, and infilling of the natural treatment wetlands north of the

city (e.g. Boeung Kak, Boeung Pong Peay) has also begun. Because Cambodia cannot afford Western wastewater treatment technology, these natural wetlands should be conserved as a cost-effective alternative. Author: irvinekn@buffalostate.edu; Online: <http://iospress.metapress.com/content/x478306367n83358/fulltext.pdf>

Mekong River Commission (2010) *State of the Basin Report 2010*. Mekong River Commission, Vientiane, Lao PDR.

The report gives a generally positive appraisal of the health of the Mekong Basin, but warns that the river ecosystem, and its ability to sustain local livelihoods, is being seriously jeopardised by planned new infrastructure, rapidly growing human populations and changing consumption patterns. More than 60 million people now live in the basin, many of whom depend heavily on fish and other aquatic organisms. The basin's rich biodiversity is still not fully known and new species are being discovered every year. Particular care is needed to protect wildlife habitats and to gain a better understanding of the interaction between the river's flow regime and its aquatic life. The estimated total production of the Mekong fishery is about 3.9 million tonnes per year, and while there are no signs of this total being threatened, studies in the Tonle Sap Lake have shown a drop in the number of larger fish being caught. Other statistics in the report include the estimated total hydropower potential of the Lower Mekong Basin at 30,000 MW, of which about 10% has already been developed. Hydropower can be a useful source of renewable energy, but the authors warn of the broad range of possible social and economic impacts: "Major interferences with natural hydrological regimes, through water management and utilisation, may have huge impacts on the integrity of the ecosystem". Online: [Full report in English] <http://www.mrcmekong.org/download/MRC-SOB-report-2010%28full-report%29.pdf>; [Summary report in Khmer] <http://www.mrcmekong.org/download/MRC-SOB-Summary-report%28Khmer%29.pdf> [Editor's note: - *The Mekong River Commission is the intergovernmental body responsible for cooperation on the sustainable man-*

agement of the Mekong Basin, whose members include Cambodia, Laos, Thailand and Vietnam. The MRC also administers the formal consultation process that developers must undergo to build dams on the Mekong River].

Muth S., Sayasone S., Odermatt-Biays, S., Phompida S., Duong S. & Odermatt, P. (2010) Chapter 7: *Schistosoma mekongi* in Cambodia and Lao People's Democratic Republic. *Advances in Parasitology*, **72**, 179-203.

The indigenous blood fluke *Schistosoma mekongi* is carried by the freshwater snail *Neotricula aperta* and causes the disease schistosomiasis in human communities along the Mekong River. High mortality rates were reported in northern Cambodia (Stung Treng and Kratie Provinces) and southern Laos (Champasack) during the early 1970s and 1990s. Control programmes entailing mass drug administration and education campaigns have been carried out in Cambodia since 1995, successfully achieving a significant reduction in schistosomiasis in this country. Some problem areas remain, however, and there is evidence that the fluke's host snail is becoming more widespread, increasing the risk of humans becoming infected. This paper calls for more concerted bilateral efforts between Cambodia and Laos to eradicate *S. mekongi*. Author: sinuonm@cnm.gov.kh

May R., Jinno, K. & Tsutsumi, A. (2010) Influence of flooding on groundwater flow in central Cambodia. *Environmental Earth Sciences*, doi: 10.1007/s12665-010-0679-z.

The Mekong, Tonle Sap and Bassac Rivers flood every year, endangering human populations and property, and changing the water quality in aquifers. A two-dimensional groundwater flow model, coupled with a groundwater recharge model, was applied to central Cambodia. The results showed that during flooding periods (August to October), all three rivers play an important role in recharging groundwater. During the dry season, the Tonle Sap River is supplied by groundwater from the Northwest. Author: kh.raksmey@gmail.com

Nagabhatla, N. & van Brakel, M. (2010) *Landscape level characterization of seasonal floodplains under*

community based aquaculture: illustrating a case of the Ganges and the Mekong Delta. CBFC Working Paper No. 4, Community-based Fish Culture in Seasonal Floodplains and Irrigation Systems (CBFC) project, World Fish Centre, Penang, West Malaysia, and CGIAR Challenge Program on Water and Food, Battaramulla, Sri Lanka.

Although it is unfinished, this report contains numerous maps and statistics describing the landscape and fisheries of the Lower Mekong area of Cambodia and Vietnam. Author: n.nagabhatla@cgiar.org; Online: http://www.worldfishcenter.org/resource_centre/CBFC/4_Nagabhatla_landscape%20report.pdf

Neang T. (2010) *An Investigation into Frog Consumption and Trade in Cambodia*. Species, Habitats and Ecosystems Team, Fauna & Flora International: Cambodia Programme, Phnom Penh, and the Angkor Centre for Conservation of Biodiversity, Siem Reap, Cambodia.

Six species of anuran amphibians are routinely harvested for local consumption and trade: (in decreasing order of reported numbers) *Hoplobatrachus rugulosus*, *Fejervarya limnocharis*, *Glyphoglossus molossus*, *Kaloula pulchra*, *Rana lateralis*, and *Bufo melanostictus*. Traditional collection on a small scale appears to be sustainable, but this may change with the rising demand from Phnom Penh and international buyers. Native frog populations are also under pressure from pesticide use, habitat loss, and the alien chytrid fungus *Batrachochytrium dendrobatidis* (newly discovered in Cambodia). Frog farming seems a logical solution to meet market needs and is already underway in many parts of the country, but there is a high risk that exotic species and diseases will escape into the wild. Author: neangthy@yahoo.com; Online: <http://www.accb-cambodia.org/en/Frog%20Consumption%20Report.pdf>

Ngoen-klan, R., Piangjai, S., Somwang, P., Moophayak, K., Sukontason, K., Sukontason, K.L., Sampson, M. & Irvine, K. (2010) Emerging helminths infection in snails and cyprinoid fish in sewage treatment wetlands waters in Cambodia. *Asian Journal of Water, Environment and Pollution*,

7, 13-21.

