Cambodian Journal of Natural History

Siamese crocodile status and ecology

New plants, ants and herpetofauna

Rotifers and freshwater quality

Sarus cranes

October 2015 Vol. 2015 No. 2

Cambodian Journal of Natural History

ISSN 2226–969X

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

Cover image: This Siamese crocodile was bred in captivity and released in Koh Kong Province in 2014 as part of a pilot project to reinforce Cambodia's depleted wild populations (© Jeremy Holden). The status of this Critically Endangered species in Cambodia is explored by Sam *et al.* in this issue (pages 153–164).

Editorial — The status of botanical exploration and plant conservation in Cambodia

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Mainland Southeast Asia, including Cambodia, is a hotspot for rare and endemic biodiversity (Mittermeier *et al.*, 1999). Unfortunately, some 40% of the region's flora and fauna faces extinction by the end of this century, making it one of the world's most threatened areas for biodiversity (SCBD, 2010). Until the 1970s, Cambodia was a tranquil backwater in the heart of Indochina endowed with extensive forests whose valuable timber was largely unexploited. Cambodia was also noted for some of Southeast Asia's most important wetlands, including mangroves along the Gulf of Thailand.

Cambodia's protected area system is a legacy of its colonial past. By the end of their century-long rule, the French had turned about 20,000 km^2 into six wildlife reserves and roughly twice as much into 173 forest reserves (RGC, 2010; Poffenberger, 2013). An additional 10,800 ha was set aside around the temples of Angkor, which became Southeast Asia's first national park in 1925. Following independence in 1953, the Cambodian government took control of the wildlife reserves. The Khmer Rouge then abolished these in the 1970s and they remained forgotten for the next decade. It was not until the United Nations arrived in the 1990s that protected areas returned to the country. Conservationists reviewed the colonial protected area system, added lowland evergreen forests which were earlier largely ignored, and expanded what had been 20,000 km^2 to 33,000 km^2 (Poffenberger, 2013). In 1993, the year that democratic elections returned to Cambodia, King Norodom Sihanouk signed a royal decree creating 23 protected areas under the jurisdiction of the new Ministry of Environment. The Ministry of Agriculture, Forestry and Fisheries in time established nine others and today, 32 protected areas cover more than a quarter of the country's surface (Save Cambodia's Wildlife, 2014), making it one of the most extensive protected area management systems in Asia.

Various laws govern the management of the country's forests and protected areas, for example a Land Law was issued in 2001, a Forestry Law in 2002, a sub-decree on economic land concessions in 2005, and finally a Protected Areas Law in 2008. Between 1994 and 1997, timber concessions covering more than six million ha, equalling 35% of Cambodia's land area, were granted by the government and rapid deforestation ensued (Anon., 2004; RGC, 2010). During this period, however, logging concessions remained outside of protected areas, sparing them the worst of the decade's deforestation.

The recent history of Cambodian forest management has been turbulent. Following a decade of anarchic logging, the national concession system was suspended in 2001. However, the government soon began granting economic land concessions (ELCs) which allowed vast amounts of forest clearance for agro-industrial crops (Save Cambodia's Wildlife, 2014). ELCs started appearing in protected areas in 2008 and 2009 and by 2012, the Ministry of Environment had approved 113 ELCs inside its protected areas (ADHOC, 2012; HRC, 2012). New data on forest fires show that the ELCs are targeting the country's best forests (Forest Trends, 2015). According to the latter study, approximately 14% of Cambodia has been allocated to domestic and foreign corporations for development and around 80% of this land is inside protected areas and forest reserves. The latest U.S. MODIS/FIRMS satellite data show that forests inside Cambodia's protected areas are disappearing as fast as forests nationwide, which recently led to the term 'un-protected areas' being coined for the protected area system (Peter & Pheap, 2015).

Botanical research

Although many Cambodian people have a workable knowledge of their country's plants, scientifically it remains one of the least known floras in the region. The flora of Cambodia is closely related to that of its surrounding countries and the Malesiana Region. Connections with other areas are distinctly less important (Dy Phon, 1982). The number of plant species in Cambodia is unknown, but around 2,300–2,400 species are mentioned

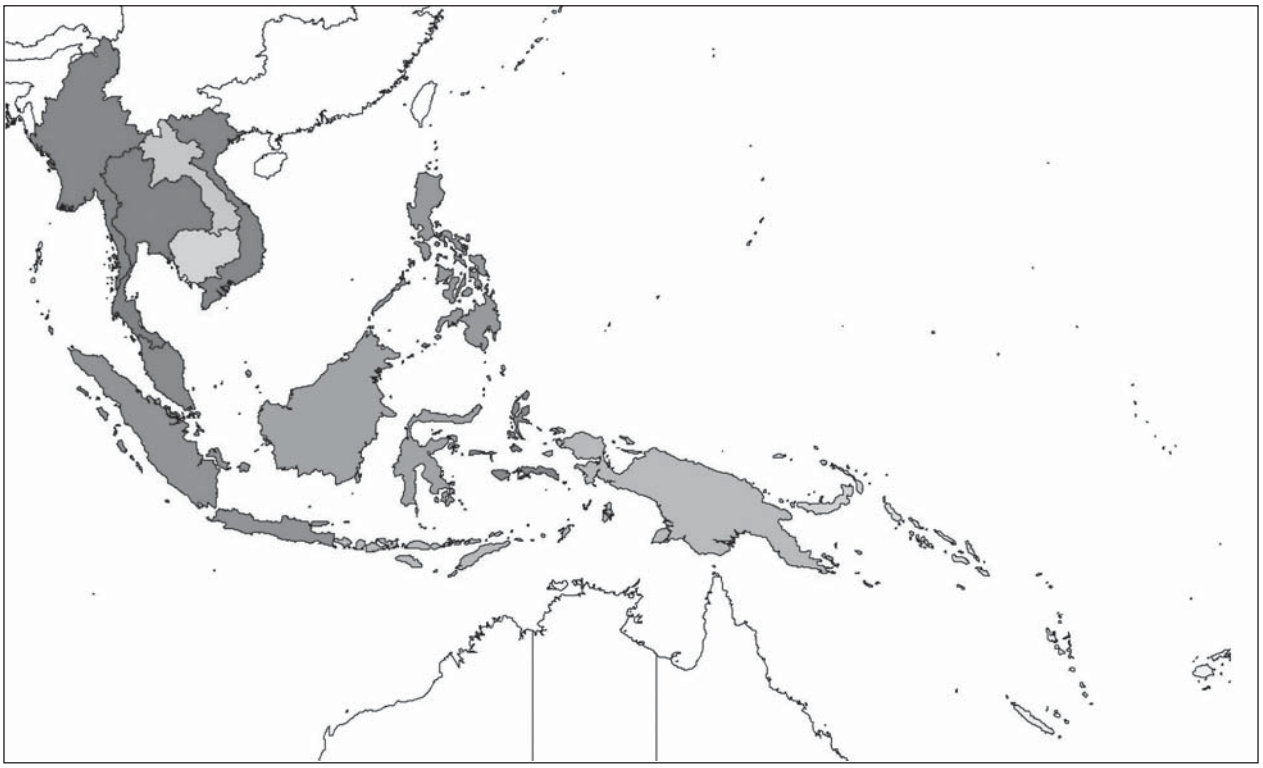

Fig. 1 Map of Southeast Asia showing generic diversity corrected for collecting intensity and area size (Marsh *et al.*, 2009). Generic diversity is shaded from light grey (poor) to dark grey (rich). (Areas in white are excluded from this analysis).

by Dy Phon (1982), Kimsan & Chetha (2013) and Webb *et al.* (2010), with around half of these occurring in Southwest Cambodia, particularly the Cardamom Mountains and Elephant Mountains. The number of endemic species is estimated to be around 5–10% (Dy Phon, 1982), while generic diversity is low with no endemic and about 686 native genera recorded. This low generic diversity is shared with Cambodia's northern neighbour Laos, which is also poorly known, but is in startling contrast with Thailand and Vietnam, which are some of the richest countries in the region in terms of their plant diversity (Figure 1, Marsch *et al.*, 2009). This difference is mainly attributable to the relatively flat landscape of Cambodia, but is also due to a lack of botanical research and low plant collection density, with only four collections per 100 km² for Cambodia versus 14 and 50 for Vietnam and Thailand respectively (Newman *et al.*, 2007).

The first western botanist to visit the country was the missionary Piere Poivre (1719–1786) whose collections now form part of the Jussieu herbarium in Paris. The first major plant collector was Clovis Thorel (1833–1911) who was part of the French Mekong Expedition (1866–1868). However, serious botanical explorations did not start until the 1870s and, in particular, after 1900, when J.B.L. Pierre (1833–1905), A.J.B. Chevalier (1873–1956) and later E. Poilane (1887–1964) began collecting on a large scale (Gagnepain, 1943). Many surveys and species lists were also published (Theilade *et al.*, 2011) and most of these collections are housed in Paris and Saigon (now Ho Chi Minh City), although others exist in herbaria across the world (Frodin, 2001). Although botanical surveys in Cambodia were disrupted from the Second World War to the end of the civil war in 1992, this effort resulted in a several landmark publications such as the *Flore Forestière de Cochinchine* (Pierre, 1879–1907) and the seven volumes of the *Flore Générale de l'Indo-Chine* (Lecomte, 1907–1950) and currently in the *Flore du Cambodge, du Laos et du Viêtnam* (Aubreville, 1960–present). The latter has now reached 34 installments, treating 84 families, and is the best resource for finding the correct names and information on plants in Cambodia. A field guide to the flora of Cambodia was also published in 2013, which includes 524 species (Leti *et al.*, 2013).

After seizing power in 1975, the Khmer Rouge destroyed all herbaria and libraries and smashed almost all laboratory equipment. They also shattered the education system and 97% of university students and graduates were killed. Of roughly 1,000 academics and intellectu-

als in the Royal University of Phnom Penh (RUPP), only 87 survived, none of whom were botanists. In 2011, the National Herbarium of Cambodia was established in the Department of Biology in the RUPP. This currently has some 12,500 specimens collected in Cambodia over the last 15 years and historical material repatriated by the Muséum National d'Histoire Naturelle, Paris. To illustrate what can be done by a competent botanist and a good herbarium in Cambodia, a single survey of the vegetation of islands on the Mekong River found one new species to science and 23 new country records (one for every 30 specimens collected) for Cambodia (Maxwell, 2009). Furthermore, 15 new country records are reported in this issue of the *Cambodian Journal of Natural History* alone (Schuiteman *et al.*, 2015; Tagane *et al.*, 2015a; Tagane *et al.*, 2015b).

Future prospects for plant conservation in Cambodia

Wet evergreen forests historically covered much the Cardamom and Elephant Mountains and parts of the Annamites adjacent to Vietnam, while evergreen, semi-evergreen and dry dipterocarp forests dominated Northern and central Cambodia (WWF, 2013). Sadly many of these forests, both inside and outside protected areas, have been cleared or severely fragmented and degraded, while only discontinuous bands of flooded forest and mangroves now remain. Furthermore, much of the remaining forest land is slated for conversion to other uses (Save Cambodia's Wildlife, 2014).

Deforestation remains high in the region and forest loss in Cambodia has accelerated faster than any other country in the world since 2001 (Global Forest Watch, 2015). Satellite data compiled by the University of Maryland affirm that the annual rate of forest loss in Cambodia since 2001 increased by 14.4%. Cambodia lost a total of 237,875 ha of tree cover in 2010. Subsequent rates of forest loss have declined, but the country still recorded a loss of 177,969 ha in 2014 (Global Forest Watch, 2015).

As part of global climate talks, the United Nations has promoted Reducing Emissions from Deforestation and Forest Degradation (REDD+). Under this programme, developing countries like Cambodia can potentially obtain financial support from donors to keep their forests and the carbon they store intact. REDD+ has been discussed in Cambodia for several years. In 2009, the country produced a Readiness Plan Idea Note (R-PIN) under the World Bank's Forest Carbon Partnership and in 2011, Cambodia produced its Readiness Preparation Proposal (R-PP). A REDD+ Readiness Roadmap has been developed with funding from UNDP and FAO. A consultation process has also been undertaken to involve NGOs and community representatives. Unfortunately, neither REDD+ nor FLEGT (Forest Law Enforcement, Governance and Trade) have had a substantial impact on the rate of deforestation in Cambodia. The REDD+ and FLEGT programmes, like protected areas, are so far seen as ineffective in preventing the root causes of deforestation, such as ELCs, logging, mining, quarrying and corruption (Forest Trends, 2015). Sadly, the rapid deforestation witnessed in Cambodia is mirrored across the entire Mekong Region. Forest cover loss in Cambodia, Thailand, Vietnam, Laos, Myanmar and China's Yunnan Province, rose by more than five times between 2001 and 2014 (WRI, 2015). Future projections are not promising, and suggest that the Greater Mekong Subregion, especially Cambodia, Myanmar and Laos, will continue to suffer elevated rates of forest loss (WWF, 2013).

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 (Bates, 2010). To ensure balanced national and sub-national land-use planning, the relevant legal, policy, and institutional frameworks need to be improved and revised, particularly if the government's National Forest Programme and any proposed FLEGT and REDD+ programmes are to be effective. First and foremost, government commitment at an altogether different level seems necessary to conserve the highly threatened biodiversity of Cambodia and the Greater Mekong Region. Urgent measures are needed to preserve Cambodia's unique natural heritage and curb deforestation. In this context, engaging indigenous and local communities is one of the most effective ways of protecting forests and restoring degraded ecosystems (Porter-Bolland *et al.*, 2012). Areas under the stewardship of indigenous peoples are some of the most pristine in the world. The way they live, the way they act, and the knowledge they have is part of the solution to conservation of biodiversity and sustainability (United Nations, 2015). We suggest a new conservation paradigm is needed to build on government-approved engagement of local communities and civil society in the management and conservation of the country's natural heritage.

We also believe that a more robust forest conservation strategy should encompass a regional vision including different land use types where social and economic needs of local inhabitants, as well as tenure rights and local capacities, are recognised. Further research to understand the institutional arrangements that derive from local governance in favour of tropical forest conservation is therefore recommended.

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Obituary— James Franklin Maxwell, 1945–2015

On 12 May 2015 we lost one of the most dedicated and talented—I should also say indefatigable—naturalists of the region. James F. Maxwell, or "Max", died apparently of a pulmonary failure in the forest while working on a project in Rayong Province, Southeast Thailand. He was doing what he loved to do, and what he was known to be best at. He would have wanted to die that way, as would many of us who love nature.

Maxwell came to Thailand in 1968 (the same year I did) while an enlisted man in the U.S. Army Military Police Corps, and was stationed at Sattahip (which had a B52 bomber base during the Vietnam War) in Southeast Thailand. By curious coincidence, I was also serving in the U.S. Army at the time (in the Medical Service Corps) and did field research in Southeast Thailand. Max, who had a bachelor's degree in botany from Ohio State University, developed a secret interest in collecting plants at that time. It soon became a compulsive life-long occupation, and after he was discharged from the army, he settled for a while in Sattahip, living with a Thai woman—a former Likay performer—and rapidly became an expert on the flora of the Southeast Thailand. His first botanical papers were on the flora of the Sattahip area. He fell in love with the plants of Thailand and never wanted to return to the USA. I didn't actually meet Max until 1974, after I had exited the army, worked in the USA for a while and then returned to Thailand to teach at Mahidol University.

I distinctly remember the days, May 22–23, whose events are carefully recorded in my field notes in India ink, with a map and sketches of new plants I learned. I was on a visit to the Khao Khieo Wildlife Sanctuary in Southeast Thailand to see some captive gibbons, and I ran into Max, who was inspecting the plants there. The next morning I walked with him on a trail through the forest, asking what was this and that, and taking notes. He pointed out to me *Ardisia solanacea*, *Ficus fistulosa*, *Phyllanthus colinense*, *Vitex limonifolia*, *Gigantochloa albociliata*, *Terminalia bellirica* and others. After my botany lesson, I headed up the mountain to search for pileated gibbons. I guess he was impressed that a zoologist could be so interested in learning about plants.

After this encounter Max and I became good friends, and I invited him many times to come on my undergraduate ecology field trips to study forest, beach, mangrove and other vegetation. In fact, I designed most of my ecology exercises as vegetation study and sampling exercises just to take advantage of Max's unique ability and insatiable desire to identify and collect every plant

Fig. 1 James Franklin Maxwell "Max" in Chiang Mai, June 2006 (© Greg Ballmer).

around. All of the university students loved Max, with his saucy and often irreverent comments, and because he really enjoyed what he did and made it fun for all.

Max was a one-off character whose frank and honest opinions were entertaining and refreshing to those who befriended him. However, he was not universally liked by forestry and university officials who were made uncomfortable by what they perceived as a lack of proper respect and decorum. His friends, however, just accepted this as part of Max and never took any offence. But students and colleagues alike respected Max most for his inexhaustible energy for fieldwork and dedicated commitment to his work. Throughout his life he never wavered from his mission of filling up herbaria with his meticulously collected and annotated specimens. Plant systematists throughout the world know Maxwell through his collections with detailed notes for which I have heard many appreciative comments.

When I first met Max he was working in the Department of Agriculture Herbarium located on the campus of Kasetsart University. After 1975 he held a series of other jobs, mostly at herbaria which he built up. He received a M.Sc. degree in botany from the University of Singapore in 1978 and was curator of the Gardens Herbarium of Singapore from 1980 to 1984. Returning to Thailand, he worked in the Prince of Songkla University (in Hat

Yai, southern Thailand) 1984–1987, Faculty of Pharmacy of Chiang Mai University (CMU) 1987–1991, and then the Department of Biology at CMU from 1992 until he died. In Chiang Mai he lived with his wonderful loving wife, Sai Jai, who made sure he had clean ironed shirts to wear on campus. Most of Max's shirts bore the stains and tears of a dozen years of sweaty fieldwork.

Max built up the CMU (Biology) herbarium into a uniquely valuable collection that served students and faculty in the biology department, as well as people in other institutions and foreign countries needing botanical help. He was given the top floor of a building to house it and manage it, but was paid no salary, even though he served on dissertation committees and collaborated in numerous research projects, especially the Forest Restoration Research Unit (FORRU), which depended heavily on Maxwell's extensive knowledge and collections of the flora of Doi Suthep–Pui Mountain. In a way, the Biology Department and CMU took advantage of Max by not offering him a position and salary: he was expected to support himself with outside jobs and consulting work, which he fortunately found no shortage of. That was the deal, and Max had to accept his situation, although he resented not having any formal recognition or remuneration for all his contributions. In any event, no official could "fire" Max from his position, or lack thereof, if they had wanted to.

I worked with Max on several major projects which also helped support him. One was an inventory of teak forests in Mae Yom National Park as part of a brief World Bank assessment of the ecological effects of the proposed Kaeng Sua Ten Dam in northern Thailand. More recently, Max finished the collection and identification of the flora of the Mo Singto forest dynamics plot in Khao Yai National Park, which will be published soon. Without Max, this work could not have been completed with such perfectionism and professionalism. Jim LaFrankie, who worked on most of the tropical Asian plots for the Center for Tropical Forest Science (CTFS) for many years, once remarked that the Mo Singto plot was probably the best-collected and vouchered plot in the network. Although the Mo Singto plot is by no means the most species-rich, this is still quite a compliment for which credit can be given to Maxwell. There are no "unidents" (unidentified species) among the trees on our plot except for one *Polyalthia* species for which we are still awaiting a botanical description and name by an expert on this group.

Maxwell was considered by many to be the best general expert on the flora of Thailand, and perhaps also most of Laos and Cambodia, with which he became involved in later years. Max made a great contribution to the establishment of the National Herbarium of Cambodia in the Royal University of Phnom Penh. On his frequent visits he was always presented with a large collection of specimens for identification, which he worked through with characteristic enthusiasm and humour. Max's identifications were considered to be reliable, because he kept up with the literature and also consulted many other experts from Europe and the USA who were specialists on particular genera. Max was also quick to correct his identifications when he obtained new information. He insisted that the names be corrected on all lists (which was quite impossible for lists that had already been printed or published). He was conservative in his use of names, however, sometimes refusing to give up old names, especially if newer revisions were based on molecular evidence or newer cladistic methods. Max did not trust molecular evidence, which resulted in many friendly arguments between us over names of Khao Yai plants in e-mails and during our late-night "drinkathons". It became clear that Max did not believe in evolutionary taxonomy, preferring to stick with the traditional classification based on simple morphological similarity, and refusing to let go of such names as the now-obsolete "Guttiferae".

Fig. 2 Max preparing a plant collection in the field at Phnom Samkos Wildlife Sanctuary, Southwest Cambodia in March, 2015 (© Ida Theilade).

The last project that engaged Max, carried out by the Faculty of Environment of Mahidol University, was a comparison of woody plants regenerating in an abandoned rubber plantation with those growing in a nearby logged and somewhat degraded primary forest, in Rayong Province. This project was supported by the Petroleum Authority of Thailand (PTT) on or near their property. My role was to establish and implement the

sampling protocol and his was, as usual, to collect and identify all the plants. Max jumped at the chance to do more work in the Southeast near his original stamping grounds. Aided by his former student and assistant Jang (Onuma), he was able to complete the exercise, but exerted himself too much on his second and last field trip. Those who worked with Max know that he would not call it a day until he was forced to by rain, darkness, or a completely full plant press.

As our later drinkathons wore on and Max became high on Thai whisky, he would become more vociferous in his complaints that my herbarium at BIOTEC was becoming disorganized and my assistants were not carrying out his instructions properly. But Max taught me and my assistants many important things during the times we were together. Here are some lessons we learned:

1. Without good voucher specimens and well-run herbaria, the flora of an area will never be known properly, no matter what methods are used in identification or classification. (Max taught all my field assistants and I how to collect and properly annotate specimens).
2. Accurate identification of plants is vital to ecological work, and without their correct names, no research on plants has much validity.
3. Collection and identification of plants is the most time-consuming part of establishing a large plot, and is a continuing effort. Documenting the local flora cannot be carried out by botanists that have become administrators who spend most of their time sitting at desks: it requires dedicated field botanists.
4. A person's true worth is not measured by his or her degree, position or dress.
5. Say and do what you think is right and don't be concerned about what others think of you.