Freshwater snails and fish belonging to Cyprinidae (carp family) were sampled in four sites in the Boeung Cheung Ek wetland, Phnom Penh. The snail *Lymnaea (Radix) auricularia rubiginosa* was found to be infected with the trematode *Gymnocephalus cercariae*, an intestinal and liver parasite of herbivorous mammals. In the same wetland, the liver fluke *Opisthorchis viverrini* was detected in 15 species of fish: *Puntius orphoides* contained the highest number of liver fluke metacercariae, followed by *Hampala dispar* and *Henicorhynchus* sp. Both snails and fish exhibited higher rates of infection during the dry season. Author: irvinekn@buffalostate.edu

Nguyen T.P. & Dang T.H.O. (2010) Striped catfish aquaculture in Vietnam: a decade of unprecedented development. *Success Stories in Asian Aquaculture*, 2010, 131-147.

The striped catfish *Pangasianodon hypophthalmus* is native to the Mekong and Chao Phraya River systems in Thailand, Vietnam, Laos and Cambodia. This paper charts the rise of commercial farming of this species in Vietnam, starting in 2000 when artificial propagation techniques were developed. By 2007, striped catfish production and export turnover reached 1,200,000 tonnes, generating US \$1 billion. This industry now employs at least 150,000 people - mostly rural women - and exports the fish to around 80 countries. Author: ntpuong@ctu.edu.vn

Nguyen V.T., Choi, J.-H. & Won, J.-S. (2009) Land-cover change detection at Tonle Sap, Cambodia, using ALOS PALSAR. *Paper presented to the 30th Asian Conference on Remote Sensing, 18-23 October, Beijing, China*.

See the next summary. Author: nvtrungvn@yonsei.ac.kr; Online: <http://www.a-a-r-s.org/acrs/proceeding/ACRS2009/Papers/Oral%20Presentation/TS40-01.pdf>

Nguyen V.T., Choi, J.-H. & Won, J.-S. (2010) Change detection of the Tonle Sap floodplain, Cambodia, using ALOS PALSAR data. *Korean Journal of Remote Sensing*, 26, 287-295.

Water levels in the Tonle Sap are largely influenced by the Mekong River. To detect changes in the Tonle Sap floodplain, this study used satellite data - particularly the L-band, which can penetrate the tree canopy to detect water in flooded forests. Change images, extracted from ratio images, coherence images and texture feature ratio images, were constructed to detect land cover change. In addition to seasonal changes in water levels, the satellite images were also influenced by seasonal leaf fall and crop cultivation. Author: nvtrungvn@yonsei.ac.kr; Online: (part) http://210.101.116.28/W_kiss61/1r600722_pv.pdf

Nguyen V.T., Choi, J.-H. & Won, J.-S. (2010) Fusion of ALOS PALSAR and ASTER data for land-cover classification at Tonle Sap floodplain, Cambodia. *Proceedings of SPIE - The International Society for Optical Engineering*, **7858**, 785815; doi: 10.1117/12.869413.

The northern floodplain of the Tonle Sap Lake is characterised by various vegetation types and settlements. The purpose of this study was to classify land cover to guide farming, fishing and conservation management. ALOS PALSAR data were fused with ASTER data acquired during the dry season, and 10 land cover classes were identified. Combining the two data sets was found to provide clearer distinctions between the land cover classes than the ASTER data alone. Author: nvtrungvn@yonsei.ac.kr

Sengheat C., Kluskens, B. & Ford, D. (2010) Determination of polychlorinated biphenyl (PCBs) and dichlorodiphenyltrichloroethane (DDTs) in sediments in Boeung Cheung Ek, Phnom Penh, Cambodia. *Asian Journal of Water, Environment and Pollution*, **7**, 3-11.

Harmful PCBs and DDTs continue to be used in electrical equipment and agriculture in Cambodia, despite being prohibited. Boeung Cheung Ek is a wetland south of Phnom Penh, which receives wastewater from the south-central part of the city. High-Performance Liquid Chromatography detected DDT, DDE (up to 100 ppb) and possibly some PCBs in the sediment where city wastewater enters

the wetland, but none of these compounds could be detected in sediment where the water leaves the wetland and enters the Bassac River. This demonstrates that Boeung Cheung Ek is effective in trapping toxic compounds and protecting river systems downstream, but people who eat fish and shellfish caught in this wetland might be at risk of poisoning. Author: chaksengheat@yahoo.com

Tiev V., Mongtoeun Y., Saneth V., Irvine, K. & Koottatep, T. (2010) Efficiency of Phnom Penh's natural wetlands in treating wastewater discharges. *Asian Journal of Water, Environment and Pollution*, **7**, 39-48.

Water quality samples were collected in three sewer channels that discharge into Boeung Cheung Ek wetland and in two sites within the wetland. Levels of copper, chromium, zinc, phosphorus, nitrates, detergents, *Escherichia coli* and total suspended solids were compared during the dry season, and water leaving the lake was found to be significantly less contaminated than water entering. Author: visoth1@yahoo.com

Forests and forest resources

Anonymous (2009) *The Importance of Forest and Wildlife Conservation in Mondulkiri Province*. WWF Greater Mekong Programme and Wildlife Conservation Society Cambodia Program, Phnom Penh, Cambodia. [In Khmer].

This report identifies management zones in Mondulkiri Province for conservation, development and multiple uses. Online: http://assets.panda.org/downloads/the_importance_of_forest_and_wildlife_conservation_in_mondulhiri_1.pdf

Chheang D. & Kamol, W. (2010) Management of the Emerald Triangle Protected Forests Complex to promote cooperation for trans-boundary biodiversity conservation between Thailand, Cambodia and Laos (Phase II), ITTO PD 289/04 Rev.1 (F). Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.

The “Emerald Triangle” comprises four protected areas in Thailand, the Phou Xieng Thong protected area in Laos, and Preah Vihear Protected Forest in Cambodia. The authors describe recent progress in an ongoing transboundary conservation initiative that aims to improve cooperation between all three nations, protect and monitor biodiversity, and promote community-based management and sustainable use of natural resources. This paper notably contains statistics on the forests and fauna in the Preah Vihear Protected Forest. Online: <http://nopheasasaki.net/conference/2010/8dany.pdf>

Chheng K. & Nophea S. (2010) Managing forests in Cambodia for multiple benefits. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

Forests play important roles in national and rural development in Cambodia, but total forest cover decreased by 0.7% per year from 1993 to 2003, emitting approximately 50 million tonnes of CO₂. To manage Cambodia’s forests more sustainably and reduce carbon emissions, the authors propose a suite of interventions tailored to different forest types, including Reduced Impact Logging (RIL), enrichment planting, assisted natural regeneration and fire prevention. The need for financial and technical support could be met in part by generating revenue from Reducing Emissions from Deforestation and Forest Degradation (REDD). The authors also call for a new system to certify foresters in Cambodia. Online: <http://nopheasasaki.net/conference/2010/1kimsun.pdf>

Gauntlett, S. (2010) Forest watershed in relation to water shortages in Cambodia. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

Cambodia’s largest watershed, the Cardamom Mountains, covers approximately 1.8 million ha, receives 3,000-5,000 mm of rain annually, has 18 major waterways, and supplies water to six prov-

inces, including the Tonle Sap Lake. This paper considers how to minimise forest loss and degradation during the construction of hydropower developments (noting plans for 11 hydrodams are in various stages of development in the Cardamom Mountains). The impact of destroying forests on watersheds is illustrated by Koh Kong town, which ran out of water in 2010, putatively due to the clearance of 20 km² of forest upstream. Online: <http://nopheasasaki.net/conference/2010/5suwanna.pdf>

Grindley, M.E. (2009) *Management Effectiveness Tracking Tool: Lomphat Wildlife Sanctuary First Reassessment, March 2009*. General Department of Administration for Nature Conservation and Protection, Phnom Penh, Cambodia, People Resources and Conservation Foundation, Amherst, USA, and BirdLife International, Hanoi, Vietnam.

The WWF/ World Bank Management Effectiveness Tracking Tool was first applied to Lomphat Wildlife Sanctuary in December 2007. Since then, the park’s score has risen from 20.5 to 36.0 (out of a possible 99 points). While this clear improvement in its management is encouraging, the report identifies a number of specific areas where more attention is needed. Author: mark.grindley@prcfunion.org; Online http://www.prcf-alliance.org/cambodia/cambodia_pdf/PD09003_METT_First_Reassessment_LWS_May_2009_EN.pdf

Hance, J. (2010) Secret titanium mine threatens Cambodia’s most untouched forest. *The Babblor*, **36**, 18-19.

Plans have been revealed for a titanium mine that would cover 15-20,000 ha of the southern Cardamom Mountains. The proposed mine is on a major Asian elephant migration route and threatens an emerging ecotourism scheme around Chi Phat. Wildlife conservationists and local communities are opposing the mine. Online: http://birdlifeindochina.org/sites/default/files/Babblor_36.pdf

Hannay, R.M. (2010) *Living landscapes: the vision and role of community forestry in sustainable development*. MA thesis, Oxford Brookes University, Oxford, UK.

This thesis incorporates two case studies from Cambodia (but presents very little data or analysis of either). Online: <http://www.brookes.ac.uk/schools/be/research/cendep/dissertations/Rachael-Hannay.pdf>

Horm C., Bampton, J.F.R., Kelley, L.C. & Brofeldt, S. (2010) Whose land is this anyway? The role of collective action in maintaining community rights to the land in Kratie, Cambodia. *Paper presented to the CAPRI Workshop on Collective Action, Property Rights, and Conflict in Natural Resources Management, 28 June - 1 July, Siem Reap, Cambodia.*

A two-year study of the contest between the Kbal Damrei Commune - which had land tenure and had applied for a community forest - and a rubber plantation company that had been granted an economic land concession in the same place. This case study demonstrates that conflict over forest resources can motivate strong, even violent collective action in Cambodian communities. Online: http://www.capri.cgiar.org/pdf/CAPRI_Conflict_Chandet.pdf

Ironside, J. (2010) The outbreak of peace: communal land management and traditional governance in a remote Cambodian province *Paper presented to the CAPRI Workshop on Collective Action, Property Rights, and Conflict in Natural Resources Management, 28 June - 1 July, Siem Reap, Cambodia.*

This paper explores the governance of land and natural resources in Ratanakiri Province. Here, communal land ownership is quickly giving way to private tenure, resulting in landlessness, dispossession and widespread forest clearing. The author advises that a better solution could be found by drawing upon traditional institutions, ownership and governance models to enable communities to develop sustainable agriculture and livelihoods in these forested upland areas. Online: http://www.capri.cgiar.org/pdf/CAPRI_Conflict_Ironside.pdf

Kajisa T., Yahara, T. & Mizoue, N. (2010) Multi-dimensional assessment of three types of forest management in Cambodia-activity report of GCOE program "Asian Conservation Ecology", Kyushu University. *Paper presented to the International Conference on Managing Forest Resources*

for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.

This presentation combines the findings from three studies on the stand dynamics of tropical seasonal evergreen forest, water cycling by native and exotic trees, and estimating biomass from satellite images. In the first study, 20 plots were established in evergreen forests in central Cambodia, where the team recorded 67 tree species, with a mean density of 545 per hectare, basal area of 23.4 m² and volume increment of 1.09 m³ per hectare per year. Online: <http://nopheasasaki.net/conference/2010/4kajisa.pdf>

Khou E.H. (2010) Lessons and experiences in strengthening the contribution of NTFP livelihoods in sustainable forest management in Cambodia. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

At least 50% of Cambodia's plants have some economic value. For forest dwellers who face rice shortages for six months per year, the collection of non-timber forest products (NTFPs) is the second most important occupation after rice farming. This paper describes ongoing projects to advance and add value to the community-based management of rattan and wild honey, and identifies other species that could be similarly promoted. The author calls for NTFPs to be integrated into the development of REDD initiatives, especially during the early stages as a means of building local support for, and benefits from, forest conservation. Online: <http://nopheasasaki.net/conference/2010/6eanghourt.pdf>

Khun V. (2010) Carbon storage of tropical deciduous forests in Mondulokiri Province, Cambodia. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

In deciduous forests in Keo Seima District, the total quantity of carbon stored was found to average 276 tonnes per hectare, most (186 tonnes) of which was held in soil organic carbon. Author: vathana.

khun@gmail.com; Online: <http://nopheasaki.net/conference/2010/12vathana.pdf>

Kiyono, Y., Furuya, N., Sum T, Umemiya, C., Itoh, E., Araki, M. & Matsumoto, M. (2010) Carbon stock estimation by forest measurement contributing to sustainable forest management in Cambodia. *Japan Agricultural Research Quarterly*, **44**, 81-92.