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Association for Tropical Biology and Conservation

The Phnom Penh Declaration: Importance of Environmental and Social Impact Assessments prior to infrastructure development in the Mondulkiri Protected Forest and other Cambodian biodiversity hotspots

The 300 participants from 29 countries who attended the meeting of the Asia-Pacific Chapter of the Association for Tropical Biology and Conservation (ATBC) held in Phnom Penh from 30 March to 2 April, 2015, organized under the main theme of *The Future of Biodiversity in Tropical Asia: Addressing Local and Global Challenges*,

1. Appreciating that the forests, river systems and other natural environments of Southeast Asia are among the most biologically diverse and environmentally important ecosystems on the Earth,
2. Recognizing that the number and proportion of threatened, endangered, and critically endangered species of mammals, birds, reptiles, amphibians, and tree species is higher in Southeast Asia than in any other region of the planet,
3. Mindful of the dependency of the livelihood of rural people in Cambodia and its neighbouring countries on sustainable use of renewable biological resources, such as freshwater fishery and non-timber forest products from natural and semi-natural ecosystems,
4. Observing that a very large number of major infrastructure projects, such as new highways, roads, hydroelectric dams, power lines, gas lines, and other energy projects, are currently being planned or are under construction in Southeast Asia,
5. Mindful that roads constructed by logging, industrial crop and infrastructure projects have been shown to sharply increase rates of immigration, non-sustainable resource overexploitation, deforestation, forest burning, poaching, illegal wildlife trade, and other serious environmental impacts,
6. Concerned that forest degradation, deforestation and land conversion threatens ecosystem services provided by forests, such as a steady supply of water, climate regulation, moderation of heat waves, soil conservation and traditional forest products,
7. Welcoming the efforts by the Royal Government of Cambodia to review and revise national land allocation policies to meet the challenge of balancing the welfare of rural people, economic development, and conservation of its natural and cultural heritages,

Make the following recommendations,

a. To work together to strengthen the decision support tools and information available that enable prioritization and decision about the best location of infrastructure projects,

b. To conduct thorough environmental and social impact assessments as part of infrastructure development in areas particularly important for conservation of biodiversity and ecosystem services,

c. To consider the views from multiple stakeholders while evaluating potential trade-offs associated with infrastructure development,

d. To carefully evaluate the alternatives and follow with the developmental plan that minimizes the environmental impacts,

e. In particular, to conduct a thorough environmental impact assessment and consider alternative developmental plans to the proposed Srea Ampos–Kbal Damrei Road in Mondulkiri Protected Forest, and any other road proposed to be built in a Protection Forest in Cambodia for the reasons detailed below.

The Mondulkiri Protected Forest is a globally important protected area that supports some of the most threatened species in Asia. The construction of the Srea Ampos–Kbal Damrei Road would require deforesting 36 kilometres of

protected forest, including 19 kilometres within the designated Special Ecosystem Zone, which forms the core of the largest area of lowland deciduous dipterocarp forest remaining in Southeast Asia.

The Mondulkiri Protected Forest provides Cambodia with substantial natural resources and ecosystem services. In addition, it has unique and global significance for biodiversity, given that it supports the world's largest population of banteng *Bos javanicus*, the largest population of leopards *Panthera pardus* in Indochina, and more than 230 bird species, including nine species listed by the IUCN as Globally Threatened.

The Special Ecosystem Zone sustains more than 150 individuals of Asian elephants *Elephas maximus*, representing the largest population in Cambodia. This population moves across the route of the proposed road as part of their annual migrations.

The current road development plan poses a high risk of diminishing the opportunity for sustainable, nature-based tourism that would be critical to secure long-term economic returns to local communities and the provincial government.

In conclusion, we recommend thorough environmental impact assessment and wise planning based on it, which may entail cancellation of road proposals for Mondulkiri Province, and other Protection Forests, and development of alternative plans, in order to minimize damage to the natural capital of Cambodia, and Southeast Asia.

Phnom Penh, 2nd April 2015

The Participants

សេចក្តីប្រកាសនៅទីក្រុងភ្នំពេញ៖ សារៈសំខាន់នៃការវាយតម្លៃផលប៉ះពាល់បរិស្ថាន និងសង្គមជាមុន មុនការអភិវឌ្ឍន៍ហេដ្ឋារចនាសម្ព័ន្ធក្នុងព្រៃការពារមណ្ឌលគីរី និងតំបន់ជីវៈចម្រុះកម្ពុជាសំខាន់ៗផ្សេងទៀត

មានអ្នកចូលរួម ៣០០នាក់ មកពី ២៩ប្រទេសបានចូលរួមការប្រជុំក្រុម Asia-Pacific Chapter របស់សមាគមជីវៈត្រូពិច និងអភិរក្ស (Association for Tropical Biology and Conservation-ATBC) ដែលបានប្រារព្ធក្នុងទីក្រុងភ្នំពេញ ពីថ្ងៃទី៣០ ខែមីនា ដល់ទី០២ ខែមេសា ឆ្នាំ២០១៥ ក្រោមប្រធានបទសំខាន់ "អនាគតនៃជីវៈចម្រុះក្នុងអាស៊ីត្រូពិច៖ ស្តីអំពីការខិតខំប្រឹងប្រែងថ្នាក់តំបន់និងថ្នាក់ពិភពលោក"

១. មានការដឹងគុណដែលព្រៃឈើ ប្រព័ន្ធទឹកទន្លេ និងបរិស្ថានធម្មជាតិផ្សេងទៀតនៃអាស៊ីអាគ្នេយ៍គឺជាហានប្រព័ន្ធដែលមានជីវៈចម្រុះខ្ពស់ និងមានសារៈប្រយោជន៍ខ្ពស់បំផុតនៅលើផែនដី

២. ការដឹងថាទាំងចំនួន និងសមាមាត្រនៃការគម្រាមកំហែង ភាពរងគ្រោះ (Endangered) និងភាពរងគ្រោះធ្ងន់ធ្ងរ (Critically Endangered) របស់ថនិកសត្វ បក្សី លូន ថលជលិកសត្វ និងដើមឈើគឺមានកម្រិតខ្ពស់ជាងគេក្នុងតំបន់អាស៊ីអាគ្នេយ៍បើធៀបនឹងតំបន់ផ្សេងទៀតនៃផែនដី

៣. ការដឹងពីភាពពំនាក់អាស្រ័យនៃជីវភាពប្រជាជនខ្មែរទីជនបទ និងរបស់ប្រទេសជិតខាង ទៅលើការប្រើប្រាស់ដោយនិរន្តរភាពនៃធនធានជីវសាស្ត្រប្រើប្រាស់ឡើងវិញ មានដូចជាការនេសាទទឹកសាប និងអនុផលព្រៃឈើ ដែលបានមកពីហានប្រព័ន្ធធម្មជាតិ និងពាក់កណ្តាលធម្មជាតិ (semi-natural ecosystems)

៤. ការសង្កេតឃើញថា មួយចំនួនធំនៃគម្រោងហេដ្ឋារចនាសម្ព័ន្ធធំៗ រួមមានមហាវិថី ផ្លូវ ទំនប់វារីអគ្គិសនី ខ្សែអគ្គិសនី បំពង់ឧស្ម័ន និងគម្រោងថាមពលផ្សេងៗ គឺត្រូវបាននឹងកំពុងត្រូវមានគម្រោងធ្វើឡើងឬត្រូវបាននឹងកំពុងសាសង់នៅអាស៊ីអាគ្នេយ៍

៥. ផ្លូវថ្នល់ដែលសាងសង់ឡើងដោយសកម្មភាពកាប់ឈើ ដំណាំឧស្សាហកម្ម និងគម្រោងហេដ្ឋារចនាសម្ព័ន្ធ ត្រូវបានគេដឹងថាវាធ្វើឲ្យមានអត្រាអន្តោប្រវេស៍កើនឡើងយ៉ាងឆាប់រហ័ស ការដកហូតធនធានហួសកំណត់ និងគ្មាននិរន្តរភាព ការកាប់បំផ្លាញព្រៃឈើ ការដុតព្រៃ ដាក់អន្ទាក់ ការជួញដូរសត្វព្រៃខុសច្បាប់ និងផលប៉ះពាល់បរិស្ថានធ្ងន់ធ្ងរផ្សេងទៀត

៦. ការព្រួយបារម្ភណ៍ដោយការធ្វើឲ្យខូចគុណភាពព្រៃឈើ ការកាប់បំផ្លាញព្រៃឈើ និងការកែប្រែដីធ្វើឲ្យមានការគម្រាមកំហែងដល់សេវាកម្មបរិស្ថានដែលបង្កើតឡើងដោយព្រៃឈើ មានដូចជាការផ្គត់ផ្គង់ទឹកឲ្យទៀតទាត់ តម្រូវអាកាសធាតុ បន្ថយកំដៅ ការពារគុណភាពដី និងផ្តល់ទិន្នផលព្រៃបៃបប្រពៃណី

៧. ការស្វាគមន៍ការខំប្រឹងប្រែងរបស់រាជរដ្ឋាភិបាលកម្ពុជាចំពោះការរំលឹក និងការសើរើគោលនយោបាយដីធ្លីដើម្បីឆ្លើយតបទៅនឹងការប្រឈមនៃតុល្យភាពសុខុមាលភាពរបស់ប្រជាជននៅទីជនបទ ការអភិវឌ្ឍសេដ្ឋកិច្ច និងការអភិរក្សមរតកធម្មជាតិ និងវប្បធម៌

ការផ្តល់អនុសាសន៍

a. **ធ្វើការរួមគ្នាដើម្បីពង្រឹងការសម្រេចចិត្តគាំទ្រ និងព័ត៌មានដែលអាចធ្វើអាទិកម្ម និងការសម្រេចចិត្តលើទីតាំងដែលល្អបំផុតសម្រាប់គម្រោងហេដ្ឋារចនាសម្ព័ន្ធ**

b. **អនុវត្តឬត់ចត់នូវការវាយតម្លៃផលប៉ះពាល់បរិស្ថាន និងសង្គមលើគម្រោងហេដ្ឋារចនាសម្ព័ន្ធនៅក្នុងតំបន់អភិរក្ស ជីវៈចម្រុះ និងសេវាកម្មបរិស្ថានសំខាន់ៗ**

c. **ពិចារណាលើទស្សនៈរបស់អ្នកពាក់ព័ន្ធក្នុងកំឡុងពេលថ្លឹងថ្លែងអត្ថប្រយោជន៍សំខាន់ៗទាក់ទងទៅនឹងការអភិវឌ្ឍន៍ហេដ្ឋារចនាសម្ព័ន**

d. **វាយតម្លៃដោយប្រុងប្រយ័ត្នលើជម្រើសផ្សេងៗ និងបន្តជាមួយគម្រោងអភិវឌ្ឍន៍ដើម្បីការបន្ថយផលប៉ះពាល់បរិស្ថាន**

e. **ជាគោលដៅ គឺដើម្បីអនុវត្តឲ្យបានឬត់ចត់នូវការវាយតម្លៃផលប៉ះពាល់បរិស្ថាន និងពិចារណាលើគម្រោងអភិវឌ្ឍន៍ដែលជាជម្រើសផ្សេងទៀតដើម្បីឆ្លើយនឹងសំណើធ្វើផ្លូវ ស្រែអំពស-ក្បាលដំរី (Srea Ampos - Kbal Damrei Road) ក្នុងព្រៃការពារមណ្ឌលគីរី និងសម្រាប់ផ្លូវស្នើឡើងផ្សេងៗទៀតដែលនឹងត្រូវធ្វើក្នុងព្រៃការពារនៃប្រទេសកម្ពុជា ក្នុងមូលហេតុលម្អិតដូចខាងក្រោម៖**

ព្រៃការពារមណ្ឌលគីរីគឺជាតំបន់ការពារដែលមានសារៈសំខាន់ជាសាកល វាទ្រទ្រង់ប្រភេទរងការគម្រាមកំហែងមួយចំនួននៅ អាស៊ី។ ការកសាងផ្លូវ ស្រែអំពស-ក្បាលដំរី នឹងតម្រូវឲ្យមានការកាប់ព្រៃការពារដែលមានប្រវែង ៣៦គ.ម ដែលក្នុងនោះ ១៩ គ.ម ស្ថិតក្នុងតំបន់ហានប្រព័ន្ធពិសេស (Special Ecosystem Zone) ដែលវាជាតំបន់ស្នូលនៃតំបន់ព្រៃរបោះទំនាបធំជាងគេបំផុតសេសសល់នៅអាស៊ីអាគ្នេយ៍។

ព្រៃការពារមណ្ឌលគីរី ផ្តល់ឲ្យប្រទេសកម្ពុជានូវធនធានធម្មជាតិ និងសេវាកម្មបរិស្ថានសំខាន់ៗ។ លើសពីនេះ វាមានលក្ខណៈពិសេសសដោយឡែក និងជាសាកលសម្រាប់ជីវៈចម្រុះ ដែលធ្វើឲ្យវាជាជំរកនៃប៉ូពុយឡាស្សុងសត្វទន្សាង (*Bos javanicus*) ធំបំផុតមួយរបស់ពិភពលាក ប៉ូពុយឡាស្សុងខ្លារខិន (*Panthera pardus*) ធំបំផុតមួយក្នុងឥណ្ឌូចិន និងបក្សីជាង២៣០ប្រភេទ ដែលរួមមាន ៩ប្រភេទត្រូវបានចុះបញ្ជីដោយ IUCN ជាក្រុមរងការគម្រាមកំហែងជាសាកល (Globally Threatened) ។

តំបន់ហានប្រព័ន្ធពិសេស ជាជំរកសុវត្ថិភាពសម្រាប់ដំរីអាស៊ី (*Elephas maximus*) ជាង ១៥០ក្បាល តំណាងឲ្យប៉ូពុយឡាស្សុងធំជាងគេបំផុតក្នុងប្រទេសកម្ពុជា។ ប៉ូពុយឡាស្សុងនេះធ្វើដំណើជារៀងរាល់ឆ្នាំឆ្លងកាត់ផ្លូវដែលបានស្នើឡើង។

គម្រោងអភិវឌ្ឍផ្លូវនេះបង្កឲ្យមានហានិភ័យខ្ពស់ដែលធ្វើឲ្យបាត់ឱកាសនិរន្តរភាពទេសចរណ៍ធម្មជាតិដែលវាផ្តល់មកវិញនូវស្ថេរភាពសេដ្ឋកិច្ចក្នុងរយៈពេលយូរសម្រាប់សហគមន៍ និងរដ្ឋាភិបាលថ្នាក់ខេត្ត។

សរុបសេចក្តីមក យើងសូមផ្តល់អនុសាសន៍ឲ្យមានការវាយតម្លៃផលប៉ះផលបរិស្ថានឲ្យបានឬត់ចត់ និងបង្កើតគម្រោងប្រកបដោយភាពឈ្លាសវៃ នឹងអាចឈានទៅដល់ការលុបចោលសំណើធ្វើផ្លូវក្នុងខេត្តមណ្ឌលគីរី និងព្រៃការពារផ្សេងទៀត និងជ្រើសរើសយកជម្រើសផ្សេងទៀតក្នុងគោលបំណងបន្តយការខូចខាតធម្មជាតិដ៏ល្អឥតខ្ចោះនៃប្រទេសកម្ពុជា និង អាស៊ីអាគ្នេយ៍។

រាជធានីភ្នំពេញ,ថ្ងៃទី០២ ខែមេសា ឆ្នាំ២០១៥

អ្នកចូលរួម

News

Cambodian Entomology Initiatives: scientific training and education

Cambodia comprises a rich mosaic of biodiversity within the Indo-Burma Region. It possesses many ecosystems and habitats, including pristine forest remnants and the largest wetland systems in mainland Southeast Asia. Although scientific research on biodiversity is needed to inform conservation planning by the government and NGOs, entomology is understudied by scientists. This poses a problem because insects comprise much higher diversity and total biomass than vertebrates, and so constitute irreplaceable components of ecosystem processes vital for ecosystem health and functions.

As part of the '*Biodiversity of Cambodian Leaf- and Treehoppers: Scientific Training and Education through Development of Bioindicators and Agriculture Pest Control*' project, the Cambodian Entomology Initiatives (CEI) was created to enhance scientific training and education. The project is supported by USAID and collaborates with the Illinois Natural History Survey, University of Illinois, USA.

The goals of the project are to: (1) Establish and inventory a national entomological collection in the Department of Biology in the Royal University of Phnom Penh (RUPP); (2) Document the species diversity of the Cambodian insect fauna through education and research; and (3) Identify insect species that are critical agricultural pests and develop tools for pest identification, management and control.

To achieve these goals, CEI personnel have received training in insect sampling and identification and established an ongoing inventory focusing on leaf- and treehopper diversity in all habitat types. CEI will work closely with local and international NGOs such as the Centre for Biodiversity Conservation in the RUPP to build capacity in entomology. The first steps will be to create a national entomological collection and train the next generation of Cambodian entomologists. CEI will provide biodiversity data for use in conservation and will also contribute to food security by identifying insect pests and control strategies.

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Tenth Annual ATBC Asia-Pacific Chapter meeting

The 10th annual meeting of the Asia-Pacific Chapter of the Association for Tropical Biology and Conservation (ATBC) will be hosted by the National University of Singapore from 29 June to 2 July 2016. The meeting, *Conservation Asia 2016*, is being jointly organised with the Society for Conservation Biology Asia Section under the theme of "*Sustainable landscapes for people, business and biodiversity*".

To facilitate scientific exchange, the conference will encourage innovative symposium formats such as panel discussions, speed talks and debates, in addition to traditional 15 minute talks. A website (www.conservationasia2016.org) has been created to facilitate the event where it is possible to:

- Sign up for website and conference updates (Potential participants should sign up to make sure they get updates).
- Submit a proposal for a symposium.
- View the details of workshops being arranged (Proposals for additional workshops may be submitted to the training committee by contacting Dr Alice Hughes at asia2@tropicalbio.org).

Important dates include:

- 15 December 2015—Symposium proposal deadline
- 1 January 2016—Abstract submission and conference registration opens
- 28 February 2016—End of early bird registration
- 28 February 2016—Abstract submission closes
- 30 April 2016—Regular registration ends

If you plan to attend just one meeting next year, please consider attending Conservation Asia 2016.

Antony J. LYNAM, Chair, Asia-Pacific Chapter, Association for Tropical Biology and Conservation. Email asia@tropicalbio.org

Short Communication

A new record of *Aphyllorchis pallida* (Orchidaceae) from Cambodia

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Paper submitted 2 December 2014, revised manuscript accepted 30 June 2015.

Aphyllorchis is a holomycoheterotrophic orchid genus that includes 20–30 species distributed mainly in tropical Asia, with two species extending to Australia (Averyanov, 2006, 2011; Sittisujjiatham, 2006; Fan *et al.*, 2011; Wood *et al.*, 2011; Govaerts, 2014). Although the genus was previously unrecorded in Cambodia, we discovered *Aphyllorchis pallida* Blume in Bokor National Park, Kampot Province, southern Cambodia during field surveys between 2011 and 2013. We hereby document the occurrence of *A. pallida* in Cambodia as a new country record. The following description is based on our Cambodian material. Given that we observed only two specimens, a greater range in variation can be expected in the population.

***Aphyllorchis pallida* Blume, Tab. Pl. Jav. Orchid. t. 16, f. 77 (1825).**

Holomycoheterotrophic herb, ca. 30 cm tall, all parts glabrous. Roots spreading, up to 9.5 cm long. Rhizome short, clothed with small scales, bearing roots. Stem erect, terete, light brown mottled with purple, with several sheaths which are dense at the base and sparse at the upper part. Inflorescence terminal, erect, racemous, with ten flowers, rachis 4.5 cm long. Bracts ovate, 3.5–4.0 mm long, 1.5 mm wide, acuminate, cream with purple stripes and spots. Flowers ca. 4 mm across, not opening widely, nodding, cream, mottled with purple on the abaxial surface of sepals and petals and also on the pedicel and ovary. Pedicel and ovary clavate-fusiform, 8 mm long. Dorsal sepal concave, oblong, ca. 4.8 by 1.0 mm, apex acute; lateral sepals oblong-ovate, ca. 4 by 1.3 mm, apex acute, petals elliptic-oblong, slightly oblique, ca. 4.5 by 2.1 mm, apex obtuse, 1-veined; lip ca. > 4 by 2 mm, contracted into epichile and hypochile; hypochile concave, ca. 1.3 mm long, epichile 3-lobed, 2.6 mm long, apical lobe ca. 1.3 by 1 mm, apically thickened, lateral lobes ca. 1 by 1.3 mm. Column obovoid-cylindrical, slightly arcuate, 1.8 mm long (Figure 1).

Examined specimen: Cambodia, Kampot Province, Bokor National Park, evergreen forest around sphagnum bog, 10°39′19.53″N, 104°03′36.61″E, alt. 928 m, 9 May 2012, *Toyama H., Tagane S., Mishima T., Tagawa K., Zang M., Chhang P., Iwanaga F., Nagamasu H. & Yahara T. 2829*, deposited in the Forest Administration herbarium in Cambodia.

Distribution: Cambodia (new record), China (Hainan), Indonesia (Java, Sumatra), Malaysia (Borneo, Peninsula), the Philippines, Singapore, Thailand, Vietnam (Dak Lak, Lam Dong, Khanh Hoa Province [Hon Ba Nature

CITATION: Tagane, S., Yukawa, T., Chhang P., Ogura-Tsujita, Y., Toyama, H. & Yahara, T. (2015) A new record of *Aphyllorchis pallida* (Orchidaceae) from Cambodia. *Cambodian Journal of Natural History*, **2015**, 128–130.

Fig. 1 *Aphyllorchis pallida* Blume, 9 May 2012, Bokor National Park: (a) Habit, (b) Lateral view, (c) Flower, front view.

Reserve, alt. 1,204 m, 12°07′29.45″N, 108°57′51.11″E, 20 July 2013, *Tagane et al. V566*, VNM; ibid, *Tagane et al. V682*, VNM]) (Backer & van den Brink Jr., 1968; Averyanov, 2006, 2011; Chong *et al.*, 2009; Fan *et al.*, 2011; Pedersen *et al.*, 2014).