Carbon stocks were measured and monitored in four carbon pools (above-ground biomass, below-ground biomass, deadwood, and litter) in 17 plots in evergreen, dry and secondary forests in various parts of Cambodia (most in protected areas). While total carbon values were found to vary among different forest types, most of the carbon stock ($84 \pm$ SD 12%) was in the above-ground (tree) biomass. By classifying forest types and determining their average tree biomass and land area, a reasonably accurate estimate of carbon stock can be obtained. To the authors' surprise, however, half of the forest plots used in this study were destroyed or heavily logged within three years. This demonstrates the need for forest researchers to allocate extra plots when attempting to conduct long term monitoring in Cambodia. Author: kiono@affrc.go.jp; Online: <http://www.jircas.affrc.go.jp/english/publication/jarq/44-1/44-01-12.pdf>

Lo Cascio, A. & Beilin, R. (2010) Of biodiversity and boundaries: a case study of community-based natural resource management practice in the Cardamom Mountains, Cambodia. *Environmental Conservation*, **37**, 347-355.

Community forestry and other forms of community-based natural resource management (CBNRM), have been promoted by international NGOs in Cambodia as a strategy to support protected area management. A study in 2005 found challenges during the early stages of a CBNRM programme in Phnom Samkos Wildlife Sanctuary and the Central Cardamoms Protected Forest because communities contested the meaning and usefulness of protected areas. Their concerns revealed power imbalances and uncertainty over long term outcomes. The authors identified the need to integrate biodiver-

sity values more effectively into local production systems. Author: rbeilin@unimelb.edu.au

Nang P. (2010) Sustainable pathways for attaining the Millennium Development Goals: ecosystem services & local livelihoods - a case study in Cambodia. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

Paper not seen. Author: nangphirun@yahoo.com; Online: <http://nopheasaki.net/conference/2010/7pirun.pdf> [*This link was inactive in December 2010*].

Nin C. (2010) The forestry management cultural landscape and environment in Angkor Park Zone. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

The Apsara Authority is responsible for the management of the 60,929-ha Angkor site, including 12,785 ha of forest. This paper outlines steps taken and planned to improve forest management, including establishing firebreaks, distributing tree seedlings to local communities, tackling illegal land grabbing, and tree surgery to prevent damage to cultural sites and infrastructure. The Authority aims to significantly increase the overall tree cover in this area. Online: <http://nopheasaki.net/conference/2010/11chansamean.pdf>

Pattnaik, A. (2010) The status of forestry education & research in managing the existing forests in Cambodia's protected areas. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

This paper questions the usefulness of rapid surveys and calls for more in-depth, longer term scientific research to fully understand the dynamics, ecology and management needs of Cambodia's forests. There is a need for greater inter-agency collaboration on collecting and sharing data, more funding for research in Cambodia, and the training and

involvement of more scientists, including undergraduate and graduate students. Online: <http://nopheasasaki.net/conference/2010/14anita.pdf>

Seak S. (2010) Biodiversity conservation as a tool to sustain forest ecosystem services. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

A diverse array of organisations and initiatives are working to conserve Cambodian forests and the ecosystem services they provide. Most projects are heavily dependent on donor support, however, and many of the techniques and approaches are being introduced by outsiders, especially international NGOs. The author recommends increased use of local technical skills and knowledge to develop conservation models that are better tailored to the Cambodian context. Online: <http://nopheasasaki.net/conference/2010/10sophat.pdf>

Shigematsu, A., Mizoue, N., Ide, K., Khun, K., Muthavy P., Yoshida, S., Kohroki, K. & Sato, N. (2010) Estimation of rubberwood production in Cambodia. *New Forests*, 28 December 2010, doi: 10.1007/s11056-010-9243-7. [E-pub ahead of print].

Using interview surveys with three rubberwood processing companies and statistics from estate rubber plantations and timber retailing companies, this study estimates that an average of 254,697 m³ of rubberwood roundwood was produced annually since 1996. Sales of natural forest timber have declined sharply in Cambodia as restrictions on logging have increased, and rubberwood is thought to account for more than 60% of the country's industrial roundwood production since 2000. The authors recommend monitoring the expansion of rubber plantations and linking Cambodia's into a regional wood resource management system. [*The rubber tree Hevea brasiliensis is native to the South American Amazon*]. Author: aki.shigematsu@gmail.com

Sokh H. (2010) Cambodia's National Forest Programme: innovative forest financing for sustainable forest management. *Paper presented to the Inter-*

national Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.

This paper describes the formation and main objectives of the National Forest Programme, which has the overall mission to "advance the sustainable management and development of our forests for their contribution to poverty alleviation, enhanced livelihoods, economic growth and environmental protection, including conservation of biological diversity and our cultural heritage." As part of the programme's objective to develop sustainable financing systems, a wide range of mechanisms are being considered including, *inter alia*, REDD, upstream protection, ecotourism, revenue from confiscated forest products, economic land concessions and timber exports. Online: <http://nopheasasaki.net/conference/2010/2sokkheng.pdf>

Tamai, K. (2010) The dependency of latent heat flux on vapor pressure deficit in lowland evergreen forest in Cambodia. *Paper presented to the 22nd Conference on Climate Variability and Change, 17-21 January, Atlanta, USA.*

Much of the original evergreen broad-leaved forests in Indochina have been replaced by agricultural land or deciduous forests, and only a relatively small area now remains in Cambodia. The evergreen broad-leaved forests transpire 6 mm per day, irrespective of season, and tall trees with extensive root systems are capable of extracting moisture from soil layers deeper than 2.5 metres. Author: a123@ffpri.affrc.go.jp

Toriyama, J., Ohta, S., Araki, M., Kosugi, K., Nobuhiro, T., Kabeya, N., Shimizu, A., Tamai, K., Kanzaki, M. & Chann S. (2010) Soil pore characteristics of evergreen and deciduous forests of the tropical monsoon region in Cambodia. *Hydrological Processes*, doi: 10.1002/hyp.7859A.