Habitat and ecology: Two individuals were found in a small population in the wet understory of tropical lower montane forest on the plateau of Bokor National Park, dominated by *Ardisia sanguinolenta* Blume, *Calamus palustris* Griff., *Calophyllum tetrapterum* Miq., *Dacrycarpus imbricatus* (Blume) de Laub., *Dacrydium elatum* (Roxb.) Wall. ex Hook., *Daemonorops jenkinsiana* (Griff.) Mart., *Ilex wallichii* Hook.f., *Plectocomia pierreana* Becc., *Rapanea neriifolia* var. *macrocarpa* (Pit.) C.M. Hu, *Rhaphiolepis indica* (L.) Lindl., *Syzygium formosum* (Wall.) Mason, and *Tristaniopsis merguensis* (Griff.) Peter G. Wilson & J.T. Waterhouse (Figure 2). The forest vegetation is somewhat similar to Sunderland heath forest (or Kerangas forest) and occurs on flat landscapes with acidic sandy soil waterlogged in the rainy season (Rundel, 1999; Rundel *et al.*, 2003). Although we found only two individuals, similar habitats are widespread on the plateau of Bokor National Park and thus this species may be found more widely. The flowering time is in early May.

Conservation status: *Aphyllorchis pallida* has not been assessed by the *IUCN Red List of Threatened Species* (IUCN, 2014). It is widespread in Southeast Asia, but in Cambodia the species is only known from the single population where the aforementioned specimen was collected. As the forests of Bokor Mountain have deteriorated rapidly under increasing pressure from resort development (Kowalczyk, 2009; Kosterin, 2012), dedicated attention is needed to conserve the Cambodian population.

Fig. 2 Habitat of *Aphyllorchis pallida* in Bokor National Park, Cambodia: (a) Forest stand, (b) Understory.

Acknowledgements

The authors would like to thank the Cambodian Ministry of the Environment and Ministry of Agriculture, Forestry and Fisheries for permitting our botanical inventories in Bokor National Park and staff from these organisations who assisted our field surveys. This study was supported by the Environment Research and Technology Development Fund (S9) of the Japanese Ministry of the Environment and also by a JSPS grant from the Global Center of Excellence Program '*Asian Conservation Ecology as a basis of human-nature mutualism*'.

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Short Communication

New records of Orchidaceae from Cambodia I

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Paper submitted 11 February 2015, revised manuscript accepted 7 July 2015.

The orchid flora of Cambodia is still inadequately known. In the most recent enumeration (Seidenfaden, 1992), 164 species were listed for the country. More species have been discovered since, especially by Cedric Jancloes and Marpha Telepova (pers. comm.), but relatively few records have been formally published (Telepova, 2009, 2013; Averyanov, 2013). It is also worth noting that 21 species of Cambodian orchids, some of which represent new records for the country, are described by Leti *et al.* (2013) and illustrated with colour photographs. Considering the high orchid species richness of the neighbouring countries of Thailand, Laos and Vietnam, it is probably a conservative estimate that at least 500 orchid species occur naturally in Cambodia.

Apart from the inaccessibility of some suitable habitats, a major problem facing orchid researchers is the highly seasonal flowering patterns of most orchids in the monsoon regions of tropical Asia. Many species flower either at the beginning or the end of the dry season, and others only during the rainy season, when access to their habitats can be difficult. In addition, because the flowers of several species last only one or a few days, they are rarely seen in flower by short-term visitors, which most researchers tend to be. Consequently, repeated visits to the same area in different times of the year would normally be required to obtain an adequate inventory of a local orchid flora. This can be costly and time-consuming.

An alternative method is to collect living specimens, which are then grown under controlled climate conditions, such as a greenhouse, until they flower. At that time they can be photographed, preserved and identified. While not all orchids are amenable to cultivation (most holomycotrophic species are not), the majority are not difficult to grow at least long enough to induce them to flower. With these considerations in mind, staff from the Royal Botanic Gardens, Kew, UK, and the Forestry Administration, Cambodia, conducted a field survey of orchids in a small part of the Cardamom Mountains in November–December 2013. In addition to herbarium and spirit samples, carefully selected living plants were collected for cultivation at Kew. As these come into flower, new records are turning up, as expected. The first selection of a dozen species is discussed below. In the interests of conservation we do not provide exact localities here. Of these 12 species, only three (*Dendrobium reflexitepalum*, *Podochilus lucescens* and *Thecostele alata*) were seen in flower during our field trip, all the others revealed their identity in cultivation, demonstrating the usefulness of living collections. In the notes below, information on species distribution ranges are generally based on Govaerts *et al.* (2015).

Species recorded

***Coelogyne filipeda* Gagnep. (Kew cult. 2013-1703; Fig. 1)**

This species was found as an epiphyte in rather dry evergreen forest with little undergrowth, at c. 900 m altitude. It is a species of the section *Elatae* that was previously known only from Vietnam (Annam) at c. 1,500 m (George & George, 2011). The original description was based on

CITATION: Schuiteman, A., Ryan, C. & Nut M. (2015) New records of Orchidaceae from Cambodia I. *Cambodian Journal of Natural History*, **2015**, 131–138.

Fig. 1 *Coelogyne filipeda* Gagnep. Inflorescence. Kew cult. 2013-1703.

Fig. 2 *Coelogyne pallens* Ridl. In situ.

Fig. 3 *Coelogyne pallens* Ridl. Flower. Kew cult. 2013-1666.

Fig. 4 *Dendrobium reflexitepalum* J.J.Sm. In situ.

Fig. 5 *Dendrobium reflexitepalum* J.J.Sm. Flowering stem. Kew cult. 2013-1580.

Fig. 6 *Micropera thailandica* (Seidenf. & Smitinand) Garay. In situ.

Fig. 7 *Micropera thailandica* (Seidenf. & Smitinand) Garay. Inflorescence. Kew cult. 2013-1763.

Fig. 8 *Pennilabium acuminatum* (Ridl.) Holttum. In situ.

Fig. 9 *Pennilabium acuminatum* (Ridl.) Holttum. Flower. Kew cult. 2013-1737.

Fig. 10 *Podochilus lucescens* Blume. In situ.

Fig. 11 *Podochilus lucescens* Blume. Flowering stem. Kew cult. 2013-1692.

Fig. 14 *Thecostele alata* (Roxb.) Parish & Rchb.f. In situ.

Fig. 12 *Podochilus microphyllus* Lindl. In situ.

Fig. 13 *Podochilus microphyllus* Lindl. Flowering stem. Kew cult. 2013-1642.

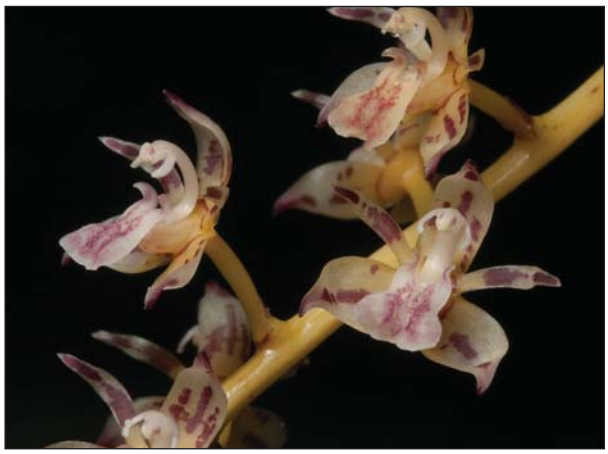

Fig. 15 *Thecostele alata* (Roxb.) Parish & Rchb.f. Flowers. Kew cult. 2013-1577.

Fig. 16 *Thelasis perpusilla* (Parish & Rchb.f.) Schuit. In situ.

Fig. 17 *Thelasis perpusilla* (Parish & Rchb.f.) Schuit. Flowering plant. Kew cult. 2013-1711.

Fig. 18 *Thrixspermum filiforme* (Hook.f.) Kuntze. In situ.

Fig. 19 *Thrixspermum filiforme* (Hook.f.) Kuntze. Flower. Kew cult. 2013-1637.

Fig. 20 *Trichotosia dasyphylla* (Parish & Rchb.f.) Kraenzl. Flowering plant. Kew cult. 2013-1710.

a watercolour painting by Eberhard, not an actual specimen, and it would seem that some of the details, such as the spreading sidelobes of the lip shown in the painting, are perhaps not accurate. This makes our identification slightly uncertain, and a comparison with specimens from the type locality would be desirable. Our specimen definitely belongs to the same species as the plant labelled *C. filipeda* in George & George (2011: 102). Interestingly, a plant of uncertain provenance cultivated by Malcolm Perry in England has flowers indistinguishable from our specimen from Cambodia, but it produces an inflorescence that continues to grow in superposed stages in the manner of species of the section *Proliferae.*

***Coelogyne pallens* Ridl. (Kew cult. 2013-1666; Figs 2 & 3)**

In contrast to the previous species, this is a widespread and common orchid whose occurrence in Cambodia was to be expected. It was found as an epiphyte on tree trunks in disturbed evergreen forest on a ridge at c. 430 m. This species also occurs in Myanmar, Thailand, Laos, Vietnam, Peninsular Malaysia, and Borneo.

***Dendrobium reflexitepalum* J.J.Sm. (Kew cult. 2013-1580; Figs 4 & 5)**

Peter O'Byrne (pers. comm.) found this small-flowered species of the section *Aporum* in Thailand, and observed that specimens from Thailand and ours from Cambodia lack the purple margins on the basal part of the lip that characterise specimens from Java and Sumatra, from where the species was previously recorded (Comber, 2001). It is very similar to the common *D. aloifolium*, and may well have been misidentified as such in Thailand and Indochina. *Dendrobium aloifolium* has still smaller flowers with narrower lobules to the mid-lobe of the lip and a labellar callus that when viewed from above extends well beyond the apex of the column. We found *D. reflexitepalum* to be a common species in the Cardamom Mountains in secondary forest and open woodland at c. 420–470 m altitude.

***Micropera thailandica* (Seidenf. & Smitinand) Garay (Kew cult. 2013-1763; Figs 6 & 7)**

This monopodial species was found as an epiphyte on small trees in open savannah on white sand at c. 420 m altitude. It was previously recorded from Thailand, Myanmar and Vietnam (Kurzweil & Saw Lwin, 2015) and probably occurs in Laos as well.

***Pennilabium acuminatum* (Ridl.) Holttum (Kew cult. 2013-1737; Figs 8 & 9)**

This is one of the more surprising new records and one of several species that may be considered a southern element in the flora of the Cardamom Mountains (see

Fig. 21 *Vrydagzynea albida* (Blume) Blume. Flowering stem. Kew cult. 2013-1723.

note under *Thrixspermum filiforme* below). The genus *Pennilabium* has its centre of diversity in Malesia, with only few species extending into continental Asia, as far north as Northeast India and China (Yunnan). Until now, *Pennilabium acuminatum* was known only from the Cameron Highlands in Peninsular Malaysia (Seidenfaden & Wood, 1992). Its flowers arise in succession at intervals of a few weeks over a period of about five months, each flower lasting a single day only. In the Cardamom Mountains it was found in humid evergreen montane forest as an epiphyte on thin tree trunks at 700 m altitude.

***Podochilus lucescens* Blume (Kew cult. 2013-1692; Figs 10 & 11)**

Along with *Appendicula hexandra* (J.Koenig) J.J.Sm. and *Podochilus microphyllus* (see below) this is one of the most frequently seen orchids in the dense evergreen forests of the Cardamom Mountains. This is not only because they are common species locally, but also because they usually grow in the shady understory of the forest rather than high up in the trees like most light-loving epiphytic orchids. This makes them easier to spot. At lower elevations, around 400 m, *P. lucescens* nearly always grows on trees along small streams, evidently requiring the higher humidity of such places for survival, while on mountain

ridges above 700 m this almost fern-like plant can be seen throughout the forest, not only near streams. This species is especially common in tropical rainforests in the Malay Archipelago, but is also found in parts of Southeast Asia with a similar climate. *Podochilus lucescens* has been recorded from Myanmar, Thailand, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, and the Philippines.

***Podochilus microphyllus* Lindl. (Kew cult. 2013-1642; Figs 12 & 13)**

Like the related *P. lucescens,* this is a small and locally common orchid from shaded places in evergreen forest, where it grows on tree trunks and rocks at around 430 m altitude. Unlike the previous species, which has tufted and patent stems, *P. microphyllus* has a more creeping habit and can be almost moss-like in appearance. It was previously known from Myanmar, Thailand, Vietnam, Peninsular Malaysia, Sumatra, Java, and Borneo.

***Thecostele alata* (Roxb.) Parish & Rchb.f. (Kew cult. 2013-1577; Figs 14 & 15)**

Like *Coelogyne pallens*, this is a widespread species whose occurrence in Cambodia was to be expected. The long, pendulous, gradually elongating inflorescence of this taxonomically isolated species may produce flowers over more than a single growing season. It has been recorded from northeast India, Bangladesh, Myanmar, Thailand, Laos, Vietnam, Peninsular Malaysia, Sumatra, Java, Borneo, and the Philippines. In the Cardamom Mountains this distinctive, small-flowered species, which is noteworthy for being the only known tropical orchid with poly-embryonic seeds, is found sporadically in dense evergreen forest at c. 500 m altitude.

***Thelasis perpusilla* (Parish & Rchb.f.) Schuit. (Kew cult. 2013-1711; Figs 16 & 17)**

This easily recognised species with its minute, 3 mm long, white flowers has until recently been included in *Eria*, as *E. perpusilla*, until the first author transferred it to *Thelasis* (Schuiteman, 2014). An examination of fresh material, made possible by our field work, showed that the structure of the pollinia and other details of plant and flowers are unlike *Eria* (or *Porpax* and *Conchidium*, which are more similar in habit), but consistent with the genus *Thelasis*. This species flowers in the middle of the dry season (February–March), when the plant is leafless. As a result, specimens in herbaria are always without leaves. It has previously been recorded from Myanmar, Thailand, Laos, and Vietnam. In the Cardamom Mountains it grows on tree trunks in evergreen forest between 430 and 900 m altitude.

***Thrixspermum filiforme* (Hook.f.) Kuntze (Kew cult. 2013-1637; Figs 18 & 19)**

Better known as *Cordiglottis filiformis* until recently, this is another species with a southern distribution, being recorded from South Thailand, Peninsular Malaysia, Borneo, and the Philippines. Of the 12 new records recorded in this paper, five could be called 'southern' (Malesian) taxa: *Dendrobium reflexitepalum*, *Pennilabium acuminatum*, *Podochilus lucescens*, *P. microphyllus*, and *T. filiforme*. These all seem to reach the northern limit of their distribution area in the Cardamom Mountains. Like *Pennilabium acuminatum*, *T. filiforme* is an orchid with short-lived flowers, which are produced even less frequently than the former species. Because the likelihood of finding this species in flower in the wild is quite low, the extent of its occurrence based on herbarium records is almost certainly grossly underestimated. Our specimens were found on the branches of a fallen tree in evergreen forest at 470 m altitude.

***Trichotosia dasyphylla* (Parish & Rchb.f.) Kraenzl. (Kew cult. 2013-1710; Fig. 20)**

This charming little epiphyte, with its pilose leaves and long creeping rhizomes, is not uncommon in the countries neighbouring Cambodia. It has been recorded from Nepal, Myanmar, China (Yunnan), Thailand, Laos, and Vietnam. We found it creeping in the crown of a recently fallen tree in evergreen ridge-crest forest at c. 900 m altitude. Like *Eria pannea* Lindl. and *Microsaccus griffithii* (Parish & Rchb.f.) Seidenf., with which it grows together in the Cardamom Mountains, this is evidently a species that prefers a bright, breezy position.

***Vrydagzynea albida* (Blume) Blume (Kew cult. 2013-1723; Fig. 21)**

This inconspicuous terrestrial orchid is quite similar in habit to certain *Zeuxine* species related to *Z. affinis*, which also occur in the Cardamom Mountains. Like them, it has ovate, green leaves with a silvery grey streak along the mid-vein. The small flowers of *V. albida* hardly open, probably providing just enough access for the proboscis of the (unknown) pollinating insect to probe the spur. Although not common, it is an extremely widespread orchid, being recorded from India (Northeast India & Andaman Islands), Bangladesh, Thailand, Vietnam, Peninsular Malaysia, Sumatra, Java, Borneo, Sulawesi, the Philippines, and New Guinea. Species of the genus *Vrydagzynea* usually grow in moist spots, sometimes even in shallow running water, and *V. albida* is no exception. We observed it growing on damp rocks along a small stream in humid montane forest with tree ferns and much herbaceous undergrowth at c. 800 m altitude.

Conclusions

There is perhaps no better evidence that the orchid flora of Cambodia is very incompletely known than the fact that, as shown in this paper, even common species may turn out to be new records. It will be worthwhile to continue exploring the remaining habitats because many new records may be expected. As yet we know very little about regional differences in the orchid floras of different parts of Cambodia, which is another reason to perform systematic inventory work throughout the country.

Acknowledgements

We thank Dr Omaliss Keo of the Cambodian Forestry Administration, for his invaluable help before and during our visit, as well as Cedric Jancloes for sharing much useful information. Christopher Ryan was supported by a Scott Marshall Travel Award, while André Schuiteman received a grant from the American Society Board of the Kew Foundation. We thank CITES Cambodia and CITES UK for providing the necessary permits. The living specimens were imported into the UK under Defra Plant Health Licence Number 2149/194627-1.

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Short Communication

Two new records for Cambodia's forest flora, *Memecylon corticosum* var. *kratense* and *M. paniculatum* (Melastomataceae)

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Paper submitted 16 August 2015, revised manuscript accepted 21 September 2015.

The rainforests of the Cardamom and Elephant Mountains in Southwest Cambodia are considered to be one of the most species-rich and intact yet least explored biodiversity hotspots of the Indochinese Region (Rundel, 1999; Olson & Dinerstein, 2002; Bunyavejchewin *et al.,* 2011). Compared to most of Indochina, which experiences varying degrees of seasonal climatic conditions, this region has ever-wet climatic conditions. This is because of its proximity to the Gulf of Thailand which results in high rainfall throughout the year. This mountainous region receives rainfall amounting to twice that of the second wettest region of the country (Ashwell, 1997; FA/CTSP, 2003). Being surrounded by seasonal forests, such as those on the sandstone Korat Plateau in Northern Thailand, this results in a unique isolated ever-wet habitat with greater similarities to the Malesian regions of Peninsular Malaysia, Sumatra and Borneo than to the surrounding Indochinese regions.

Biodiversity exploration of the region is still in its infancy. For instance, the first six-month survey of amphibians in the region found 19 new species records, which doubled the number of species known for Cambodia at the time (Ohler *et al.,* 2002). This was further increased by six new records including three new species in an additional survey (Grismer *et al.,* 2008). While recent botanical exploration in the region has resulted in new species and new records in various taxonomic groups (Mey *et al.,* 2010; Heatubun 2011; Kato, 2011; Savinov, 2014; Tagane *et al.,* 2015a, b; Naiki *et al.,* in press; Tanaka *et al.,* in press; Toyama *et al.,* in press), documentation of the plants found in the region remains poor overall and there is a need for more intensive floristic surveys.

Memecylon Linnaeus (1753: 349) (Melastomataceae) is a genus of woody trees in the Old World tropics and comprises 343 species (Renner *et al.,* 2007). Taxonomic revisionary work on the genus has been carried out in Borneo, Peninsular Malaysia and is ongoing in Thailand (Bremer, 1983; Hughes & Wijedasa, 2012; Wijedasa & Hughes, 2012; Hughes, 2013). There are few collections known for the Indochinese region outside of Thailand with particularly low numbers in Cambodia and Laos. So far in Cambodia, 11 species of genus *Memecylon* have been recorded: *M. acuminatum* Sm., *M. bokorense* Tagane, *M. caeruleum* Jack, *M. chevalieri* Guillaumin, *M. edule* Roxb., *M. floribundum* Blume, *M. geoffrayi* Guillaumin, *M. harmandii* Guillaumin, *M. laevigatum* Blume, *M. pierre* Hance (syonym, *M. edule* var. *ovata* C.B. Clarke), and *M. scutellatum* (Lour.) Hook. & Arn. *var. scutellatum* (synonym, *M. edule* var. *scutellatum* (Lour.) Triana) (Guillaumin, 1921; Dy Phon, 2000; Tagane *et al.,* 2015a).

CITATION: Tagane, S., Wijedasa, L.S., Chhang P., Toyama, H. & Yahara, T. (2015) Two new records for Cambodia's forest flora, *Memecylon corticosum* var. *kratense* and *M. paniculatum* (Melastomataceae). *Cambodian Journal of Natural History*, **2015**, 139–143.

During botanical surveys in the Cardomom and Elephant Mountains in the Koh Kong Province (May and December in 2012; February 2013) and in Kampot Province (December 2011; May, July and October in 2012; February, August, and December in 2013), we found two *Memecylon* species with characteristic 4-winged twigs and relatively larger leaves (Figure 1). The two species, *Memecylon corticosum* Ridl. var *kratense* (Craib) Wijedasa and *M. paniculatum* Jack, are here reported as new records for the flora of Cambodia.

The following description is based on our Cambodian materials. DNA barcoding of *rbcL* and *matK* region was also conducted in accordance with the recommendation of the CBOL Plant Working Group (2009). The analyses followed published protocols (Kress *et al.*, 2009; Dunning & Savolainen, 2010; Toyama *et al.*, 2015). Voucher specimens were deposited in the herbarium of the Forest Administration of Cambodia (hereafter Cam), the Herbarium of the Museum of Kyushu University (FU) and partly in the the Royal Botanic Gardens Kew (K) and Muséum national d'Histoire naturelle (P). In the accounts below, the herbarium codes follow the Index Herbariorum (Thiers, continuously updated). We use an exclamation mark (!) to signify specimens that were examined by ourselves.

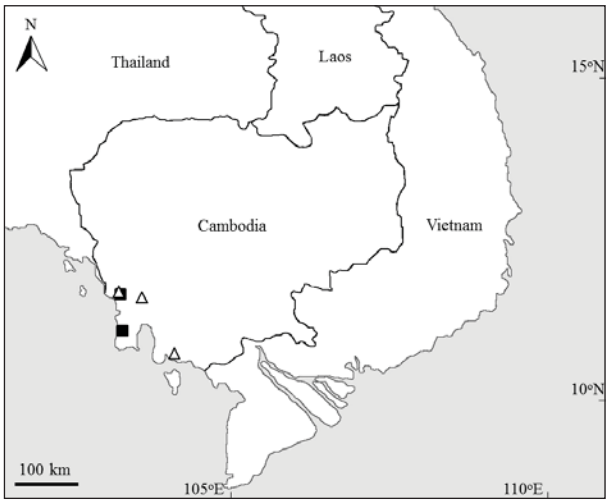

Fig. 1 Collection sites for *Memecylon corticosum* var. *kratense* (Craib) Wijedasa (closed squares) and *M. paniculatum* Jack (open triangles) in Cambodia.