The soil pore characteristics of evergreen and deciduous forest stands were studied in three provinces in Cambodia. Soils in evergreen forests had significantly bigger pores than the deciduous forest soils: mean water capacity was 0.107 m³ and

0.146 m³ per cubic metre of soil in evergreen and deciduous forests respectively. A simulation model for rain storms in the early dry season indicated a greater gain in soil water in evergreen forests than in deciduous forest soils. Author: jtori@affrc.go.jp

Yahara, T. (2010) Three types of forest management in Cambodia as an opportunity to optimize different goals towards sustainable society. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

This paper contains findings from a forest study in Kampong Thom Province. Out of 243 tree species encountered, 88 (36%) could not be identified in the field, but some of these were subsequently identified in the laboratory using DNA barcoding. The author highlights the need to build plant identification capacity in Cambodia, for example, by establishing herbariums and laboratories, and producing a "Forest Flora of Cambodia." Online: <http://nopheasasaki.net/conference/2010/18yahara.pdf>

Payments for conservation services, including carbon

Anonymous (2010) *Cambodia REDD+ Roadmap, ver. 3.1. UN-REDD - the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, United Nations, Washington DC., USA.*

The first national action plan for the Royal Government of Cambodia to achieve "REDD+ Readiness". This detailed plan was developed by the inter-ministerial REDD+ Taskforce in consultation with international NGOs and local civil society groups. Online: <http://nopheasasaki.net/reddcambodi/>

Anonymous (2010) *National Programme Document - Cambodia. UN-REDD - the United Nations Collaborative Programme on Reducing Emissions from Deforestation and Forest Degradation in Developing Countries, United Nations, Washington DC., USA.*

A costed two-year proposal to enable Cambodia to implement the *Cambodia REDD+ Roadmap* [above], including developing the necessary institutions, policies and capacity. Online: <http://nopheasasaki.net/reddcambodi/>

Anonymous (2010) *REDD+ Partnerships: National Workshops for Government & Civil Society: 24-26 February 2010, Sunway Hotel, Phnom Penh, Cambodia.* RECOFTC - the Center for People and Forests, Bangkok, Thailand, and Institute for Global Environmental Studies, Hayama, Japan.

The proceedings of a workshop in Cambodia that aimed to build government and civil society awareness on REDD+, foster and strengthen national REDD+ networks, and identify and address critical capacity-building needs. Online: http://www.iges.or.jp/en/fc/pdf/activity_201003/Summary_Reports/IGES_Workshop_REPORT_Cambodia_v4_TD_100410r.pdf [Mostly in English, with some powerpoint presentations in Khmer].

Chervier, C., Neang M. & Depres, C. (2010) Emergence of the notion of environmental services (ES) in forest conservation policies and the international influence: field evidences from Cambodia. *Paper presented to the International Conference on Environment and Natural Resources Management in Developing and Transition Economies, 18-19 November, Clermont Ferrand, France.*

Initial strategies for managing forests in Cambodia were based on regulatory approaches (protected areas), with apparently limited success in halting deforestation. In recent years, the concept of environmental services has become more prominent, with the development of payment for environmental services strategies. Foreign influence from international donors and conservation NGOs has had a major role in this paradigm shift, chiefly by providing financial and scientific support and placing international technical advisers in decision-making networks. There is, however, an opportunity for greater application of the environmental services concept in domestic policies. Author: c.depres@vetagro-sup.fr; Online: <http://www.cerdi.org/uploads/>

sfCmsContent/html/323/D%C3%A9pr%C3%A9s.pdf

Eang S. (2010) Climate change, forest conversion and illegal logging, driver for change in the Cambodian forest sector. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

While national and international forums have proposed to combat deforestation and forest degradation by implementing REDD schemes, it is important not to overlook the root causes of forest conversion and illegal logging. This paper summarises actions taken by the Royal Government of Cambodia to conserve forests to date, e.g. placing more than 4.5 million ha (25% of the total country area) under conservation and protection, establishing 424 forestry communities in 20 provinces (total area 396,710 ha), reclaiming 246,600 ha of forestland that had been illegally cleared and occupied, and implementing two REDD pilot projects in two provinces (total area 248,028 ha). The Government remains committed to the National Forest Programme, REDD and the ITTO project *Strengthening Capacity of Forest Law Enforcement and Governance*. Online: <http://noph-easasaki.net/conference/2010/3savet.pdf>

Evans, T. (2010) Development of the Seima Protection Forest REDD Project. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

Slowing deforestation may be a cost-effective way to mitigate global warming. This REDD project takes place in the 187,000-ha core area of Seima Protection Forest, where the carbon stock of live trees is estimated to average 133 tonnes per hectare. This paper outlines the technically challenging steps that have been taken to assess the site's current carbon stocks, evaluate the baseline rate of deforestation, and estimate net carbon losses if the area were deforested. While there are additional stages to complete, the first sales through an existing voluntary carbon

market could be made in 2011. Online: <http://noph-easasaki.net/conference/2010/16tom.pdf>

Grogan, K., Hansfort, S.L., van Beukering, P.J.H. & van der Leeuw, K. (2009) *Reduced Emission from Deforestation and Degradation in the Southern Cardamom Ecosystem, Cambodia*. IVM Report (R-09/11), Institute for Environmental Studies, VU University, Amsterdam, The Netherlands.

There has been increasing pressure on the forest resources of the Southern Cardamom Mountains. Carbon credits from REDD offers an opportunity to conserve the forest, reduce CO₂ emissions, support and develop local communities; and generate revenues for the Cambodian government and Wildlife Alliance. If deforestation can be controlled, the potential value of reduced emissions would be between 0.4 and 1.3 million tonnes CO₂ per year. Online: http://www.ivm.vu.nl/en/Images/R09-11_tcm53-95750.pdf [A "Decision Makers Summary" is at http://www.ivm.vu.nl/en/Images/R09-13%20decisionmakers%20summary_tcm53-95569.pdf].

Kapos, V., Ravilious, C., Chivin L., Bertzky, M., Osti, M., Clements, T. & Dickson, B. (2010) *Carbon, Biodiversity and Ecosystem Services: Exploring Co-benefits. Cambodia*. UNEP-WCMC, Cambridge, UK.