***Memecylon corticosum* var. *kratense* (Craib) Wijedasa, *Phytotaxa*, 66: 8 (2012)**

Memecylon kratense Craib, *Bull. Misc. Inform. Kew* 1930 (7): 326 (1930); Hughes, *Fl. Penins. Malaysia* 4: 290 (2014). Type: THAILAND. Chanthaburi Province, Krat, Kao Saming, 23 January 1927, *Put 531* (lectotype ABD!, isolectotypes BK!, K!).

Description: Shrub to 4 m tall. Twigs 4-winged in young shoots, then terete in old, internodes 1.2–4.5 cm apart, grey to greyish brown, glabrous. Leaves: petiole 1.5 mm long, glabrous; blades elongate lanceolate to linear lanceolate, 11.5–20 × 2.1–4.1 cm, base subcaordate, channelled above near the petiole, apex gradually acuminate, drying pale greyish brown and slightly glossy above, slightly paler below, glabrous; midrib sunken above, prominent below, secondary veins 15–18 pairs, indistinct to invisible on both surfaces, visible looping veins 1–2 mm from the margin. Inflorescence axillary, in leafy of older branches, just behind or with the leaves, peduncles 1–2 mm long, (2–)7–12-flowered, condensed. Flowers: pedicel slender, 3.5–4 mm long, calyx ca. 3 mm in diameter, cream, slightly pinkish in vivo, yellowish to reddish brown in dry, calyx lobes 4, very shallowly triangular ca. 0.3 × 1.8 mm; petal, suborbicular, ca. 2 × 2 mm, purplish blue one third near base, the other part cream in vivo. anthers 8, J-shaped, ca 1.1 mm long, connective purplish blue in vivo, glands on connectives 0.3 mm in diameter, filaments ca. 1 mm long, purplish blue in vivo; pistils ca. 3 mm long, purplish blue in vivo. Fruits: pedicel ca. 5 mm long; fruit globose, ca. 7 mm in diameter, calyx remnant prominent, areolus ca. 3 mm in diameter Seeds globose, ca. 5.5 mm in diameter, yellowish brown (Figs 2a–e).

Specimens examined in Cambodia: Koh Kong Province [11°33′27.95″N, 103°10′39.84″E, alt. 236 m, 17 May 2012, *Toyama H. et al. 3385* (FU!, K, Cam!); 11°3′20.36″N, 103°09′26.23″E, alt. 146 m, 5 December 2012, *Toyama H. et al. 4666* [fl.] (FU!, Cam!); 11°33′27.32″N, 103°10′42.39″E, alt. 233 m, 14 February 2013, *Toyama H. et al. 5442* [fr.] (FU!, K, Cam!).

GenBank accession no.: *Toyama et al. 4666*--LC025616 (*rbcL*), LC025619 (*matK*).

Distribution: Cambodia (new record), Myanmar (Mergui), Thailand (Southeast, Peninsula) and Malaysia (northern Peninsular Malaysia).

Fig. 2 (next page) *Memecylon corticosum* var. *kratense* (Craib) Wijedasa, Koh Kong Province: (a) flowering branch, (b) abaxial leaf surface, (c) portion of young twigs, (d) inflorescence, (e) fruit. *Memecylon paniculatum* Jack, Koh Kong: (f) leafy branch, (g) portion of young twig and leaves (abaxially). [Dates of photopgraphs— (a), (b), (d): 5 December 2012; (c), (f), (g): 17 May 2012; (e): 14 February 2013].

Habitat and ecology: *Memecylon corticosum* var. *kratense* is occasionally found in and around primary wet seasonal evergreen forests in Koh Kong Province. These forests were dominated by *Hopea pierrei* Hance (Dipterocarpaceae) (number of trunks wider than 7.5 cm d.b.h.: 68–164/ha) and with *Aglaia cucullata* (Roxb.) Pellegr. (Meliaceae), *Archidendron quocense* (Pierre) I.C. Nielsen (Fabaceae), *Garcinia hanburyi* Hook.f. (Clusiaceae), *Lithocarpus* sp. (Fagaceae), *Parkia sumatrana* Miq. (Fabaceae), *Schima crenata* Korth. (Theaceae), *Shorea hypochra* Hance (Dipterocarpaceae) and *Symplocos caudata* Wall. ex G. Don (Symplocaceae). The flowering specimen was collected in December and the fruiting specimen was collected in February.

***Memecylon paniculatum* Jack, *Malayan Misc.* 2 (7): 62 (1822)**; J.F. Maxwell, *Tr. Fl. Malaya,* 4: 194 (1989); Hughes, *Fl. Penins. Malaysia,* 4: 314 (2014). Type: INDONESIA. Sumatra, *Teijsmann s.n.* (lectotype L!, isolectotype GH!).

Description: Small tree. Twigs 4-winged in young, terete in old, internodes 3.5–6.5 cm apart, reddish brown, glabrous. Leaves: petiole subsessile to 3 mm long, glabrous; blades elliptic, elliptic-oblong, ovate-oblong, 14–21.5 × 4.6–7 cm, thinly leathery, base subcordate, apex acuminate, drying reddish brown; midrib sunken above, prominent below, secondary veins 11–16 pairs, indistinct or slightly sunken above, prominent below, looping veins 2–5 mm from the margin. Flower and fruits not seen (Figs 2f–g).

Specimens examined in Cambodia: Kampot Province [Bokor National Park, evergreen forest, 10°38′02.73″N, 104°05′17.73″E, alt. 760 m, 24 Oct. 2012, *Yahara T. et al. 4501* (FU!, K, Cam!)]; Koh Kong Province [Central Cardamom, evergreen forest, 11°41′37.65″N, 103°29′29.34″E, alt. 534 m, 19 Apr. 2011, *Toyama H. et al. 658* (FU, Cam!); 11°33′27.95″N, 103°10′39.84″E, alt. 236 m, 17 May 2012, *Toyama H. et al. 3393* (FU!, Cam!)].

GenBank accession no.: Toyama et al. 658--LC025614 (rbcL), LC025617 (matK); Yahara et al. 4501--LC025615 (rbcL), LC025618 (matK).

Distribution: Cambodia (new record), Indonesia (Java, Kalimantan, Sumatra, Sulawesi), Malaysia (Borneo, Peninsular Malaysia), the Philippines, Singapore, Thailand (Peninsular Thailand).

Habitat and ecology: *Memecylon paniculatum* is occasionally and common locally where present in the primary wet seasonal evergreen forest in Koh Kong Province and Bokor National Park of Kampot Province.

Remarks: This species is easily distinguished even in the sterile materials by its having 4-winged young twigs and larger leaves with very clear secondary veins like a species of *Syzygium* P. Browne ex Gaertn. (Myrtaceae).

Acknowledgements

The authors cordially thank the Cambodian Ministry of the Environment and the Ministry of Agriculture, Forestry and Fisheries for permitting our botanical inventories in Bokor National Park, Kampot, and the permanent forest plots in Koh Kong Province. We also sincerely thank the staff of these organisations who assisted our field surveys and Keiko Mase (Kyushu University) for DNA experiments. This study was supported by the Environment Research and Technology Development Fund (S9) of the Ministry of the Environment, Japan.

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Short Communication

A contribution to the knowledge of ant genera of Cambodia (Hymenoptera: Formicidae)

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Paper submitted 3 June 2015, revised manuscript accepted 3 September 2015.

In recent years, the increase in studies on ant diversity by myrmecologists has made it possible to analyse ant assemblages on a global scale (Guenard *et al.,* 2012). However, the lack of comprehensive myrmecological surveys in some countries has impeded our understanding of some ant genera in these global analyses. Cambodia is relatively unexplored in terms of its ants, but is part of an important biogeographical region (Monastyrskii *et al.,* 2011; Zryanin, 2011). Despite recent surveys employing standardized protocols such as time unit sampling and Winkler extraction, which focus on the general distribution patterns of ant assemblages (Hosoishi *et al.,* 2012, 2013), few studies have been conducted on rare ant genera in Cambodia.

This paper documents several rare ant genera collected by nest and general sampling. Voucher specimens are deposited in the Institute of Tropical Agriculture, Kyushu University, Japan (KUEC). Nest samples are represented with colony codes, e.g. 'SH10-Cam-171'.

Subfamily Formicinae

Genus *Gesomyrmex* Mayr

The genus *Gesomyrmex* is assigned to the tribe Gesomyrmecini (Bolton, 2003). Workers of the genus are easily recognised by the following features: elongated compound eyes; antennal scape passing below the eye; masticatory margin of mandible with more than four teeth (Bolton, 1994).

One worker of *Gesomyrmex* sp. (Figure 1) was collected by hand on low vegetation in a dry forest in Phnom Bokor National Park, Kampot Province, Cambodia (Figure 6). Among the Indochinese fauna, *Gesomyrmex tobiasi* is known from North Vietnam (Dubovikov, 2004) and one unidentified species from Tam Dao National Park, also in North Vietnam (Eguchi *et al.,* 2005).

Specimen examined: CAMBODIA: one worker, Phnom Bokor National Park, 663 m alt., Kampot Province, 13.xii.2011 (S. Hosoishi) (KUEC: KUMANT028).

Subfamily Myrmicinae

Genus *Anillomyrma* Emery

The genus *Anillomyrma* is assigned to the tribe Solenopsidini (Ward *et al.,* 2014). Workers of the genus are recognised by the following features: 10-segmented antennae; postpetiole attached to top of anterior face of first gastral segment (Bolton, 1994; Eguchi *et al.,* 2010).

We collected workers of *Anillomyrma decamera* (Figure 2) by Winkler extraction in a lowland forest in Koh Kong Province, Cambodia (Figure 6). Among the Indochinese fauna, *A. decamera* is known from Vietnam (Eguchi *et al.,* 2011). The collected specimens agree well with the description of *A. decamera* in having the 4-toothed masticatory margin of the mandible, and the posterior slope of propodeum weakly expanding posterodorsad (Eguchi *et al.,* 2011).

Specimens examined: CAMBODIA: two workers, Koh Kong Province, 17-19.v.2012 (Winkler extraction) (S. Hosoishi & S.-H. Park) (KUEC: KUMANT029).

CITATION: Hosoishi, S., Park, S.-H. & Ogata, K. (2015) A contribution to the knowledge of ant genera of Cambodia (Hymenoptera: Formicidae). *Cambodian Journal of Natural History*, **2015**, 144–147.

Fig. 1 *Gesomyrmex* sp.

Fig. 2 *Anillomyrma decamera*

Fig. 3 *Rotastruma* sp.

Fig. 4 *Vombisidris* sp.

Fig. 5 *Emeryopone* sp.

We collected one colony of *Rotastruma* sp. (Figure 3) in regrowth forest in Kampong Thom Province, Cambodia (Figure 6). Two species are currently recognised: *Rotastruma recava* from Singapore and Borneo, and *R. stenoceps* from China (Bolton, 1991). According to a key to species (Bolton, 1991), the collected specimens are similar to *R. stenoceps* in having the occipital margin transverse and sides of head straight, but differ slightly by having propodeal spines curving upward.

Specimens examined: CAMBODIA: four workers and one dealate queen, regrowth forest, Kampong Thom Province, 24. xi. 2010 (dead twig on tree) (SH10-Cam-172) (S. Hosoishi) (KUEC: KUMANT030).

Genus *Rotastruma* Bolton

The genus *Rotastruma* is assigned to the tribe Crematogastrini (Ward *et al.,* 2014). Workers of the genus are recognised by the following features: frontal carinae present; mesosoma marginate dorsolaterally (Bolton, 1994; Eguchi *et al.,* 2011).

Genus *Vombisidris* Bolton

The genus *Vombisidris* is assigned to the tribe Crematogastrini (Ward *et al.,* 2014). Workers of the genus are recognised by the following features: frontal carinae absent; side of head below eye having longitudinal groove (Bolton, 1994).

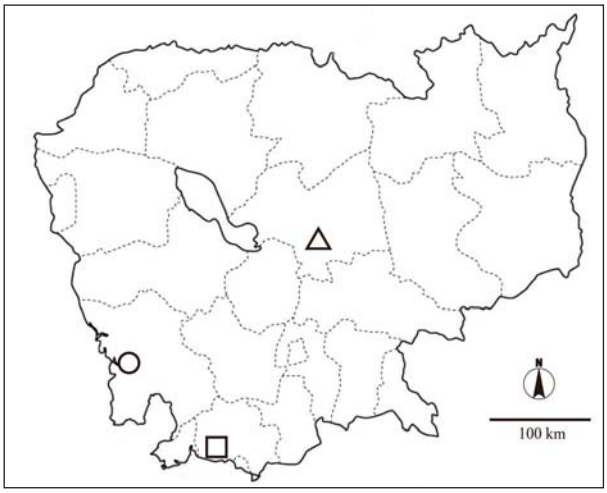

Fig. 6 Collection sites of rare ants in Cambodia: Phnom Bokor National Park, Kampot Province (square); Lowland forest in Koh Kong Province (circle); Regrowth forest in Kampong Thom Province (triangle).

We collected colonies of *Vombisidris* sp. (Figure 4) by nest sampling in a regrowth forest in Kampong Thom Province, Cambodia (Figure 6). In his revision of the genus, Bolton (1991) listed 12 species and provided a key to the species with descriptions. His collections did not include any Indochinese specimens. The specimens collected in this study were assigned to the *V. philax*-group based on the following features: subocular groove complete; legs and antennae relatively long; propodeal spines long and downcurved; metanotal groove absent. Our specimens are similar to *V. nahet* (head width 0.66–0.68 mm, $n = 2$), but the body is relatively smaller (head width 0.50–0.55 mm, $n = 4$).

Specimens examined: CAMBODIA: five workers and one dealate queen, regrowth forest, Kampong Thom Province, 24.xi.2010 (dead twig on tree) (SH10-Cam-171) (S. Hosoishi) (KUEC: KUMANT031); three workers, regrowth forest, Kampong Thom Province, 17.xii.2011 (dead twig on tree) (S. Hosoishi & S.-H. Park) (KUEC: KUMANT032).

Subfamily Ponerinae

Genus *Emeryopone* Forel

The genus *Emeryopone* is assigned to the tribe Ponerini (Bolton, 2003). Workers of the genus are easily recognised by having an elongate-triangular mandible bearing five long, slender, spiniform teeth (Bolton, 1994).

We collected workers of *Emeryopone* sp. (Figure 5) by Winkler extraction in a dry forest in Phnom Bokor National Park, Kampot Province, Cambodia (Figure 6). Among the Indochinese fauna, *Emeryopone buttelreepeni* Forel is known from Thailand (Jaitrong & Nabhitabhata, 2005).

Specimens examined: CAMBODIA: three workers, Phnom Bokor National Park, 444 m alt., Kampot Province, 11-13.v.2012 (Winkler extraction) (S. Hosoishi & S.-H. Park) (KUEC: KUMANT033).

Acknowledgements

We would like to thank Phourin Chhang and Choeung Hong Narith (Forestry Administration, Phnom Penh, Cambodia), Dr Tsuyoshi Kajisa (Kagoshima University), Dr Nobuya Mizoue (Faculty of Agriculture, Kyushu University) and Dr Tetsukazu Yahara (Faculty of Science, Kyushu University) for helping our field surveys in this study. We also thank Dr Seiki Yamane for valuable information on ant identification. Thanks are also due to Mark Lorenz (Forte Inc.) for improving the English. This work was supported in part by JSPS KAKENHI (Grant-in-Aid for Scientific Research [C]) Grant Number 26440221, JSPS KAKENHI (Grant-in-Aid for Scientific Research [B]) Grant Number 26304014 and Global COE Program (Center of Excellence for Asian Conservation Ecology as a basis of Human-Nature Mutualism), MEXT, Japan.

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Short Communication

Rotifers as bio-indicators of freshwater quality: a case study from the upper Cambodian Mekong River Basin

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Paper submitted 3 July 2015, revised manuscript accepted 2 September 2015.

Among the minor invertebrate phyla, the Rotifera are the most diverse. Rotifers are small invertebrates (50-2,000 μm) (Wallace *et al.,* 2006) with a short life span, but are qualitatively (species richness) and quantitatively (species abundance) important components of zooplankton in aquatic ecosystems (Sharma, 2010). These animals typically represent more than 60% of the zooplankton population in lakes (Armengol *et al.,* 1998). Even though rotifers are microscopic, they are important in maintaining ecological balances in freshwater ecosystems as they form natural food links between primary producers (algae) and zooplanktivorous fish (Wallace, 2002).

In addition, rotifers have been considered effective biological indicators because they are capable of rapidly exploiting suitable environments and are relatively tolerant of minor environmental perturbations (Arora, 1966). They can also function as biological indicators of nutrient status and as food for higher-order species in fluvial drainage systems (Arora, 1966). The population dynamics of rotifers are strongly related to the trophic state of their environment (Duggan *et al.,* 2001). For instance, the ratio of the number of species within the genus *Brachionus* relative to those in the genus *Trichocerca* can indicate the trophic status of water; *Brachionus* spp. being associated with eutrophic conditions, *Trichocerca* spp. being associated with oligotrophic conditions (Sládecek, 1983).

In many parts of Cambodia, especially within the Mekong River Basin, which includes the Tonle Sap Great Lake, people depend greatly on natural resources (Pech & Sunada, 2008). Inland waters are crucial for local livelihoods because they support productive freshwater fisheries, water transportation and provide drinking water (McKenney & Tola, 2002). Lakes and reservoirs are typically used in most areas for water every day. Such waterbodies are very common in the upper Cambodian Mekong River Basin, and are poorly known in terms of their trophic condition.

Relatively little research has been undertaken on the rotifers of Cambodia, e.g. Berzins (1973), Mekong River Commission (2008), Meas & Sanoamuang (2010), Segers *et al.* (2010), Min *et al.* (2011) and Sor *et al.* (2015), and very few studies have used rotifers to assess water quality. In this study, we present a descriptive overview of rotifer species composition in the upper Cambodian Mekong River Basin and assess seasonal variation in the trophic conditions of different localities using two genera of rotifers.

Twenty samples were collected from 10 lakes and artificial reservoirs using a 30 μm mesh plankton net in the upper Cambodian Mekong River Basin. One lake and one reservoir were sampled in Kratie Province, one lake and three reservoirs in Stung Treng Province, and three lakes and one reservoir in Ratanakiri Province (Figure 1). Geo-coordinates for each sample site are given in Table 1. Ten samples were collected at every site in the late dry season (25–30 April 2010) and a further 10 from the same localities during the late rainy season (7–12 November 2010). Each sample was obtained by dragging the plank-

CITATION: Sor R., Segers, H., & Meas S. (2015) Rotifers as bio-indicators of freshwater quality: a case study from the upper Cambodian Mekong River Basin. *Cambodian Journal of Natural History*, **2015**, 148–152.

Table 1 Study locations in the upper Cambodian Mekong River Basin (UTM zone = 48P)

Site	Habitat	Province	Locality	Easting	Northing	Altitude (m)
L1	Lake	Kratie	Koh Sokrom	619806	1376088	23
L2	Lake	Stung Treng	Veal Ampe	623370	1486520	154
L3	Lake	Ratanakiri	Ven Sai	696711	1544755	92
L4	Lake	Ratanakiri	Ban long	715011	1520863	297
L5	Lake	Ratanakiri	Ratanakiri	718454	1518762	303
R1	Reservoir	Kratie	Thmor Kre	610763	1385581	19
R2	Reservoir	Stung Treng	Krang Deisor	606977	1488694	72
R3	Reservoir	Stung Treng	Oklong	611849	1490957	73
R4	Reservoir	Stung Treng	Kilo eight	613749	1501552	56
R5	Reservoir	Ratanakiri	Ochum	716444	1524616	272

ton net through water near the shoreline 15 times. All samples were preserved by adding concentrated formaldehyde (37–40%) to obtain a final concentration of about 4%.

Rotifer specimens were identified to species under a compound microscope, using Koste (1978), Nogrady & Segers (2002), Nogrady *et al.* (1995), Segers (1995) and de Smet & Pourriot (1997). A digital camera fitted on an Olympus BX51 microscope was used to photograph rotifer specimens where appropriate. Species lists were then compared to previous records and Segers (2007).

Numbers of species in the *Brachionus* and *Trichocerca* genera were counted in each sample. The relative proportion of species in both genera, or the "*Brachionus*: *Trichocerca* quotient" (QB/T) (after Sládecek, 1983), was used to calculate a value indicating the trophic condition of each sample locality. These values range from 1.00–4.00, values of <1.00 indicating oligotrophic conditions, values of 1.00–2.00 indicated mesotrophic conditions and values of >2.00 indicated eutrophic conditions (Sládecek, 1983). Even though a Kolmogorov-Smirnov test indicated the data were normally distributed ($p = 0.16$), a Levene test indicated co-variances were not homogenous ($p = 0.04$). Dry and wet season values were therefore compared using the non-parametric Wilcoxon Signed Ranks Test. In all tests, values of $p < 0.05$ were considered significant.

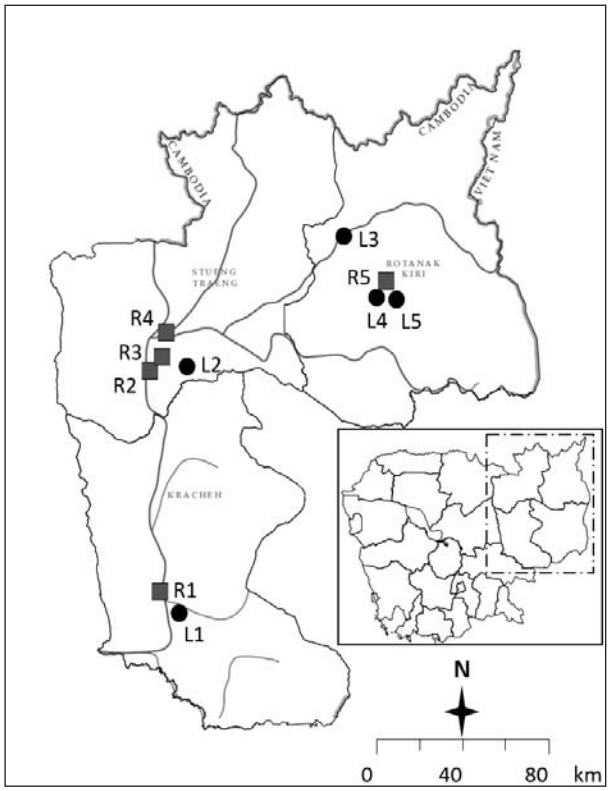

Fig. 1 Study locations in the upper Cambodian Mekong River Basin: L = Lake, R = Reservoir.

Rotifer species

A total of 107 rotifer species belonging to 33 genera and 18 families were recorded over the course of the study. Similar to the study of Meas & Sanoamuang (2010) and Min *et al.* (2011), the family Lecanidae (27 species) contained the most species. The next most species-rich families were Bracnionidae (16 species), Trichocercidae (14 species), and Colurellidae (13 species). Among the 107 species encountered, 69% (74 taxa) had been previously recorded in Cambodia, while 23% (25 taxa) were

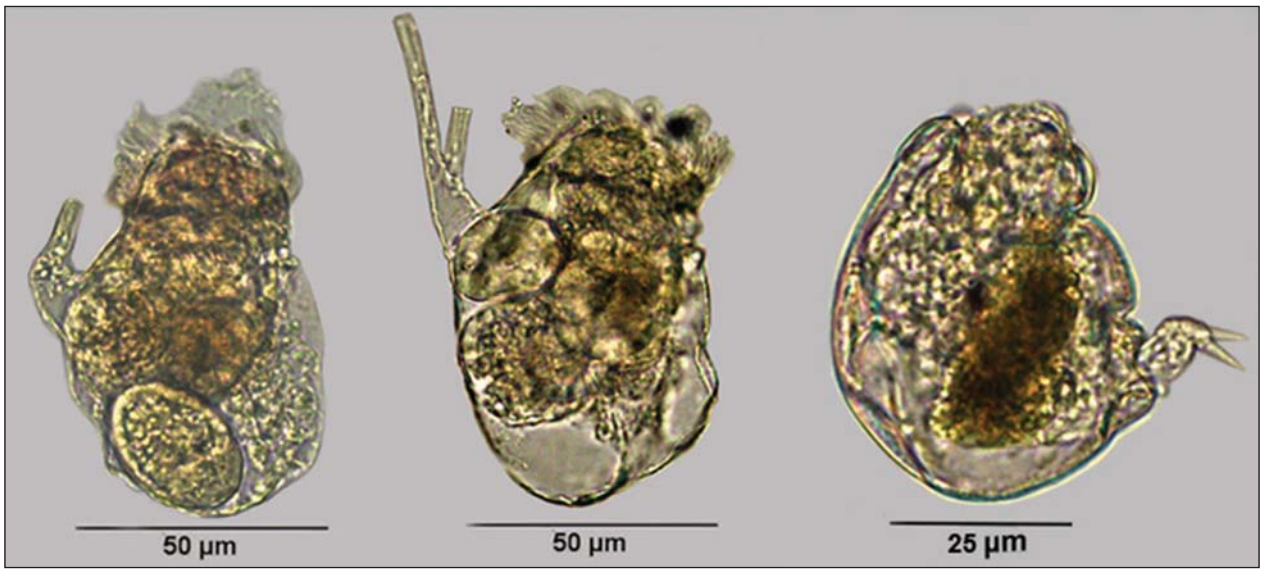

Fig. 2 New genus records for Cambodia: (left to right) *Conochilus coenobasis* (Skorikov, 1914), *Conochilus* sp. and *Gastropus hyptopus* (Ehrenberg, 1838).

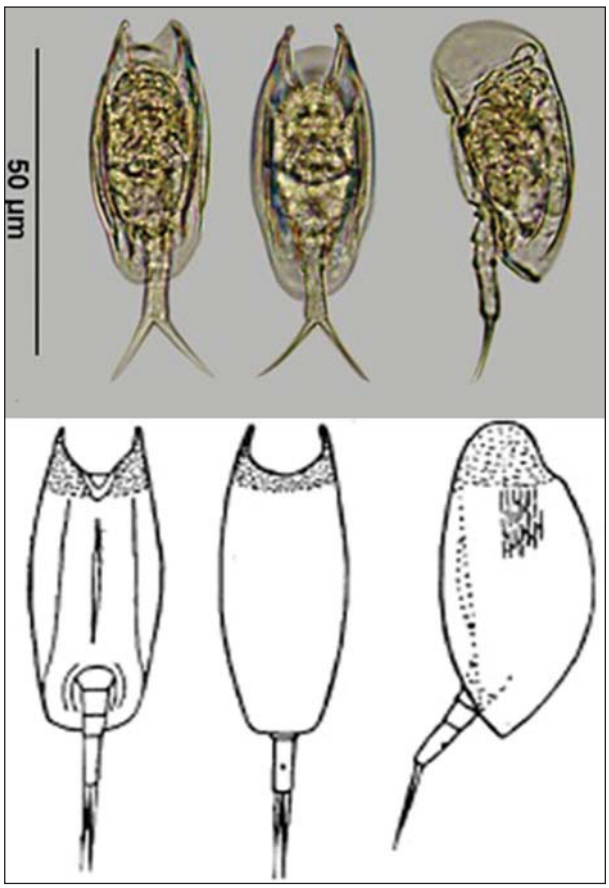

Fig. 3 Possible species new to science: *Colurella* sp. (above), compared to *Colurella oblonga* Donner, 1943 (below).

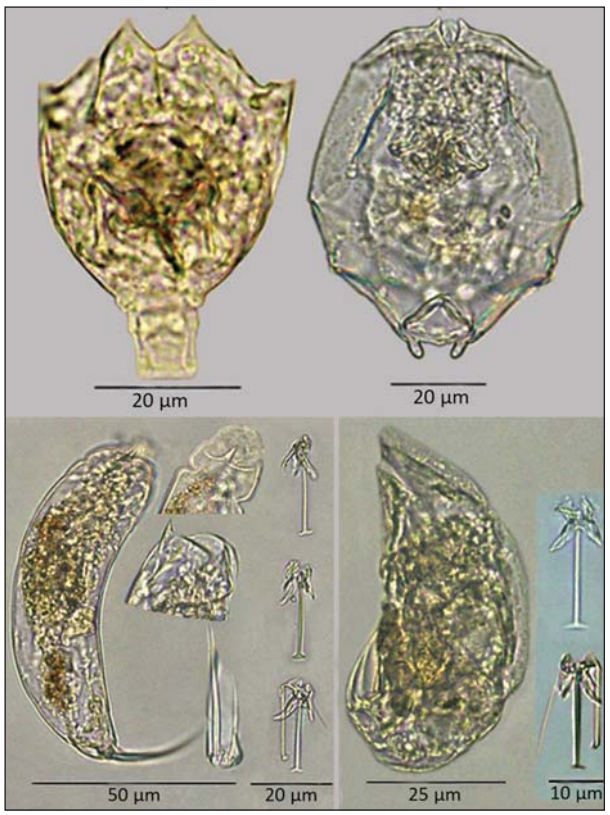

Fig. 4 Selected species within the *Brachionus* and *Trichocerca* genera. Above: *B. sessilis* Varga, 1951 (left) and *B. angularis* Gosse, 1851 (right). Below: *T. tenuior* (Gosse, 1886) (left) and *T. bidens* (Lucks, 1912) (right).

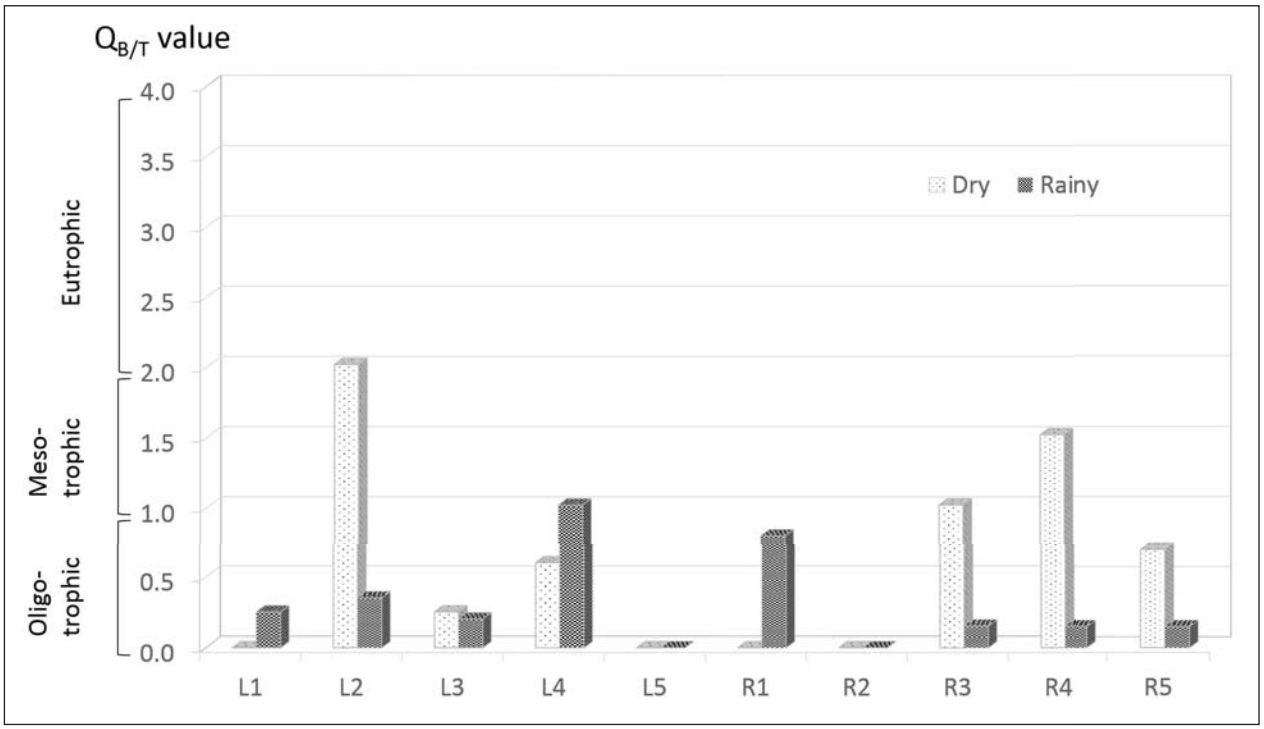

Fig. 5 QB/T quotient values in the dry and rainy seasons. L = Lake; R = Reservoir. Sites lacking bars possess a value of 0.

new records for the country and 8% (8 taxa) were not identifiable to species level (for the list of taxa, see Sor *et al.*, 2015). Two of the new records, *Conochilus coenobasis* (Skorikov, 1914) and *Gastropus hyptopus* (Ehrenberg, 1838), are the first members of these genera to be found in Cambodia (Figure 2). The species most frequently found in our samples were *Trichocerca similis* (Wierzejski, 1892) (19 out of 20 samples), *Anuraeopsis fissa* Gosse, 1851 (18 samples), *Hexarthra* cf. *intermedia* Wiszniewski, 1929 (15 samples), *Lecane bulla* Gosse, 1851 and *L. hamata* Stokes, 1869 (14 samples). This contrasts with Min *et al.* (2011) who found that *Brachionus falcatus* Zacharias, 1898, *Keratella tropica* (Apstein, 1907) (80% of samples) and *A. coelata* de Beauchamp, 1932 (70% of samples) were the commonest species in ponds.

Of the eight taxa that could not be identified to species level, several appear to be unnamed forms, including *Conochilus* sp. and *Ptygura* sp., the latter being a sessile genus recently found by Segers *et al.* (2010). Another taxon belonging to the genus *Colurella* may also be a new species to science as it lacks the ventrally displaced foot possessed by its nearest relative, *Colurella oblonga* Donner, 1943 (Figure 3), in addition to having a distinctly different lorica.

***Brachionus*: *Trichocerca* quotient (QB/T)**

Brachionus spp. (Figure 4) were found at six sample sites during the dry season, ranging from 1–4 species, and at eight sample sites during the rainy season, ranging from 1–6 species. *Trichocerca* spp. (Figure 4) were found at all sample sites during both the dry and rainy seasons, ranging from 1–6 and 3–7 species respectively.

During the dry season, QB/T values ranged from 0.00 to 2.00 (oligotrophic to mesotrophic). Seven sites (with QB/T values ranging from 0.00 to 0.86) were considered oligotrophic, with no levels of pollution, while the remaining three sites were recognised as mesotrophic (L2, QB/T = 2.00; R3, QB/T = 1.00 and R4, QB/T = 1.50) (Figure 5). Nine sites were found to be oligotrophic during the rainy season (QB/T <1.00), and only site (L4) was found to be mesotrophic (QB/T = 1.00). The mean QB/T value for dry season samples (0.62) was slightly higher than that for rainy season samples (0.32), suggesting differing trophic conditions. However, the Wilcoxon Signed Ranks Test found no significant difference in trophic conditions between seasons ($n = 20$, $p = 0.32$).

Only three sites (L2, R3 and R4) were found to be mesotrophic during the dry season and their QB/T values decreased during the rainy season. As the water volume of these sites decreases markedly during the dry season

(to approximately 80–90% of their rainy season volume), this may explain why they become mesotrophic in the dry season.

Even though most sites in our study were classified as oligotrophic according to their QB/T values, variation was apparent nonetheless. Given that the QB/T measure originated from Czechoslovakia and surrounding countries (Sládecek, 1983), where levels of species richness within *Brachionus* and *Trichocerca* may differ from Southeast Asia, further research may be desirable to determine whether this ratio performs equally well in Cambodia. Furthermore, as our study is based on a relatively small number of waterbodies, additional sampling to determine the trophic status of waterbodies within the Cambodian Mekong River Basin is also warranted, as is validation of the QB/T with other water quality matrices measurement such as Secchi disk depth, chlorophyll-a concentration, and total phosphorus concentration (Silsbe *et al.*, 2006; James *et al.*, 2009).

Acknowledgements

This work was supported by the Centre for Biodiversity Conservation (CBC) and the Department of Biology, Faculty of Science, Royal University of Phnom Penh and Fauna & Flora International, Cambodia. The authors thank Dr Ken Wong for his contribution to this work.

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Status, distribution and ecology of the Siamese crocodile *Crocodylus siamensis* in Cambodia

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Paper submitted 13 February 2015, revised manuscript accepted 21 September 2015.

សេចក្តីសង្ខេប

ក្រពើភ្នំ/ក្រពើត្រី (Siamese crocodile) ជាប្រភេទជិតផុតពូជបំផុតនៅភូមិភាគអាស៊ីអាគ្នេយ៍ ហើយដែលគេជឿជាក់ថា ប្រទេសកម្ពុជាជាកន្លែងដែលប្រភេទនេះនៅមានសេសសល់ច្រើនជាងគេក្នុងធម្មជាតិ។ ដើម្បីចងក្រងជាឯកសារស្តីពី រប៉ាយ អេកូឡូស៊ី ស្ថានភាព និងការគំរាមកំហែងលើប្រភេទក្រពើភ្នំ ការសិក្សាស្រាវជ្រាវ និងសម្ភាសន៍បានធ្វើឡើងដោយថ្មើជើង និងទូកចាប់តាំងពីឆ្នាំ២០០០ដល់ឆ្នាំ២០១៤។ ក្រពើភ្នំត្រូវបានរកឃើញនៅចំនួន៣៥ទីតាំង ក្នុង១១ខេត្តទូទាំងប្រទេសដែលទីតាំងនីមួយៗមានក្រពើភ្នំចំនួនចន្លោះពី០១ទៅ៤០ក្បាល។ ទីតាំងជាង៧០ភាគរយ និងក្រពើប្រមាណ៩០ភាគរយត្រូវបានរកឃើញនៅភូមិភាគនិរតីនៃប្រទេសកម្ពុជា ហើយក្រពើដែលមានចំនួនច្រើនបំផុត គឺនៅជិតលំនៅដ្ឋានរបស់សហគមន៍ជនជាតិដើមភាគតិច ដែលជាអ្នកមានប្រពៃណីគោរពសត្វក្រពើ។ យើងប៉ាន់ស្មានតាមបែបអភិរក្ស សត្វក្រពើនៅក្នុងប្រទេសកម្ពុជាមានចំនួនចន្លោះពី២០០ទៅ៤០០ក្បាល(ក្រពើពេញវ័យ១០០ទៅ២០០ក្បាល)។ តាមការវិភាគលាមកសត្វក្រពើជាង៦៥០សំណាកបង្ហាញថាក្រពើស៊ីចំណីច្រើនប្រភេទក្នុងនោះភាគច្រើនគឺពស់និងត្រី។ ក្រពើភ្នំត្រូវបានគេរកឃើញនៅតាមត្រពាំង វាលភក់ និងស្ទឹងដែលមានទឹកហូរតិចៗនៃតំបន់ទឹកសាបចាប់ពីតំបន់ក្បែរមាត់សមុទ្ររហូតដល់តំបន់ដែលមានរយៈកំពស់៦០០ម៉ែត្រពីនីវ៉ូសមុទ្រ។ ការគំរាមកំហែងលើសត្វក្រពើរួមមាន៖ ការចាប់ និងជាប់ឧបករណ៍នេសាទដោយចៃដន្យ ការប្រមាញ់ ការបាត់បង់ និងខូចគុណភាពទីជម្រក បញ្ហាជាន់ឈាមក្នុងការបង្កាត់ពូជ ព្រមទាំងហានិភ័យដទៃទៀតដែលទាក់ទងទៅនឹងចំនួនតិចបំផុតនៃប្រភេទក្រពើនេះក្នុងធម្មជាតិ។ នៅក្នុងប្រទេសកម្ពុជា គ្មានភ័ស្តុតាងណាមួយដែលបានបញ្ជាក់ថាក្រពើភ្នំវាយប្រហារទៅលើមនុស្សនៅឡើយ។ ក្រពើភ្នំបន្តពូជពុំបានល្អប្រសើរឡើយក្នុងធម្មជាតិ គឺមានចំនួនតិចជាង០៥សំបុកត្រូវបានរកឃើញជារៀងរាល់ឆ្នាំ។ ការសាកល្បងលែងក្រពើភ្នំទៅក្នុងធម្មជាតិតាំងពីឆ្នាំ២០១២បានបង្ហាញថាការបង្កាត់ពូជក្រពើអាចជួយស្តារចំនួនក្រពើភ្នំក្នុងធម្មជាតិឡើងវិញបាន ប៉ុន្តែត្រូវធ្វើសិក្សាពីសេនេទិច ដើម្បីជៀសវាងការលែងក្រពើពូជកាត់។ វឌ្ឍនភាពល្អ គឺកើតចេញពីការចូលរួមសហប្រតិបត្តិការរបស់សហគមន៍មូលដ្ឋានក្នុងកិច្ចការការពារតំបន់ដ៏សើមសំខាន់ៗ ប៉ុន្តែក៏តម្រូវឲ្យមានបន្តការគាំទ្រពីរដ្ឋាភិបាល អង្គការក្រៅរដ្ឋាភិបាលផងដែរ ដើម្បីស្តារប្រភេទដែលកំពុងទទួលគ្រោះថ្នាក់ជិតផុតពូជបំផុតមួយនេះ។

CITATION: Han S., Hor L., Nhek R., Sorn P., Heng S., Simpson, B., Starr, A., Brooke, S., Frechette, J.L. & Daltry, J.C. (2015) Status, distribution and ecology of the Siamese crocodile *Crocodylus siamensis* in Cambodia. *Cambodian Journal of Natural History*, 2015, 153–164.

Abstract

The Siamese crocodile is one of Southeast Asia's most endangered species, and Cambodia is believed to hold the largest remaining wild population. Between 2000 and 2014, interviews and field surveys were conducted on foot and by boat to document the species' distribution, ecology, status and threats. Crocodiles were confirmed in 35 locations in 11 provinces, each holding between one and 40 individuals. Over 75% of sites and 90% of individuals were found in Southwest Cambodia, with the largest groups located near settlements of indigenous communities who traditionally revere crocodiles. We conservatively estimate the national wild population to number approximately 200–400 individuals (100–200 mature adults). Analysis of over 650 faeces revealed a wide variety of prey, with snakes and fish being the most frequently recorded. Crocodiles were found in freshwater lakes, swamps and slow-moving rivers, from near sea level to an elevation of 600 metres. Threats include accidental capture and drowning in fishing gear, poaching, habitat loss and degradation, and inbreeding and other risks associated with very small populations. No evidence was found of crocodiles attacking people in Cambodia. The crocodiles are not reproducing well, with fewer than five nests reported annually. Trial releases since 2012 indicate that captive-bred crocodiles could help repopulate and reinforce wild stocks, but they must be genetically tested to avoid releasing hybrids. Good progress has been made in enlisting the cooperation of local communities to protect key wetlands, but continued efforts from the government and NGOs are also required to enable this Critically Endangered species to recover.

Keywords

Camera trapping, community-based conservation, crocodilian, faecal analysis, protection, Southeast Asia, wetlands.

Introduction

The Siamese crocodile *Crocodylus siamensis* is a stocky freshwater crocodile that rarely exceeds a total length of 3.5 metres. Adult females are typically smaller, at less than 2.7 metres (Simpson, 2006). It is Critically Endangered and one of the least known of the world's 27 crocodilians (Bezuijen *et al.,* 2012; Grigg & Kirschner, 2015).

Siamese crocodiles used to be abundant and widespread in rivers and swamps throughout Southeast Asia, including Cambodia, Indonesia, Laos, Malaysia, Myanmar, Thailand and Vietnam, but their numbers fell during the 20th century due to collection for crocodile farms, hunting, and habitat loss. By the early 1990s, Siamese crocodiles were feared to be "effectively extinct" in the wild (Thorbjarnarson, 1992).