This report contains maps and statistics on Cambodia's carbon stocks, organised by ecosystem types and management designation (e.g. protected areas and forest concessions). Much of Cambodia's terrestrial carbon stock is in areas important for biodiversity conservation, many of which have some form of protection (e.g. the Cardamom Mountains range is singled out as the largest area of very high carbon density). REDD+ schemes in such areas could achieve substantial biodiversity-related benefits. Some areas of biodiversity importance have relatively low carbon stocks (including most of the Important Bird Areas in the lowlands), however, and will therefore need to seek funding from other mechanisms. Planning for forest carbon management in Cambodia must take account the numerous existing plans and designations for land management. Online: <http://www.unep-wcmc.org/climate/>

pdf/Cambodia%20Summary%20Report%202010.pdf

Oum P. (2010) Payment of environmental services development in Cambodia. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

Payments for Environmental Services (PES) can take many forms such as cash, tax breaks, tenure security, and skills training. The payment must be at least match the opportunity costs of foregoing alternative land uses, and transaction costs should be minimal. PES schemes require mutual trust between sellers and buyers, and their rights and responsibilities must be defined. There needs to be good supporting institutions, legal frameworks and policies, and financial mechanisms. Finally, PES also requires monitoring systems to link payments to performance. A wide range of PES projects have been piloted in Cambodia, and the author draws particular attention to the potential for linking hydropower dam development to PES. Author: piseyoum@hotmail.com; Online: <http://nopheasasaki.net/conference/2010/9pisey.pdf>

Sasaki, N. (2010) Carbon-based payments for tropical forest conservation - a case study for evergreen forest in Cambodia. *Paper presented to the Shinshu University International Symposium, February 2010, Shinshu, Japan.*

Cambodia's evergreen forests are the first priority for conservation if carbon payments are available. Using inventory data and timber royalties, this paper compared the costs of, and revenues from, timber harvesting against five different land uses. Annual Equivalent Values were \$8.23-81.87 per hectare for timber harvesting, \$0.92-16.16 for converting forests to teak plantations, and \$0.92-16.65 for rubber plantations, but forest conservation offered the best value at \$46.38-461.35 per hectare. Conversion to acacia and oil palm were found to be unprofitable in Cambodia due to low productivity and relatively high production costs. Author: nopsasaki@gmail.com

Sasaki N. & Ty S. (2010) Managing concession forests in Cambodia under the REDD+ mechanism. *Paper presented to the International Conference on Managing Forest Resources for Multiple Ecosystem Services under Robust and Fragile Environments, 9-10 August, Phnom Penh, Cambodia.*

92% of Cambodians depend on wood fuel and 85% live in wooden houses. If more forests are protected for their carbon benefits under REDD+, the demand for timber and fuel wood will increase, raising prices and therefore the opportunity costs. For REDD+ schemes to survive, this ongoing demand cannot be ignored. This paper asks whether concession forests can meet the public demand for wood in addition to achieving net carbon sequestration? This should be feasible in Cambodia, but the country will first need to overcome a number of obstacles, including demarcating forest boundaries, classifying forests according to their use and degradation, and building capacity. Author: nopsasaki@gmail.com; Online: <http://nopheasasaki.net/conference/2010/17nophea.pdf>

Schmidt, L. & Theilade, I. (2010) *Conservation of Prey Long Forest Complex, Cambodia*. Working Papers Forest & Landscape No. 50-2010, University of Copenhagen, Copenhagen, Denmark.

This 25-page report summarises the findings from three biological survey expeditions to Prey Long, "the largest lowland evergreen forest in Cambodia, and probably in the Indo-Burma Hotspot". The authors present the main values of and threats to this forest, and outline a conservation strategy that includes a reduced emissions from deforestation and forest degradation (REDD) scheme. Author: lsc@life.ku.dk; Online: http://en.sl.life.ku.dk/upload/fwlp50_preylong.pdf

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

Two REDD pilot projects are underway in Cambodia: the Community Forestry Carbon Offset Project (CFCOP) in Oddar Meanchey Province and the Seima Protection Forest Project (SPF) in Mondulki-

ri Province. In both cases, local communities have been granted forest access rights and the projects have legitimized their tenure rights. In the CFCOP, more than 50% of the revenue from the future sale of carbon credits is to be shared with local communities, while in the SPF the sharing of revenue was still under discussion when this study was conducted. Lessons learned from this research could guide other REDD projects with regard to securing the rights of local communities to access forests and benefit from conservation. Author: yeangdonal@gmail.com; Online: <http://edepot.wur.nl/145608>

Climate change

Buckley, B.M., Anchukaitisa, K.J., Penny, D., Fletcher, R., Cook, E.R., Sanod, S., Le Canh N., Wichienkeo, A., Ton T.M. & Truong M.H. (2010) Climate as a contributing factor in the demise of Angkor, Cambodia. *Proceedings of the National Academy of Sciences of the United States of America*, **107**, 6748-6752.

The capital of the Khmer Empire experienced decades-long drought during the 14th and 15th Centuries, interspersed with intense monsoons, which likely contributed to its eventual demise. The evidence of these climatic events comes from a robust 759-year record in the growth rings of trees in southern Vietnam. The Angkor droughts were long and severe enough to disrupt the city's water supply and agricultural production, while years of high rainfall damaged its water control infrastructure. Remarkably, rainfall patterns in this region were found to be strongly and inversely correlated with tropical Pacific sea surface temperature, suggesting that a warm Pacific and El Niño events can induce droughts in Southeast Asia. Author: bmb@ldeo.columbia.edu; Online: <http://www.pnas.org/content/107/15/6748.full.pdf+html>

Sann V. & Ngo B. (2010) Animal genetic resource conservation and climate change in Cambodia: reducing livestock to decrease GHG emission? In *Moving Forward: Southeast Asian Perspectives on Climate Change and Biodiversity* (eds P.E. Sajise, M.V. Ticsay & G.C. Saguiguit Jr), pp. 87-99. ISEAS

and Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA), Laguna, The Philippines.