Verbal reports from the 1990s suggested that Siamese crocodiles were still widespread in Cambodia (Nao & Tana, 1994), but it was not until 2000 that wild crocodiles were confirmed during biodiversity surveys by the Government of Cambodia's Forestry Administration and Fauna & Flora International (Daltry & Chheang, 2000). Since then, individuals and small colonies have also been found in Laos, Thailand, Vietnam and Indonesia (Simpson & Bezuijen, 2010).

This paper presents the main findings of field surveys for Siamese crocodiles throughout the Royal Kingdom of Cambodia by the authors from 2000 to 2014. Although we have presented and discussed our research at various conferences of the IUCN/SSC Crocodile Specialist Group and other forums during this period, this paper contains new and updated information that has not been published before.

Methods

Determining where crocodiles are present

Every year from 2000 to 2014, between four and eight trained field personnel searched waterways throughout Cambodia for evidence of crocodiles. Potential sites were identified by interviewing fishers and other local people, studying topographic maps and satellite images, and by soliciting information from government departments and non-governmental organisations in every province. Field teams usually worked in pairs to search the banks on foot for faeces, footprints and tracks, stopping occasionally to scan the water and banks with binoculars for crocodiles. When possible and safe to do so, we conducted night surveys by boat or on foot to search for crocodile 'eye-shine' reflected in flashlight beams. Most waterways were surveyed during the dry season between November and April, when access was easier and signs less likely to be washed away.

We measured the maximum diameter of intact faeces (not broken or squashed) and collected them in individual plastic bags for analyses (below). We measured the length and width of clear, intact footprints using the

method of Daltry *et al.* (2003). All confirmed localities were recorded using GPS and entered into a database. We also recorded the depth of the water body, the surrounding vegetation type, and evidence of fishing or other human activities.

When crocodiles were sighted, we identified the species. Cambodia has two native crocodiles, the other being the saltwater crocodile *C. porosus*. The species can be differentiated in the field by various morphological differences, one of the most conspicuous being that *C. siamensis* bears a row of four large post-occipital scales on its neck, which are typically absent from *C. porosus* in this part of their range (Simpson, 2006).

Population counts

For every waterway where crocodiles were detected, we used the evidence from sightings and signs to count the minimum number of individuals present. Because one crocodile can leave multiple faeces and tracks, we distinguished individuals based on the sizes of their faeces and tracks. For example, if some faeces measured 50 mm in diameter and others were only 20 mm in diameter, we inferred at least two individuals were present. Faeces were assigned to size classes based on their maximum diameter in millimetres (2.0–4.9, 5.0–8.9, 9.0–12.9, etc.) and footprints assigned to size classes based on maximum width in centimetres (forefoot width: 6.0–7.9, 8.0–9.9, 10.0–11.9, etc.; hind foot width: 2.0–4.9, 5.0–8.9, 9.0–12.9, etc.). Faeces and footprints were measured and included in the study only if they were intact and undamaged. Because this method did not distinguish between individuals of similar size, we increased these counts when crocodiles of equal size were seen at the same time (e.g. if faeces in a large size class were found, we conservatively recorded one large adult, but increased the count to three if three large crocodiles were actually seen).

We tested the use of camera traps to determine whether camera trapping could help improve our population counts during the dry seasons of 2007 and 2008 in Veal Veng Marsh (Pursat Province; Reconyx TrailMaster 1550, $n = 5$, and Non-Typical DeerCam DC-300, $n = 5$); in 2008 along the Areng River (Koh Kong Province; Reconyx TrailMaster 1550, $n = 6$); and in 2010 along the Kompong Chey River (Koh Kong Province; Reconyx RC55, $n = 5$) (Starr *et al.* 2010). Camera traps were directed at riverbanks used by crocodiles for basking, judging by the presence of faeces and flattened substrate. Photographs were used to identify individuals from the spots on their flanks and other distinguishing features: a method commonly used for identifying and counting big cats and other animals (Karanth, 1995; Mendoza *et al.*, 2011) and recently applied to gharials *Gavialis gangeticus* (Nair *et al.*, 2012).

Diet analysis

All faeces found were taken to Phnom Penh and sun-dried, crumbled by hand and carefully inspected for any remains of prey. Prey were identified to major taxonomic class (e.g. bird, mammal, reptile, fish, crustacean), and to more specific taxa where possible. Crocodiles digest bone and flesh, but structures made of keratin (e.g. hair, feathers, fish scales) and chitin (e.g. arthropod exoskeletons) are excreted intact (Daltry *et al.*, 2003).

Nest studies

Sites confirmed to have crocodiles were revisited between March and June to search for nests. If present, eggs were counted, measured, weighed and replaced, taking care not to turn them (Simpson, 2006). Where possible, nests were routinely inspected by the authors and/or local community wardens (villagers trained and recruited to patrol and monitor four of the most important breeding sites) to monitor their fate.

To overcome the high natural mortality experienced by wild eggs and juveniles, headstarting was conducted for three clutches from nests near the Areng River. Most of the fertilized eggs from each clutch (10 eggs in 2009, 17 in 2012, and 15 in 2013) were collected, and the 42 hatchlings were raised for between one to two years in Prek Svay (Areng) Village before being released back to the wild.

Results

Distribution

Figure 1 shows locations reported by local people (white dots), all of which were investigated in addition to other areas with suitable habitat. Wild crocodiles were confirmed to be present in 35 localities in 11 provinces (Table 1; dark dots, Figure 1). Over 75% of the occupied waterways, and over 90% individuals were found in Southwest Cambodia, especially in and around the Cardamom Mountains. In almost all cases, the crocodiles were in relatively remote areas, far from cities and highways.

All of the confirmed records shown in Figure 1 are believed to be Siamese crocodiles, not saltwater crocodiles. Every individual seen by the authors— including individuals captured by the project team for radiotelemetry studies (e.g. Simpson *et al.*, 2006), caught by fishers and poachers, and seen in camera trap images— was *C.*

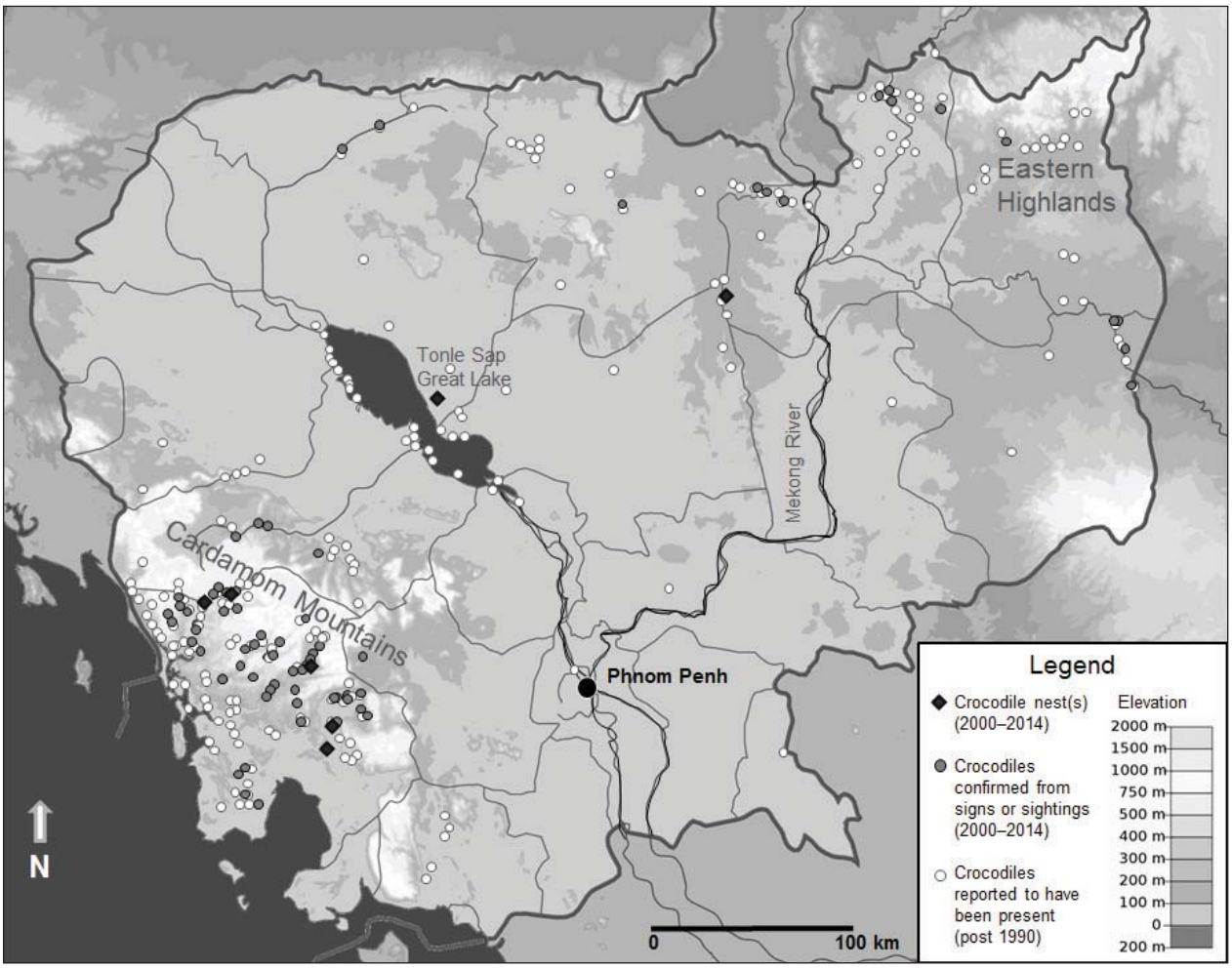

Fig. 1 Reported and confirmed distribution of Siamese crocodiles in Cambodia.

siamensis. Although we cannot completely exclude the possibility of some tracks or faeces being those of saltwater crocodiles *C. porosus*, no proof has been obtained of this species living wild in Cambodia in recent years (Platt *et al.*, 2006a; Webb *et al.*, 2010).

Habitat

Crocodiles were found in a wide range of freshwater bodies, including lakes, swamps and slow-moving rivers, especially the deep-water sections ('anlong' in Khmer). Most sites had gently sloping banks and a mixture of open and heavily shaded areas, usually surrounded by forest. The highest documented site was 600 metres above sea level in the Central Cardamom Mountains.

A shared feature of all permanently occupied waterbodies was that even at their lowest water levels during the dry season, they contained at least 1.1 metres depth of water.

Population size

Most sites confirmed to have crocodiles contained evidence of only one or two individuals, with no juveniles or nests found to prove they were breeding. Table 1 shows a list of sites with the minimum number of crocodiles present. Sites with the largest number of individuals were re-visited multiple times (every year since 2002 in the case of Veal Veng Marsh and Areng River, and every year since 2007 in Chay Reap).

Based mainly on signs, we counted 224 individuals nationwide between 2000 and 2014, including 26 captive-bred crocodiles that were released in 2012 and 2014 (see Table 1). This is probably an underestimate of the total number of crocodile present during the course of

Table 1 Confirmed crocodile locations and population estimates in Cambodia (2000–2014).

Site No.	Name of location	Province	Year(s) surveyed	Minimum no. of crocodiles (all ages)
1	Pursat River (upper)	Pursat	2003, 2004	3+
2	Pursat River (lower)	Pursat	2003, 2004	4+
3	Peam River	Pursat	2004	1+
4	Veal Veng Marsh	Pursat	2000–2015	40
5	Koi and Krau Rivers	Pursat	2002, 2003	14+
6	Russei Chrum (upper)	Koh Kong	2004	1+
7	Russei Chrum (lower)	Koh Kong	2006	1+
8	Kiew River (Upper)	Koh Kong	2004, 2009	7+[a]
9	Kiew River (Lower)	Koh Kong	2004, 2009	1+
10	Kep River	Koh Kong	2002, 2009	10+
11	Tatai River (Upper)	Koh Kong	2002	11+[b]
12	Tatai & Touch Rivers	Koh Kong	2002	11+
13	Tatai River (Lower)	Koh Kong	2002	5+
14	Areng River (Upper)	Koh Kong	2002	1+
15	Areng River (Central)	Koh Kong	2002–2015*	30
16	Trapeang Rung	Koh Kong	2005	11+
17	Kompong Chey River/ Trapeang Peang	Koh Kong	2003, 2007–2015*	36+[c]
18	Sre Ambel River	Koh Kong	2008*	7+
19	Kul River, Botum Sakor	Koh Kong	2005, 2009*	1+
20	O'Plai (tributary of Srepok River)	Mondulkiri	2005	1+
21	Srepok River (Srepok Protected Forest)	Mondulkiri	2003, 2004, 2009, 2010*	8+
22	O'Lieou (tributary of Srepok River)	Mondulkiri	2003, 2004, 2009, 2010	1+
23	Sesan River	Ratanakiri	2005, 2006	1+
24	O'Lalay River	Ratanakiri	2005, 2006	3+
25	Sekong / O'Kampa River	Stung Treng	2005, 2006	8+
26	O'Chay River	Stung Treng	2005, 2006	2+
27	O'Kandal River	Preah Vihear	2004	1+
28	Sen River	Preah Vihear	2004, 2007	1+
29	Beung Pradak	Preah Vihear	2004	1+
30	Porung River	Kampong Thom	2004, 2008*	1+
31	Chi Kreng (Tonle Sap)	Siem Reap	2004*	2+
32	Prek Toal (Tonle Sap)	Battambang	2004, 2007*	6+
33	O'Talas River	Stung Treng	2006	4+
34	Anlong Veng	Oddar Menchey	2006	3+
35	O'Te River	Kratie	2003	1+
			Total	**224+**

* Sites with nests/hatchlings

[a] Includes two individuals relocated from Atay River hydro dam site in 2010 and Areng River in 2013.

[b] Includes nine juvenile Siamese crocodiles released in 2010 (headstarted from a wild nest from the Areng River).

[c] Includes 26 captive-bred Siamese crocodiles released in 2012 and 2014.

this study because, as explained in the Methods, tracks or faeces of equal size were conservatively ascribed to a single individual unless more were seen. It is also possible some occupied sites were overlooked, especially those with only one or two individuals. On the other hand, some of the records in Table 1 date back to the early 2000s and we are uncertain whether those crocodiles are still present. Allowing for this, we suggest that Cambodia's crocodile population currently numbers in the low hundreds, with likely between 200 and 400 individuals aged one or more years.

Reproduction

Since 2000, nests and/or juveniles were found in only 11 of the 35 sites in Table 1. A total of 22 nests were found, all towards the end of the dry season (between March and May). The mound nests were under trees on the banks of rivers or ponds and usually in deep shade, apart from three that were on floating vegetation. The adult females remained close to the nest throughout incubation. In several localities, including Veal Veng Marsh and the Areng River, females were observed re-using the same nesting sites year after year. Clutch sizes ranged from 16 to 25 eggs. Of the 14 nests whose fate is known, five (36%) were poached, one (7%) was raided by wild animals, two (14%) were destroyed by flooding, and the remaining six (43%) hatched successfully. In one well protected lake in the Areng Valley, we monitored 23 Siamese crocodile hatchlings from 2007 to 2008, and found only five (22%) survived their first year.

Diet

Six hundred and fifty faeces were sampled from the three largest known breeding colonies (Veal Veng Marsh, Areng River and Chay Reap) between 2000 and 2014, representing all size classes from hatchlings to very large adults. The contents of the faeces included fish (30.9% of faeces), reptiles (29.6%), invertebrates (detected in 11.5% of faeces, including ants, beetles, scorpions and crabs), mammals (4.9%) and birds (3.0%). One fifth of faeces, most of them in the smallest size classes, contained no identifiable remains. Reptiles and fish were identified chiefly by the presence of scales in the faeces. At least 88.1% of the reptiles were snakes (present in 26.1% of all faeces examined), which were confirmed from their ventral scales. Most of the mammal hairs were consistent with rats or other rodents. The largest documented prey were adult wild boar *Sus scrofa*, which we identified from coarse hairs in the faeces of very large adults. Amphibians were not confirmed, probably because their bodies were fully digested. However, it is likely that some of the small invertebrates we recorded had been secondarily ingested along with amphibians and other insectivores.

Discussion

Current distribution and population size

Historical records indicate that Siamese crocodiles used to be common and widespread in Southeast Asia (Simpson & Bezuijen, 2010), but Cambodia's remaining wild crocodiles are now largely confined to small water bodies in remote areas (Figure 1). Since 2000, more than 200 individuals have been confirmed at 35 sites on 30 rivers or wetland systems in 11 provinces (Table 1), but the national population is small, severely fragmented and likely declining as some of the river systems have been subjected to high levels of habitat degradation, overfishing, and hunting. We failed to detect crocodiles in more than 50% of sites where crocodiles were reportedly seen in the 1990s (Figure 1), which may be indicative of a rapid rate of decline. Many of the sites we found contained only one or two isolated individuals and showed no signs of breeding taking place.

Among the most important known crocodile sites in the country are Veal Veng Marsh (Pursat Province) and the Areng, Kampong Saom (Sre Ambel), Kep, Koi, Pursat, Sekong, and Srepok rivers. Field surveys and interviews were conducted all over the country, inside and outside of protected areas, but most of the sites confirmed to have crocodiles were state forestlands in and around the Cardamom Mountain range, up to 600 metres above sea level. These cooler, higher elevations may be marginal habitat for this species, and are probably associated with slower rates of growth and reproduction than the larger, warmer water bodies in the lowlands.

Obtaining accurate population counts was not easy. Crocodile surveys in other parts of the world often entail quietly travelling by boat at night and using a flashlight to detect crocodiles from their eye-shine (Bayliss, 1987), but we found this method to be of limited practical use in Cambodia. Most waterways are too remote, narrow, swampy or densely vegetated to use a boat, and Siamese crocodiles are scarce and wary. We often failed to see eye-shine even in areas where crocodile presence was confirmed from fresh faeces and tracks. Our pilot study using camera traps in Veal Veng Marsh met with little success because these crocodiles are wary of unfamiliar objects: they stopped using their usual basking areas when posts were installed to hold the cameras. We achieved more consistent results by using our novel method of identifying and counting crocodiles based on

the sizes and distribution of tracks and faeces, supplemented with sightings, but further research is needed to test the accuracy of the count data shown in Table 1.

We conservatively counted a total of 224 individuals between 2000 and 2014, and estimate that Cambodia currently has around 200–400 Siamese crocodiles in the wild, approximately half of which are adults. While modest, these figures are higher than the best supported estimates for any other range state (Daltry *et al.,* in press). In Laos, for example, where surveys using similar methods were carried out between 2004 and 2008, Bezuijen *et al.* (2013) documented only 36 individuals in 13 sites in six river systems (1–11 individuals per site).

Reproduction

Wild clutches found in Cambodia, Laos and Vietnam contain between 16 and 31 eggs (Platt *et al.,* 2006b; Cox & Phothitay, 2008; Bezuijen *et al.,* 2013; this survey), smaller than the clutches of up to 50 that have been recorded in captivity (Youngprapakorn *et al.,* 1971). In a study of captive Siamese crocodiles in Cambodia, Platt *et al.* (2011) found the mean incubation period to be 72±3 days and eggs hatched from early May to mid-August (the rainy season).

Adult females remain close to the nest through incubation, and hatchlings may stay with their mother for more than a year (J. Daltry, pers. obs.). In captivity, both parents of this species have been observed to vigorously defend their nest and young when approached by humans (John Brueggen, St Augustin Alligator Farm and Zoo, pers. comm.). In Vietnam, a non-fatal attack by a Siamese crocodile on a man fishing illegally in Cat Tien Lake in 2008 was inferred to be in defence of nearby hatchlings (Incident #100-3403, CrocBITE database, www.crocodile-attack.info). In our experience in Cambodia, however, wild adults immediately retreated from view when approached by humans, even when their eggs were handled or their offspring made alarm calls.

Nests were found by the authors and our colleagues in 10 waterways in eight provinces in Cambodia, but the number of active breeding sites is declining. Fewer than five nests are reliably reported each year and, while some nests may go undetected, this is consistent with the low numbers of juveniles reported in the wild. This low level of reproduction is not sufficient to maintain the wild population, especially given that many clutches are lost to floods, predators and poachers. Our observations of a well-protected nesting site in the Areng Valley found 60% of nests were destroyed by flooding and natural predators, and only 22% of hatchlings survived their first year. Low rates of survival are not unusual among nests and young crocodilians, with some studies reporting fewer than 2% of hatchlings surviving their first year (e.g. Green *et al.,* 2010).

Diet

Siamese crocodiles are generalist predators that feed on a very wide variety of animals including crabs and other large invertebrates, fish, frogs, reptiles, birds and mammals, including carrion (this study). The present study is the largest to date on the diet of this species in the wild, and our findings are consistent with the smaller sample in Laos studied by Bezuijen (2010). Faecal analysis cannot be used reliably to quantify the relative importance of different prey animals because they vary in digestibility. However, the very high frequency of faeces containing snake scales and fish scales suggests these animals form a particularly important part of the diet of Siamese crocodiles. Future studies could consider using stomach flushing (Fitzgerald, 1989) to quantify the numbers eaten, compare the diets of different crocodile age groups and to identify their prey to species level.

Interactions with humans

During interviews with over 2,000 fishers, district officials, rangers and other people nationwide, we found no record of wild Siamese crocodiles preying upon or otherwise attacking a human in Cambodia. This is consistent with historical observations from the early 1900s, when this species was still abundant (Smith, 1919), and with recent findings in Laos (Bezuijen *et al.,* 2006). The CrocBITE database (www.crocodile-attack.info) attributes to Siamese crocodiles only three attacks on humans over the past century (one each in Thailand, Vietnam and Indonesia), at least two of which were defensive and not fatal. All in all, the evidence points to this being a species that typically hunts small prey and avoids human contact. Communities that have lived in areas with Siamese crocodiles for generations continue fishing, bathing and swimming in the same waterbodies with little hesitation. However, Cambodians living in areas where crocodiles have been absent for several decades or longer tend to be fearful of them (Chantha *et al.,* in prep).

It can be no coincidence that the largest remaining colonies in Cambodia are in areas occupied by indigenous peoples (e.g. Veal Veng Marsh and the Areng, Tatai and Kampong Tachay rivers). Members of certain ethnic minority groups, including the 'Por' people of the Cardamom Mountains, believe that crocodiles represent their ancestor spirits and bring good luck (Daltry *et al.,* 2003). They believe killing or even disturbing crocodiles can bring serious misfortune. This may be why crocodiles in

these areas were able to avoid much of the persecution and poaching that occurred elsewhere.