Cambodia had become a net emitter of greenhouse gases by 2000, producing the equivalent of 6,244 Gg CO₂. The main source of the pollution is "land use conversion and forestry" (71.5% of emissions in 2010), followed by agriculture (22.1% of emissions, and rising), nearly half of which is attributed to methane and other emissions from livestock. The author advises on how to reduce and mitigate greenhouse gas emissions from cattle farming in Cambodia. Author: vathana20@yahoo.com

Nguyen H., Shaw, R. & Prabhakar, S.V.R.K. (2010) Chapter 4 - Climate change adaptation and disaster risk reduction in Cambodia. In *Climate Change Adaptation and Disaster Risk Reduction: An Asian Perspective (Community, Environment and Disaster Risk Management, Volume 5)* (ed. R. Shaw), pp. 59-79. Emerald Group Publishing, Bingley, UK. doi: 10.1108/S2040-7262(2010)0000005010

Cambodia is one of the countries most vulnerable to climatic change, with flooding a primary concern along the Tonle Sap and Mekong Rivers. The National Committee for Disaster Management has the mandate for reducing risk, and disaster management committees have been established at provincial, district, and commune levels. Nevertheless, this study identified an urgent need for a more effective institutional framework in Cambodia. In particular, the Provincial Committees for Disaster Management require a partnership agreement and implementing guidelines to facilitate coordination and cooperation between the various committees, NGOs and international organisations. In addition, policy makers must rapidly increase their understanding of climate change issues and build capacity to agree and implement appropriate programmes. Author: huykyoto@gmail.com

WWF - World Wide Fund for Nature (2009) *The Greater Mekong and Climate Change: Biodiversity, Ecosystem Services and Development at Risk*. WWF Greater Mekong Programme, Bangkok, Thailand.

The Greater Mekong Region is exceptionally vulnerable to the impacts of climate change, and Cambodia and Laos are especially poorly equipped to cope with the consequences. Across the region, temperatures have already risen by 0.5-1.5 °C in the past 50 years, with further rises of 2-4 °C predicted over the next century. This report warns of increased droughts, flooding, crop failures, disease epidemics and water shortages. WWF recommends three climate change adaptation strategies: (i) protecting regional ecosystems, (ii) reducing additional stresses such as hydropower dams and over-extraction of natural resources, and (iii) implementing a regional climate change adaptation agreement. Online: http://assets.panda.org/downloads/final_cc_report_low_res.pdf

Yusuf, A.A. & Francisco, H. (2009) *Climate Change Vulnerability Mapping for Southeast Asia*. Economy and Environment Program for Southeast Asia (EEPSEA), Singapore.

This 26-page report provides information on the regions, districts and provinces most vulnerable to climate change impacts in Southeast Asia. The study entailed overlaying climate hazard maps, sensitivity maps and adaptive capacity maps in line with the vulnerability assessment framework of the United Nations' Inter-governmental Panel on Climate Change (IPCC). The results show that the most vulnerable regions in Southeast Asia are as follows: all of the Philippines; the Mekong River Delta in Vietnam; almost the whole of Cambodia; northern and eastern Laos; the Bangkok region of Thailand; and, in Indonesia, West Sumatra, South Sumatra, West Java and East Java. Within Cambodia, the most vulnerable provinces are Mondulkiri, Ratanakiri, and Kampong Speu, and the most resilient is Kratie. Author: arief.yusuf@fe.unpad.ac.id; Online: http://www.idrc.org/uploads/user-S/12483270391Mapping_Reportv02.pdf

Miscellaneous

Anonymous (2010) Pesticides – a threat to human health and wildlife in Cambodia. *The Babbler*, **35**, 37.

Dangerous and prohibited pesticides continue to be widely used in Cambodia. Over 90% of pesticide users have fallen ill from exposure to these chemicals. A survey revealed that most farmers were untrained in pesticide use and 89% were unaware that pesticides could be harmful. A major problem is that labelling on pesticides is rarely in Khmer. Besides their use in agriculture, pesticides are illegally used for hunting and fishing, incurring serious risks for both people and wildlife. Online: <http://birdlifeindochina.org/sites/default/files/Babbler%2035.pdf> [This article cites the *Wildlife Conservation Society* as its source - Ed.].

Giam, X., Ng, T.H., Yap, V.B. & Tan, H.T.V. (2010) The extent of undiscovered species in Southeast Asia. *Biodiversity Conservation*, **19**, 943-954.

Based on recent rates of discovery, this paper forecasts the number of species yet to be discovered in Southeast Asia, including Cambodia. Of the eight major taxa evaluated, amphibians, freshwater fishes, hawk moths, mammals, and leguminous plants were predicted to harbour the greatest proportions of unknown species, and more taxonomic research is required on these groups. Birds were considered to have the most complete inventory in this region, with far lower prospects of finding new species. Author: xgiam@princeton.edu; Online: <http://www.springerlink.com/content/y646106t55289523/fulltext.pdf>

Gillespie, J. (2009) Protecting World Heritage: regulating ownership and land use at Angkor Archaeological Park, Cambodia. *International Journal of Heritage Studies*, **15**, 338-354.

This paper considers how proprietary interests in land and land use are affected by a World Heritage listing, using the Angkor Archaeological Park as a case study. Listing was found to impose significant constraints on land use and ownership, directly impacting the resident communities of Angkor,

and the existing regulatory framework proved to be inadequate. Concepts of ownership can be complicated in a World Heritage Site of “outstanding universal value” and this paper highlights the challenges facing managers in trying to satisfy both local needs and the international expectations of a World Heritage Site. Author: jgil0729@usyd.edu.au

Hin, S., Bell, R.W., Newsome, D. & Seng V. (2010) Understanding variability in texture and acidity among sandy soils in Cambodia. *Paper presented to the 19th World Congress of Soil Science, Soil Solutions for a Changing World, 1–6 August, Brisbane, Australia.*

Cambodia is dominated by sandy soils. Samples were collected from different soil layers at eight sites in four provinces in eastern and southern Cambodia, and analysed for particle size distribution, soil pH and exchangeable Al. Close proximity to granite mountains (e.g. Phnom Aural) and the coast was associated with coarser sand fractions, while sandstone and quartzite parent rocks were associated with finer sands. Clay content was similar at most sites, being low in surface layers and generally higher below a depth of one metre. Soils tended to be acidic (pH 3.4–4.7) across all sites, but samples from Kampot and Ponhea Krek were distinguished by their high exchangeable Al (0.44–1.13 cmol/kg). Author: S.Hin@murdoch.edu.au; Online: <http://www.iuss.org/19th%20WCSS/symposium/pdf/2399.pdf>

Janjai, S., Pankaewa, P., Laksanaboonsonga, J. & Kitichantaropas, P. (2010) Estimation of solar radiation over Cambodia from long-term satellite data. *Renewable Energy*, **36**, 1214–1220.

Average daily global solar irradiation over Cambodia was estimated from satellite data (GMS5, GOES9 and MTSAT-1R) from 1995 to 2008, and a model was developed to estimate surface solar radiation. Five new solar radiation measuring stations were established in Siem Reap, Kompong Thom, Phnom Penh, Sihanoukville and Kampot cities to validate and refine the model. The resulting solar radiation maps for Cambodia showed that solar radiation is

strongly influenced by monsoons. Author: serm@su.ac.th

Sodhi, N.J. & Erlich, P.R. (eds) (2010) *Conservation Biology for All*. Oxford University Press, Oxford, UK.

This text book strives to “...provide cutting-edge but basic conservation science to a global readership”. Written by many top names in conservation, the book covers such topics as balancing conservation and human needs, climate change, conservation planning, designing and analysing conservation research, ecosystem services, endangered species management, extinctions, fire, habitat loss, and invasive species. Although there are few specific mentions of Cambodia, this will be a useful reference for Cambodian scholars and decision makers. Importantly, the book is freely available electronically (while the paperback version costs around \$70). Online: The complete book is at: http://www.dbs.nus.edu.sg/staff/details/sodhi/aConservation_Biology_for_All.pdf (6.2 Mb). Chapters can also be downloaded individually: <http://www.oxfordscholarship.com/oso/public/content/biology/9780199554232/toc.html>

Tran T.H. (2010) CEPF Mid-term assessment in Indo-Burma Hotspot. *The Babbler*, **35**, 4–8.

The Critical Ecosystem Partnership Fund (CEPF) launched a \$9.5 million, five year investment plan in the Indo-Burma Hotspot in July 2008. Sixty grants were awarded in the first two years, most of less than \$20,000. National meetings have been held to evaluate the progress made towards achieving the goals set out in the CEPF Ecosystem Profile and to identify additional funding priorities. Another call for proposals was issued in August 2010. Author: huong@birdlife.org.vn; Online: <http://birdlifeindochina.org/sites/default/files/Babbler%2035.pdf> [*This issue of The Babbler also contains brief progress reports from the following CEPF-supported projects in Cambodia: “Research and Conservation Action for Tortoises and Freshwater Turtles in Indochina” (Conservation International); “Freshwater Biodiversity Assessments in the Indo-Burma Biodiversity Hotspot: Fishes, Molluscs, Odonates and Plants” (IUCN); “Protecting*

the Biological Diversity of the Mekong River (International Rivers Network); and *Assessment of the Status and Distribution of Globally Threatened Plant Species in Indochina* (Missouri Botanical Garden)].

VBNK & Results Based Management Group (2010) *Cambodia Country Study Report: Phase Two Evaluation of the Paris Declaration*. Unpublished report to the Council for the Development of Cambodia, Royal Government of Cambodia, Phnom Penh, Cambodia.

This study evaluates the development outcomes, including poverty reduction, associated with implementing the Paris Declaration in Cambodia. The report covers many aspects of economic and social development, but highlights the importance of conserving natural resources and the need for environmental sustainability. For example, the report concludes that Cambodia's ongoing dependency on wood and charcoal for 80% of its energy consumption is "a major driver for deforestation and

a barrier to livelihood development and security." A table shows that investment by NGOs and development partners in the environment in Cambodia rose from US\$3.4 million in 2008 to US\$7 million in 2009 (but represented only 3.4% of the total funding invested in Cambodia in that year). Online: http://www.cdc-crdb.gov.kh/evaluation/final_cambodia_country_study_report.pdf

The Recent Literature section was compiled by JENNY C. DALTRY, with additional contributions from Tom Dacey, Neil Furey, Markus Handschuh, Amy Hinsley, Neang Thy, Eric Neilson and Tran Thanh Huong. All Internet addresses were correct at the time of publication. Please send contributions (published or grey literature, including project technical reports and conference abstracts) dated 2010 or 2011 by email to: Editor. CJNH@gmail.com

Instructions for Authors

Purpose and Scope

The *Cambodian Journal of Natural History* is a free journal that is published biannually by the Centre for Biodiversity Conservation at the Royal University of Phnom Penh. The Centre for Biodiversity Conservation is a non-profit making unit, dedicated to training Cambodian biologists and the study and conservation of Cambodia's biodiversity.

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

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

The Journal especially welcomes material that enhances understanding of conservation needs and has the potential to improve conservation management in Cambodia.

The primary language of the Journal is English. Authors are, however, encouraged to provide a Khmer translation of their abstract.

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The Journal's readers include conservation professionals, academics, government departments, non-governmental organizations, students, and interested members of the public, both in Cambodia and overseas. In addition to printed copies, the Journal is freely available online.

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- Research on the status or ecology of habitats.

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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.

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

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

Preparation of Manuscripts

Authors should consult examples in this issue for general style. Full papers follow a similar style to those in *Oryx – The International Journal of Conserva-*

tion. Contributions should be in English, with UK English spelling (if in doubt, Microsoft Word and similar software should be set to check spelling and grammar for 'English (UK)' language). Manuscripts should be double-spaced. Submissions can be in 'doc', 'docx', 'rtf' or 'wpd' format, preferably as one file attached to one covering email. The order of the sections of the manuscript should be: cover page, main text, references, short biography of each author, tables, figures and plates (photographs). The cover page should contain the title and full mailing address and email address of the Lead Author and the addresses of all co-authors. All pages should be numbered consecutively.

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

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

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

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

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

The following are examples of house style:

Papers:

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

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

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

Books and chapters:

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

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

Rawson, B. (2010) The status of Cambodia primates. In *Conservation of Primates in Indochina* (eds T. Nadler, B. Rawson & Van N.T.), pp. 17-25. Frankfurt Zoological Society, Frankfurt, Germany, and Conservation International, Hanoi, Vietnam.

Reports:

Lic V., Sun H., Hing C. & Dioli, M. (1995) *A brief field visit to Mondolkiri Province to collect data on kouprey (Bos sauveli), rare wildlife and for field training*. Unpublished report to Canada Fund and IUCN, Phnom Penh, Cambodia.

Theses:

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

Websites:

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

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

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

Appendices: Long tables and 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.

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