Conflicts can arise, however, when crocodiles break fishing nets and other equipment, or prey on small livestock (CCCP, 2012). The authors were informed of a number of cases of Siamese crocodiles being killed in retaliation for killing hunting dogs. Like most wild animals, crocodiles will bite in self-defence when trapped, and reportedly some fishers have been bitten while attempting to catch crocodiles or disentangle them from nets and hooks.

Summary of threats to Cambodia's crocodiles

Poaching— Interviewees in many parts of the country described gangs of crocodile hunters who flushed the reptiles into nets and dug them out of the river bank burrows to sell them alive to crocodile farms, especially during the 1980s and 1990s. Illegal capture and trade continue to be a severe threat to Siamese crocodiles in Southeast Asia, with live wild adults fetching up to US$1,800 each in Cambodia (Daltry & Thorbjarnarson, 2004). According to our interviews and direct observations, at least 61 wild crocodiles were illegally captured in Cambodia between January 2001 and March 2004, more than 10% of the estimated wild population at that time (Daltry & Thorbjarnarson, 2004). Poaching levels appear to have fallen (e.g. only three individuals were reported to be killed or removed alive in 2010: Starr *et al.,* 2010), but any extraction is a serious concern, given how few remain in the wild. One factor contributing to illegal trade is that there are many hundreds of crocodile farms in Cambodia that are permitted to rear Siamese crocodiles, but it is difficult for authorities to monitor so many farms and ensure none purchases or launders wild-caught crocodiles (Jelden *et al.,* 2005). Unauthorised cross-border trafficking of crocodiles is also ongoing in Southeast Asia, despite wild populations being included on CITES Appendix I (Daltry *et al.,* in press).

Drowning and injuries inflicted by fishing gear— Fishing occurs in most waterways across Cambodia, including almost every site in Table 1. Even in protected areas that, on paper, prohibit the collection of any wild animals, fishers are usually at liberty to catch fish, frogs and other small aquatic animals. Fishing is considered to be an essential subsistence and economic activity for many rural Cambodians (e.g. Hortle, 2007), but this means almost all Siamese crocodiles are at risk from fishing practices. The most destructive fishing methods, such as electrofishing, spear fishing and the use of explosives or poisons, are prohibited by law but still continue in remote areas. Gill nets and hooks, which are lawfully used in most areas, can drown even large crocodiles, and many deaths have been reported and confirmed (Daltry & Thorbjarnarson, 2004). The relatively recent progression from natural fibres to nylon nets and lines has enabled Cambodian fishers to leave their equipment in the water for longer than they did in the past, and makes it harder for crocodiles to break free.

Habitat loss and degradation— Loss and conversion of wetlands and adjoining habitats for rice farming and other forms of agriculture is ongoing. Besides subsistence-level farming, economic land concessions have been awarded to allow huge areas to be mined or converted to rubber, oil palm, banana and other enterprises (e.g. Neef *et al.,* 2013). Even wetlands in protected areas are not safe from this threat. For Siamese crocodiles, of greatest concern are the many dozens of hydroelectricity dams that have been proposed or are under construction, both in Cambodia and in countries upstream (Ziv *et al.,* 2012). Such developments are not only associated with habitat loss and alteration, but with new roads, in-migration of workers, and other changes that make wildlife more vulnerable to illegal activities. In 2011, for example, Forestry Administration rangers discovered a young wild-caught Siamese crocodile in the possession of Chinese builders of the Steung Atay hydroelectric dam in Koh Kong Province.

Hybridization with other species of crocodiles— In crocodile farms and zoos throughout Cambodia and elsewhere in the region, captive Siamese crocodiles have been hybridized with two other species of crocodiles, the Cuban crocodile *C. rhombifer* and saltwater or estuarine crocodile *C. porosus*, on multiple occasions (Jelden *et al.,* 2005). Hybrid offspring are fully fertile (i.e. they are capable of breeding with one another or with other species) and tend to grow larger and may behave more aggressively than pure-bred *C. siamensis*. The number of farms containing hybrids is unknown, but of the 40 crocodiles whose DNA was analysed from Phnom Tamao Wildlife Rescue Centre in the past three years 14 have been hybrids (35%) (most of the Centre's stock were derived from farms in Cambodia) (Starr *et al.,* 2009; unpublished data). It is not known whether any hybrids have been released or escaped into the wild, but they pose a clear danger to the genetic integrity of wild Siamese crocodiles. Furthermore, by posing a greater danger to humans, hybrids could also seriously harm public perceptions of crocodiles in Cambodia. Unfortunately, the only reliable way to identify hybrids is using genetic analysis. Currently, these tests are expensive and can only be conducted overseas (FitzSimmons *et al.,* 2002).

Risks associated with small and fragmented populations— With an estimated total of 200–400 individuals, Cambodia's wild Siamese crocodile population falls far short of the several thousand individuals that most species require to be viable (Traill *et al.,* 2007). Their low numbers and fragmented distribution makes Cambodia's crocodiles intuitively vulnerable to local extinction due to natural disasters, other stochastic (chance) hazards and/or loss of genetic diversity (linked to such problems are lower fertility and reduced resistance to disease) (Gilpin & Soulé, 1986). Small population sizes also make the potential impact of natural predators more serious. Wild animals, including wild boar, monitor lizards (*Varanus* spp.) and macaques (*Macaca* spp.), prey on the eggs of crocodiles. Adult Siamese crocodiles in Cambodia have no known natural predators (although where their ranges overlapped, they may have been attacked by larger saltwater crocodiles historically), but juvenile crocodiles are easily captured by monitor lizards, large snakes, storks and other large wetland predators. Natural mortality rates are uncertain, but the authors' limited data indicate only around 40% of clutches survive to hatching and, even in protected sites, less than 25% of hatchlings survive their first year.

In addition, radiotelemetry studies of wild and released captive-bred crocodiles in the Cardamom Mountains indicate that Siamese crocodiles could be so sedentary that even individuals from different sections of the same river might never meet and breed (Simpson & Sam, 2004; unpublished data), let alone recolonise vacant waterways.

Conservation Management and Recommendations

Conserving Siamese crocodiles in Cambodia will require concerted protection and reinforcement of wild populations to enable them to increase from the low hundreds to a more viable size:

Community-based and government protection— Cambodia has made progress in reducing poaching and other dangers by forming groups of trained local wardens to monitor and patrol crocodile areas, providing appropriate livelihoods assistance to local communities so they can avoid damaging wetlands, and developing community regulations to avoid using the more high-risk types of fishing gear at crocodile breeding sites (Daltry *et al.,* 2005; Oum *et al.,* 2009). Given that the current population of crocodiles is very small and fragmented, such site-based intervention is critical. However, local management needs to be underpinned with higher level government protection and support to ensure people involved in the illegal capture and trade of wild crocodiles are caught, penalised and held up as warnings to others, and to safeguard the most essential waterways and their watersheds from incompatible developments. We recommend that at least eight of the best Siamese crocodile sites in Table 1 should be afforded special protection by the Royal Government of Cambodia to ensure their habitats remain intact.

Reinforcement and reintroduction— The release of captive-bred and/or headstarted crocodiles is essential to enable Cambodia's depleted, fragmented and poorly-breeding wild population to achieve a more viable size (Daltry & Starr, 2010). This approach is proving vital to the recovery of the Critically Endangered Philippine crocodile *C. mindorensis* (van Weerd *et al.,* 2010), which was also reduced to a few extremely small colonies. It is, however, imperative that the captive crocodiles are first genetically tested to confirm they are purebred (not hybrid) Siamese crocodiles, and that hunting, persecution and other threats have been sufficiently reduced or removed from the proposed release site (IUCN/SSC, 2013). This means releases should take place only into very well protected waterways and with the prior informed consent of local stakeholders. In 2010 the Phnom Tamao Wildlife Rescue Center established a captive breeding programme to produce healthy Siamese crocodiles for release. The breeding programme is still in its infancy, but pilot releases by the authors of 26 captive-bred crocodiles in community-protected wetlands in 2012 and 2014 have shown excellent results so far, including high rates of survival and positive responses from the local communities. Further information on the reintroduction and reinforcement programme will be published separately.

Education and outreach— If Siamese crocodiles are to repopulate wetlands from which they have been extirpated, it is vital to gain the cooperation of local people and decision-makers. Surveys in the Philippines have demonstrated that people living in areas that no longer have crocodiles are often significantly more afraid of crocodiles than people who are still accustomed to living alongside them (Merlijn van Weerd, pers. comm.), and the same pattern has been found from interviews in Cambodia (Chantha *et al.,* in prep). There is therefore a need for further outreach using a range of media to raise awareness of Siamese crocodiles, their protected status and importance to Cambodia, and to demonstrate that people and Siamese crocodiles can coexist harmoniously. Villagers in the Cardamom Mountains who protect their local crocodiles could potentially be ambassadors for teaching and reassuring others that Siamese crocodiles are an asset and pose no danger when treated with respect.

In addition, given that this species is scattered across multiple sites, all of which require skilful management, it is very important to continue to share methods, findings and lessons learned with other organisations and government agencies that are interested in the conservation of this species and its habitats, both in Cambodia and in other range states. We hope this paper will be a useful contribution towards this end.

Acknowledgements

The authors are most grateful to His Excellency Cheng Kimsun, Director General of the Forestry Administration, His Excellency Nao Thuok, former Director General of the Fisheries Administration and now Secretary of State, Ministry of Agriculture, Forestry and Fisheries, and His Excellency Ty Sokhun, Secretary of State, Ministry of Agriculture, Forestry and Fisheries, for graciously supporting the many years of research and consultations that have gone into this paper.

Many other individuals and organisations contributed valuable information and assistance to the authors, including hundreds of villagers across southern Cambodia, members of the IUCN/SSC Crocodile Specialist Group and Re-introduction Specialist Group, Frontier, Wildlife Alliance, Wildlife Conservation Society, and WWF. GIS support was provided by Chhuon Phirom (FFI) and Jeremy Holden provided training and support on camera trapping. Special mention must be made of the late Ponn Chamroeun, FA staff member of the Cambodian Crocodile Conservation Programme, and the late Dr John Thorbjarnarson of the Wildlife Conservation Society, who was among the first to recognise the plight of the Siamese crocodile. This paper is dedicated to them.

Conservation management and research on the wild Siamese crocodiles in Cambodia has been generously sponsored since 2000 by the Asia Development Bank, Association of Zoos & Aquariums, BBC Wildlife Fund, Conservation Food & Health Foundation, Critical Ecosystem Partnership Fund, Disney Conservation Fund, members and staff of Fauna & Flora International, Mohammed bin Zayed Species Conservation Fund, Ocean Park Conservation Foundation Hong Kong, Oren Taylor, the Species Fund, SOS—Save Our Species and US Fish and Wildlife Service (Critically Endangered Animals Conservation Fund), among others.

We also thank Dr Nick Souter and two anonymous reviewers for their helpful advice on an earlier draft of this manuscript.

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Foraging preferences of eastern sarus cranes *Antigone antigone sharpii* in Cambodia

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Paper submitted 28 July 2015, revised manuscript accepted 15 September 2015.

មូលន័យសង្ខេប

អន្លង់ព្រីង គឺជាតំបន់អភិរក្សមួយក្នុងចំណោមតំបន់ទាំងបីសម្រាប់សត្វក្រៀល(*Antigone antigone sharpii*) រកចំណីនៅរដូវមិនបន្តពូជក្នុងប្រទេសកម្ពុជា។ ខណៈពេលដែលអត្តសញ្ញាណ និងប្រភេទចំណីសំខាន់ៗដែលស៊ីដោយសត្វក្រៀលនេះមិនទាន់មានការចងក្រងជាឯកសារនៅឡើយនៅប្រទេសនេះ ដូច្នេះយើងបានធ្វើការវាយតម្លៃនៅតាមកន្លែងដែលវាបានជ្រើសរើសរកចំណីថាតើវាបានទទួលរងនូវឥទ្ធិពលពីវត្តមាន និងភាពសម្បូរបែបនៃប្រភេទរុក្ខជាតិផ្សេងៗ ព្រមទាំងកត្តាគ្មានជីវិតមួយចំនួននៅតំបន់នេះដែរឬទេ។ យើងបានរកឃើញថា ដង់ស៊ីតេសត្វក្រៀលមានការប្រែប្រួលគួរឱ្យគត់សម្គាល់រវាងកន្លែងនីមួយៗ(ចន្លោះពី ០.០៣- ៤.០៩ ក្បាលក្នុងមួយហិកតា)ដែលប្រែប្រួលទៅតាមប្រភេទរុក្ខជាតិ ដីទទេ និងទឹកគ្របដណ្តប់។ លទ្ធផលនេះបង្ហាញថា នៅអន្លង់ព្រីង សត្វក្រៀលចូលចិត្តរកស៊ីនៅតាមកន្លែងដែលសម្បូរទៅដោយប្រភេទប្លុងមានមើម (ប្លុងខ្នឹមធំ ឬប្លុងធំ *E. dulcis* និងប្លុងខ្នឹមតូច ឬប្លុងតូច *E. spiralis*)ហើយមានទឹករាក់ៗ ព្រមទាំងមានទំនាក់ទំនងជាមួយសមាសភាពរុក្ខជាតិ ដែលជួយឱ្យដីស្រទាប់លើមានភាពធូរ។ ដូច្នេះយើងផ្តល់ជាអនុសាសថា កត្តាទាំងពីរនេះ គឺជាអាទិភាពសម្រាប់ការគ្រប់គ្រងតំបន់ទាំងឡាយណា ដែលមានវត្តមានសត្វក្រៀលនៅក្នុងប្រទេសកម្ពុជា ក៏ដូចជាធ្វើការសិក្សាបន្ថែមដើម្បីពង្រឹងការយល់ដឹងពីអេកូឡូស៊ីចាំបាច់របស់វា។

Abstract

Anlung Pring is one of three areas dedicated to eastern sarus crane *Antigone antigone sharpii* conservation during the non-breeding season in Cambodia. Because the identity and availability of major food items consumed by the species are undocumented in the country, we assessed whether foraging areas selected by sarus cranes are influenced by the presence and abundance of different plant species and edaphic factors in the site. Crane densities varied significantly between sampling areas (ranging from 0.03–4.09 cranes/ha), as did vegetation, bare soil and water cover. Our results suggest that sarus cranes in Anlung Pring prefer foraging areas characterized by an abundance of *Eleocharis* species that produce underground tubers (namely *E. dulcis* and *E. spiralis*) and shallow water, which influences vegetation composition and facilitates sub-surface access. We consequently recommend both factors as priorities for management at sites where the species congregates in Cambodia, as well as additional studies to improve understanding of its ecological requirements.

Keywords Anlung Pring, foraging preferences, sarus crane.

CITATION: Yav N., Parrott, M., Seng K & van Zalinge, R. (2015) Foraging preferences of eastern sarus cranes *Antigone antigone sharpii* in Cambodia. *Cambodian Journal of Natural History*, 2015, 165–171.

Introduction

The eastern sarus crane *Antigone antigone sharpii* is one of three extant sarus crane subspecies (Figure 1) and occurs in Cambodia, southern Laos, Myanmar and southern Vietnam (Krajewski & Fetzner, 1994; Wood & Krajewski, 1996; Meine & Archibald, 1996; Archibald *et al.*, 2003; Jones *et al.*, 2005; ICF, 2012; Tanee *et al.*, 2009; Insee *et al.*, 2014). Once widespread across Southeast Asia, its regional populations have declined sharply due to the loss and degradation of wetlands, hunting and egg collection. The species is currently listed as Vulnerable on the *IUCN Red List of Threatened Species* (Aryal *et al.*, 2009; BirdLife International, 2012) and has been extirpated from Malaysia, the Philippines and Thailand (Johnsgard, 1983; Wood & Krajewski, 1996; Meine & Archibald, 1996; BirdLife International, 2012; Insee *et al.*, 2014), but recently reintroduced to Thailand (Tanee *et al.*, 2009; Insee *et al.*, 2014). Annual counts of the population in Cambodia and southern Vietnam normally range between 650–878 birds, but numbers counted have decreased in recent years (van Zalinge & Triet, 2014).

To conserve national populations of the species, the Cambodian government has designated three Sarus Crane Conservation Areas (SCCAs) at key feeding sites used in the non-breeding season (November to June): Ang Trapeang Thmor (Banteay Meanchey Province), Boeung Prek Lapouv (Takeo) and Anlung Pring (Kampot). Conservation management in these sites currently focuses on alleviating human pressures and disturbance (BirdLife International, 2012; WWT, 2013). During the breeding season (July to October), the birds disperse to wet meadows in dry deciduous forests in North and Northeast Cambodia (Goes, 2013).

Habitat selection by birds is strongly influenced by security and food availability (Tortosa & Villafuerte, 2000; Aryal *et al.*, 2004, 2009), which can significantly affect reproductive performance (Zanette *et al.*, 2000). Insufficient food can reduce the rate, and delay the initiation, of reproduction (Lack, 1954; Marshall *et al.*, 2002) and can influence species mortality (Lack, 1954). However, the major food items consumed by sarus cranes, and their availability at sites where the species congregates during the non-breeding season, are largely unknown in Cambodia. This paper presents research undertaken to improve the understanding of these factors at Anlung Pring SCCA in South Cambodia. The site was chosen because it is the only SCCA where crane numbers have recently increased, according to annual surveys (Triet & van Zalinge, 2013).

Methods

Study site

Anlung Pring SCCA covers 217 ha and is located in Kampong Trach District, Kampot Province (10°28′40′′N, 104°31′32′′E), in South Cambodia, approximately one kilometre from the border with Vietnam within the lower Mekong Floodplain (Figure 2). The area is low-lying with an elevation range of 0.0–3.5 m above sea level (Aruna Technology, 2015) and is next to a small river that experiences tidal influences even though the site is approximately 20 km from the Cambodian coast. Vegetation in the site mostly comprises sedges, interspersed with *Melaleuca* scrub. The SCCA is divided into two sectors by a road embankment, the first of which covers 33 ha, lies in the extreme north of the site and retains freshwater. The second occupies 184 ha in the central and southerly portions of the site and contains slightly saline water.

Field sampling

The study was undertaken in February 2013, which is the middle of the dry season in Cambodia. This is approximately midway through the non-breeding season for the sarus crane and when numbers of the species typically peak in Anlung Pring SCCA (van Zalinge *et al.*, 2009). For instance, in census counts in the site during the study period, the monthly count of sarus cranes rose from 265 cranes in January to 311 in February, which was the peak count in 2013 (Triet & van Zalinge, 2013).

To identify areas used by cranes and to assess foraging preferences, we divided the SCCA into six discrete blocks (1–6) based on natural geographical boundaries (e.g. water channels and scrub edges) to avoid sampling activities influencing crane foraging behaviour. The sizes of the six blocks was 32.83, 38.51, 22.67, 31.71, 44.32 and 46.73 ha respectively (Figure 2).

Direct counts of cranes were conducted using a boat-based transect twice a day for 16 consecutive days: first between 08:00–09:30 hrs, and second between 14:30–16:00 hrs, both being periods when the cranes are actively feeding. The transect spanned most of the north to south extent of the reserve, with a total length of ≈3.45 km and passed through each of the six blocks in turn. During each sampling session, the boat moved slowly (5.2 km/h) to minimise disturbance to the cranes, with two persons dedicated to recording their numbers and foraging activity at each location, resulting in 32 separate counts of cranes throughout the SCCA.

Vegetation surveys were undertaken to determine the relative abundance of different plant species in each

Fig. 1 Sarus cranes and *Eleocharis* spp. in the Anlung Pring Sarus Crane Conservation Area in South Cambodia (© Yav Net).

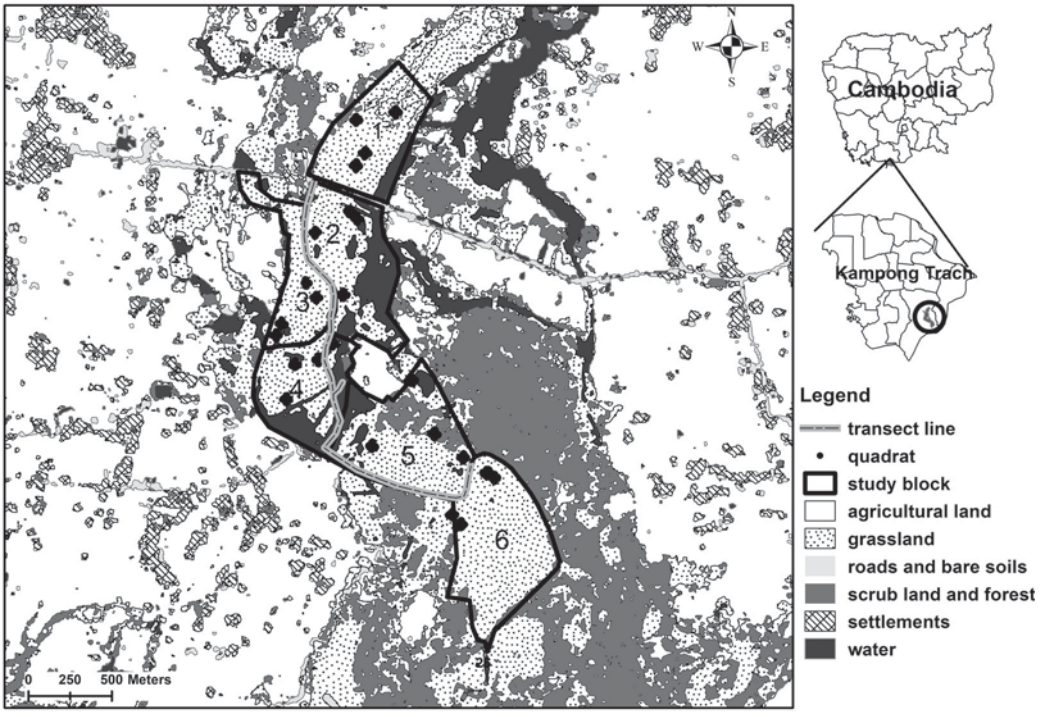

Fig. 2 Anlung Pring Sarus Crane Conservation Area in South Cambodia. Numbers refer to the six sectors in this study and quadrat locations are denoted by black diamonds.

block directly after the transect counts were completed so as not to influence crane behaviour during the latter. In total, 600 ground quadrats (1 x 1 m) were sampled across the six blocks, with 100 quadrats sampled per block. Within each block, 50 quadrats were situated in areas where cranes were observed foraging, whereas the remainder were randomly located in non-overlapping areas where no cranes were observed foraging and few signs of their presence (footprints and beak marks) were recorded.

The quadrats were positioned in batches of five: the first quadrat in each batch being randomly allocated and the four remaining quadrats located 20 m from this point at 90° intervals. In each quadrat, the percentage cover of each plant species was recorded, as was water and bare soil cover. The height of the tallest living stem of each species was measured and water depth was measured in the centre of each quadrat. Individual plants of each species were excavated to determine if they possessed underground tubers. Where found to do so, tubers were collected for these species from identified foraging areas in blocks 1 and 2, sun-dried for one hour to remove surface moisture and then weighed to the nearest gram.

Analysis

Mean density of cranes in each of the six blocks was calculated as the mean number of birds counted over the course of the 32 transect-based observations. Areas covered by water in each block were excluded from these calculations. Because the density data were not normally distributed ($p < 0.05$), a Kruskal-Wallis test was used to test for significant differences between the six blocks, with post hoc testing using pairwise Mann-Whitney U tests. Vegetation data (species cover and height) were also compared between blocks and between crane foraging areas and non-foraging areas identified in each block. Depending on the distribution of the data, these were tested using one-way ANOVA or Kruskal-Wallis tests as appropriate to test for significant differences, with *post hoc* testing using Mann-Whitney U tests. Because data were not normally distributed, tuber weights were also compared between species using the latter. Finally, because mean values for crane density and vegetation cover and height per block were normally distributed, relationships between these were assessed using Pearson product-moment correlation tests.

Results

Over the course of the 32 transect observations, an average of 255 cranes were observed across the six blocks, with a minimum count of 166 and a maximum of 430 birds. Crane density differed markedly between blocks ($p < 0.001$), ranging from 0.03–4.09 cranes/ha and was significantly greater in block 2 (all pairwise values of $p < 0.001$; Table 1). Even though crane densities in blocks 1, 3 and 5 did not differ significantly from one another ($p > 0.05$), they were significantly greater than blocks 4 and 6 (all pairwise values of $p < 0.001$).

The vegetation survey recorded seven plant species: *Eleocharis dulcis*, *E. spiralis*, *E. philippinensis* (Cyperaceae), *Cynodon dactylon* (Poaceae), *Acrostichum aureum* (Pteridaceae), *Scirpus littoralis* and *Scirpus* sp.A (Cyperaceae) (Table 2). *Eleocharis* spp. occurred in most of the SCCA (five to six blocks) as did *C. dactylon* (five blocks), whereas *Scirpus* sp.A occurred in four blocks and *A. aureum* and *S. littoralis* in only three blocks. In terms of mean percentage cover, the most dominant species were *E. spiralis* (24.3%), *E. philippinensis* (19.5%), *C. dactylon* (9.1%) and *E. dulcis* (5.7%). Only two of these were found to possess underground tubers: *E. dulcis* and *E. spiralis*. Tubers of *E. dulcis* ($n = 119$) were significantly heavier than *E. spiralis* ($n = 119$) (mean = 1.23 vs. 0.38 g respectively, $p < 0.0001$) (Figure 3).

With the exception of *A. aureum*, significant variation occurred in mean percentage cover and height of

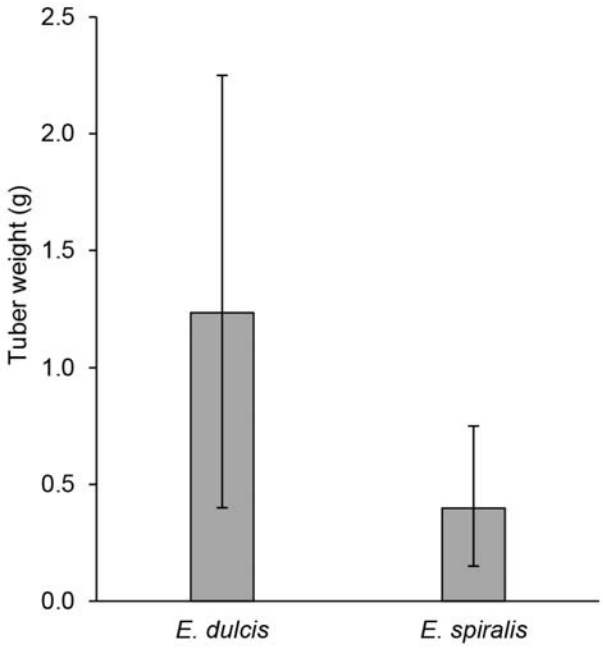

Fig. 3 Tuber weights (mean ± SE) of *Eleocharis dulcis* and *E. spiralis* in the Anlung Pring Sarus Crane Conservation Area.

Table 1 Sarus crane abundance and density in six blocks in the Anlung Pring Sarus Crane Conservation Area. Abundance and density values are given as mean ± SE.

Block	Block Area (ha)	Water area (ha)	Crane abundance	Crane density (individuals/ha)
1	32.83	2.83	42.09 ± 7.73	1.40 ± 0.23
2	38.51	15.37	94.69 ± 9.83	4.09 ± 0.44
3	22.67	3.29	33.19 ± 5.03	1.71 ± 0.33
4	31.71	12.63	10.16 ± 2.94	0.53 ± 0.18
5	44.32	6.99	73.56 ± 12.12	1.97 ± 0.43
6	46.73	0.20	1.59 ± 1.59	0.03 ± 0.03
	216.77	**41.31**	**255.28**	**9.73**

Table 2 Vegetation in six blocks in the Anlung Pring Sarus Crane Conservation Area. All values are given as mean ± SE with significantly different values ($p < 0.05$) in bold font. '-' indicates areas where a plant species was not found.

Species	Parameter	Block					
		1	2	3	4	5	6
Eleaocharis dulcis	Cover (%)	11.45 ± 1.96	**18.52 ± 2.13**	1.17 ± 0.57	1.16 ± 0.42	1.99 ± 0.91	-
	Height (cm)	**32.96 ± 3.40**	**30.80 ± 2.87**	4.70 ± 1.51	4.24 ± 1.46	4.31 ± 1.59	-
Eleaocharis spiralis	Cover (%)	**69.66 ± 2.06**	16.80 ± 2.17	13.97 ± 2.02	17.88 ± 1.89	26.73 ± 3.13	0.30 ± 0.26
	Height (cm)	**57.71 ± 1.41**	22.83 ± 2.21	23.65 ± 2.47	29.54 ± 2.31	30.77 ± 3.09	0.46 ± 0.46
Eleaocharis philippinensis	Cover (%)	-	0.10 ± 0.07	25.94 ± 3.25	17.96 ± 2.51	24.70 ± 3.17	**48.56 ± 2.78**
	Height (cm)	-	0.54 ± 0.54	31.80 ± 3.30	27.42 ± 3.08	29.74 ± 3.23	**66.14 ± 1.76**
Cynodon dactylon	Cover (%)	-	13.16 ± 1.35	13.16 ± 1.60	**18.02 ± 1.43**	6.94 ± 1.60	3.54 ± 0.89
	Height (cm)	-	31.35 ± 2.26	32.72 ± 2.51	**42.10 ± 2.06**	12.13 ± 2.17	13.45 ± 2.15
Acrostichum aureum	Cover (%)	-	-	-	0.10 ± 0.07	0.10 ± 0.07	0.66 ± 0.42
	Height (cm)	-	-	-	0.41 ± 0.04	1.60 ± 1.17	2.42 ± 1.40
Scripus littoralis	Cover (%)	-	-	-	0.30 ± 0.22	**3.31 ± 0.85**	0.24 ± 0.14
	Height (cm)	-	-	-	1.36 ± 0.96	**14.43 ± 2.73**	1.93 ± 1.13
Scripus sp.A	Cover (%)	-	-	0.05 ± 0.05	0.25 ± 0.15	0.66 ± 0.35	**14.6 ± 1.72**
	Height (cm)	-	-	1.04 ± 1.04	2.96 ± 1.75	6.33 ± 3.27	**61.50 ± 5.89**
Water	Cover (%)	-	**46.86 ± 1.79**	**46.19 ± 2.19**	33.35 ± 1.85	33.27 ± 2.29	22.87 ± 1.94
	Depth (cm)	-	**8.52 ± 0.45**	**8.99 ± 0.53**	4.48 ± 0.35	5.37 ± 0.36	3.79 ± 0.50
Bare soil	Cover (%)	**18.27 ± 1.64**	4.39 ± 0.67	0.10 ± 0.07	10.28 ± 1.49	2.55 ± 0.99	8.11 ± 1.39

plant species across the six blocks of the SCCA ($p < 0.05$; Table 2). Mean cover of *E. dulcis* was significantly greater in block 2, although the mean height of the species was slighter greater in block 1. Mean cover and height of *E. spiralis* were significantly greater in block 1, whereas *E. philippinensis* and *Scripus* sp.A were more abundant and taller in block 6, and likewise, *C. dactylon* in block 4, and *S. littoralis* in block 5. Water cover and depth were significantly greater in blocks 2 and 3 (which did not differ significantly), whereas bare soil cover was significantly greater in block 1.

Strong positive correlations were found between mean crane density and mean percentage cover and height of *E. dulcis* (r = 0.80, p = 0.57 and r = 0.63, p = 0.18 respectively) and mean water cover and depth (r = 0.48, p = 0.34 and r = 0.54, p = 0.26). Weak positive correlations were found between crane density and mean cover and height of *E. spiralis* (r = 0.10, p = 0.85 and r = 0.18, p = 0.73) and *C. dactylon* (r = 0.22, p = 0.67 and r = 0.15, p = 0.77), whereas these were negligible in the case of *S. littoralis* (r = 0.05, p = 0.92 and r = 0.01, p = 0.98). Strong negative correlations were found between mean crane density and mean cover and height for the remaining species: *E. philippinensis* (r = -0.66, p = 0.15 and r = -0.69, p = 0.12), *Scripus* sp.A (r = -0.56, p = 0.25 and r = -0.57, p = 0.23) and *A. aureum* (r = -0.62, p = 0.19 and r = -0.52, p = 0.30). The same was true for bare soil cover (r = -0.36, p = 0.49).

These correlations were largely reflected in differences in vegetation and soil and water conditions between crane foraging and non-foraging areas. In block 2 (where the highest density of cranes occurred), mean cover and height of *E. dulcis* and *C. dactylon* were significantly greater in foraging areas than non-foraging areas (all values of $p < 0.0001$). The opposite was true for *E. spiralis* and bare soil cover (all values of $p < 0.0001$), whereas values for water cover and depth, though among the highest of all six blocks (Table 2), did not significantly differ ($p > 0.1$). In blocks 3 and 5 (where crane density was second and third highest), while *E. dulcis* occurred only marginally in foraging areas and was absent from non-foraging areas, mean cover and height of *E. spiralis* was significantly greater in foraging areas ($p < 0.0001$). Values for water cover and depth and bare soil cover, although not significantly different ($p > 0.05$), were also consistently high and low respectively compared to other blocks (Table 2).

Discussion

Our results suggest that sarus cranes at Anlung Pring SCCA prefer foraging areas characterized by an abundance of *Eleocharis* species. Both *E. dulcis* and *E. spiralis* produce tubers (those of *E. dulcis* being significantly larger), though *E. philippinensis* was not found to produce tubers at Anlung Pring. There was a strong positive correlation between crane numbers and the presence of *E. dulcis*, a weak positive correlation with *E. spiralis*, and a strongly negative correlation with *E. phillipinensis*. This mirrors the results of other studies which suggest that that tubers of *Eleocharis* spp. are important food items (Johnsgard, 1983; Meine & Archibald, 1996; Aryal *et al.,* 2004, 2009). The weak positive correlation with *C. dactylon* may indicate this species is also eaten, but because *C. dactylon* grows in and around patches of *E. dulcis* and *E. spiralis* in Anlung Pring, this correlation could be merely an artefact of that association. We consequently recommend further studies on the tuber-producing capabilities of plants in sites where sarus cranes congregate in Cambodia.

Similar to studies in India (Monichan & Sharma, 2003), our results also indicate that sarus cranes prefer foraging in areas that include shallow water and avoid areas with excessive bare soil cover. This is presumably because shallow water conditions promote the growth of *Eleocharis* spp. and allow access to tubers and other sub-surface food items such as small fish and insects. Maintenance of natural hydrological conditions is therefore likely to be essential to management of the cranes' preferred foraging habitats. According to annual census data and other studies (van Zalinge *et al.,* 2011; Triet & van Zalinge, 2013; van Zalinge & Triet, 2014), numbers of sarus cranes using the Tonle Sap floodplain have increased compared to the Mekong Delta since 2008. The Cambodian population also appears to have declined in recent years, however, and the reasons for this have yet to be confirmed (van Zalinge & Triet, 2014).

Reductions in the quality and extent of wetlands, hunting, and pollution are likely to have caused the local extinction of the species in Malaysia, the Philippines and Thailand (Medsen, 1981; Meine & Archibald, 1996; Tanee *et al.,* 2009; BirdLife International, 2012; Jeyarajasingam & Pearson, 2012), but it has been reintroduced to Thailand (Tanee *et al.,* 2009; Insee *et al.,* 2014). Similarly, land use and hydrological changes (principally conversion of and water abstraction from wetlands for agricultural use) are believed to threaten the suitability of sites such as Boeung Prek Lapouv SCCA in southern Cambodia (van Zalinge *et al.,* 2011). We consequently recommend maintaining the natural hydrological conditions of sites where the species congregates, together with additional studies to improve understanding of its ecological requirements.

Acknowledgements

The authors thank the Centre for Biodiversity Conservation, International Crane Foundation, Wildfowl & Wetlands Trust, BirdLife International Cambodia Programme and Royal University of Phnom Penh for their financial and technical support. We are indebted to Dr Neil Furey, Dr Nick Souter and Dr Tommaso Savini for their advice and to Dr Le Phat Quoi and Mr Nguyen Huu Thien for their identification of plant species in Anlung Pring SCCA.

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New herpetofauna records and range extensions for *Daboia siamensis* (Smith, 1917) and *Gekko petricolus* Taylor, 1962 from Cambodia

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Paper submitted 12 July 2015, revised manuscript accepted 30 September 2015.

មូលន័យសង្ខេប

ឯកសារនេះរាយការណ៍ពីថលជលិកចំនួនពីរប្រភេទ និងល្មួនចំនួនបីប្រភេទដែលទើបបានធ្វើកំណត់ត្រាជាលើកដំបូងនៅប្រទេសកម្ពុជា។ ប្រភេទទាំងនោះមាន: កញ្ជាញ់ចេកយក្ស (*Rhacophorus maximus*) និងកញ្ជាញ់ចេកច្រើនពណ៌ (*R. robertingeri*) បង្គួយក្បាលខៀវថ្ពាល់ឆ្នូតលឿង (*Calotes bachae*) និងពស់ពណ៌ត្នោតងាន់សុន (*Dendrelaphis ngansonensis*) និងពស់ ប្រឡែក (*Gongylosoma scriptum*)។ របាយការណ៍នេះរាប់បញ្ចូលទាំងកំណត់ត្រាជាលើកដំបូងនៃពូកពស់ *Gongylosoma* Theobald, 1868 សម្រាប់ប្រទេសកម្ពុជាផងដែរ។ ដែនរបាំយថ្មីៗនៃតុកែថ្ម *Gekko petricolus* និងពស់ស្រកាចាស់ (*Daboia siamensis*) ដែលកម្របានជួបប្រទះក៏ត្រូវបានចុះបញ្ជី។ ការកើនឡើងនៃចំនួនថលជលិក និងល្មួនដែលបានរកឃើញ បានធ្វើឲ្យតម្លៃជីវៈចម្រុះនៃប្រទេសកម្ពុជាកាន់តែកើនឡើង ហើយដែលគួរទទួលបានចំណាប់អារម្មណ៍សម្រាប់ការអភិរក្ស។ ការរកឃើញទាំងនេះក៏បញ្ជាក់ឲ្យឃើញដែរថាទិន្នន័យថលជលិក និងល្មួននៃប្រទេសនេះនៅមិនទាន់មានគ្រប់គ្រាន់នៅឡើយ ហើយដែលតម្រូវឲ្យមានការស្រាវជ្រាវបន្ត។

Abstract

We report five herpetofaunal species for the first time from Cambodia: two tree frogs (*Rhacophorus maximus* and *R. robertingeri*), one lizard (*Calotes bachae*) and two snakes (*Dendrelaphis ngansonensis* and *Gongylosoma scriptum*). This paper includes the first report of the snake genus *Gongylosoma* Theobald, 1868 for Cambodia. A range extension for *Gekko petricolus* and a rare record of the snake *Daboia siamensis* are also documented. The growing number of herpetofaunal species confirmed for Cambodia represent additional biodiversity deserving of conservation. They also highlight the lack of knowledge concerning amphibians and reptiles and demonstrate a need for continued field research.

Keywords

Biogeography, Cardamom Mountains, Eastern Plains, herpetofauna, Indochina, karst, Mekong, Prey Lang, Southeast Asia.

CITATION: Neang T., Grismer, L.L., Hun S. & Phan C. (2015) New herpetofauna records and range extensions for *Daboia siamensis* (Smith, 1917) and *Gekko petricolus* Taylor, 1962 from Cambodia. *Cambodian Journal of Natural History*, 2015, 172–182.

Introduction

Cambodia is part of the Indo-Burma and Indochina biodiversity hotspots (Myers *et al.,* 2000; Bain & Hurley, 2011; Tordoff *et al.,* 2012). Recent and drastic land use changes have led to decreased and irreplaceable loss of biodiversity in Cambodia (Hor *et al.,* 2014; Stibig *et al.,* 2014). Thus, urgent conservation action is needed to safeguard the known fauna and flora of the country as well as species that are not yet known to science (Sodhi *et al.,* 2010). Sustainable management of natural resources requires an understanding of biological diversity. Amphibians and reptiles are two of the most important groups of vertebrates and among the least studied, with many new species still being discovered (Uetz & Hošek, 2015). Besides their significant contribution to science, herpetological data also facilitate identification of conservation priorities, and amphibians and reptiles can act as indicators of healthy environments (Wilson & McCranie, 2003).

Following three decades of civil conflict, knowledge of Cambodia's herpetofauna has improved with recent field surveys (e.g. Daltry & Wüster, 2002; Ohler *et al.,* 2002; Stuart *et al.,* 2006, 2010; Stuart & Emmett, 2006; Grismer *et al.,* 2007a,b, 2008a,b; Bejuizen *et al.,* 2009; Neang *et al.,* 2010; Hartmann *et al.,* 2013b). However, the identification of some amphibians and reptiles collected in the Phnom Samkos Wildlife Sanctuary and Thma Rung area of the Cardamom Mountains, and in Virachey National Park in Northeast Cambodia remains doubtful. A recent field study in a central low-lying area of Prey Lang, Preah Vihear Province, has suggested a range extension for *Gekko petricolus* (Neang & Hun, unpublished data). Additionally, photographs of pit vipers taken by colleagues in Siem Reap and Oddar Meanchey were provisionally identified as *Daboia siamensis,* a species previously reported by Saint Girons (1972) from a single locality in Cambodia. Examination of the above specimens and photographs revealed several amphibian and reptile species that have not been reported or are poorly known from Cambodia. This paper reports five new herpetological records and documents range extensions for *G. petricolus* and *D. siamensis* within the country.

Methods

Field surveys were undertaken between 2010 and 2015 in Phnom Samkos Wildlife Sanctuary (2010), Thma Rung area (2015), the central lowlands of Prey Lang (2014), Preah Vihear Province (2014) and in the northwestern section of Virachey National Park (2014) (Figure 1). In each area, amphibians and reptiles were opportunistically sampled during the day and night and were photographed prior to euthanasia with tricaine methanesulphonate (Finquel MS-222®, Argent Chemical Laboratories Inc., Redmond, USA). They were then fixed in 10% formalin in the field prior to transfer to 70% ethanol for storage in the zoological collection of the Centre for Biodiversity Conservation in the Royal University of Phnom Penh, Cambodia.

Morphological characters were examined with a Nikon SMZ 645 dissecting microscope and measured using digital callipers to the nearest 0.1 mm. For morphological characters we followed Ziegler & Vogel (1999) for *Dendrelaphis ngansonensis*; Grismer *et al.* (2003) for *Gongylosoma scriptum*, Orlov *et al.* (2012) for *Rhacophorus robertingeri*; Hartmann *et al.* (2013a) for *Calotes bachae*; Günther (1858) and Luu *et al.* (2014) for *R. maximus*. Abbreviations used in the text as follows: snout to vent length (SVL)—measured from the tip of the snout to anterior margin of the vent; tail length (TaL)—measured from posterior margin of the vent to the tip of the tail.

Results

***Rhacophorus maximus* Günther, 1858** (Fig. 2)

Material examined: LSUHC 12231, adult female, collected by Neang Thy, 18 January 2010, 14°19′29.0″N, 106°31′03.1″E, 293 m a.s.l. (above sea level), O'Peam, Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, Southwest Cambodia.

Description: A single adult female specimen (SVL 103.2 mm) matches the description of Günther (1858), Wildenhues *et al.* (2010) and Luu *et al.* (2014) in the following characters: head wider than long; snout rounded in lateral profile, longer than horizontal diameter of eye, protruding beyond lower jaw; nostril closer to tip of snout than to eye; tympanum rounded, half the size of eye; greater than tympanum–eye distance; supratympanic fold extending from eye to above forearm; vomerine teeth present; all digits bearing expanded discs; finger with incomplete webbing (nearly full webbing between third and fourth), toes fully webbed; subarticular tubercles on all digits distinct; inner metatarsal tubercle weekly developed; outer metatarsal tubercle absent; supracloacal dermal ridge absent; dermal fringe on outer toe weakly developed, extending to ankle; skin of dorsal surfaces smooth; skin of gular, pectoral, abdominal and ventral region of thigh pebbled. Colouration in life: dorsal surface of head, dorsum, upper before flank, making it to upper flank and limb uniform green; a white stripe extending along edge of lower jaw through axilla to flank, groin and hind legs, clearly separating between

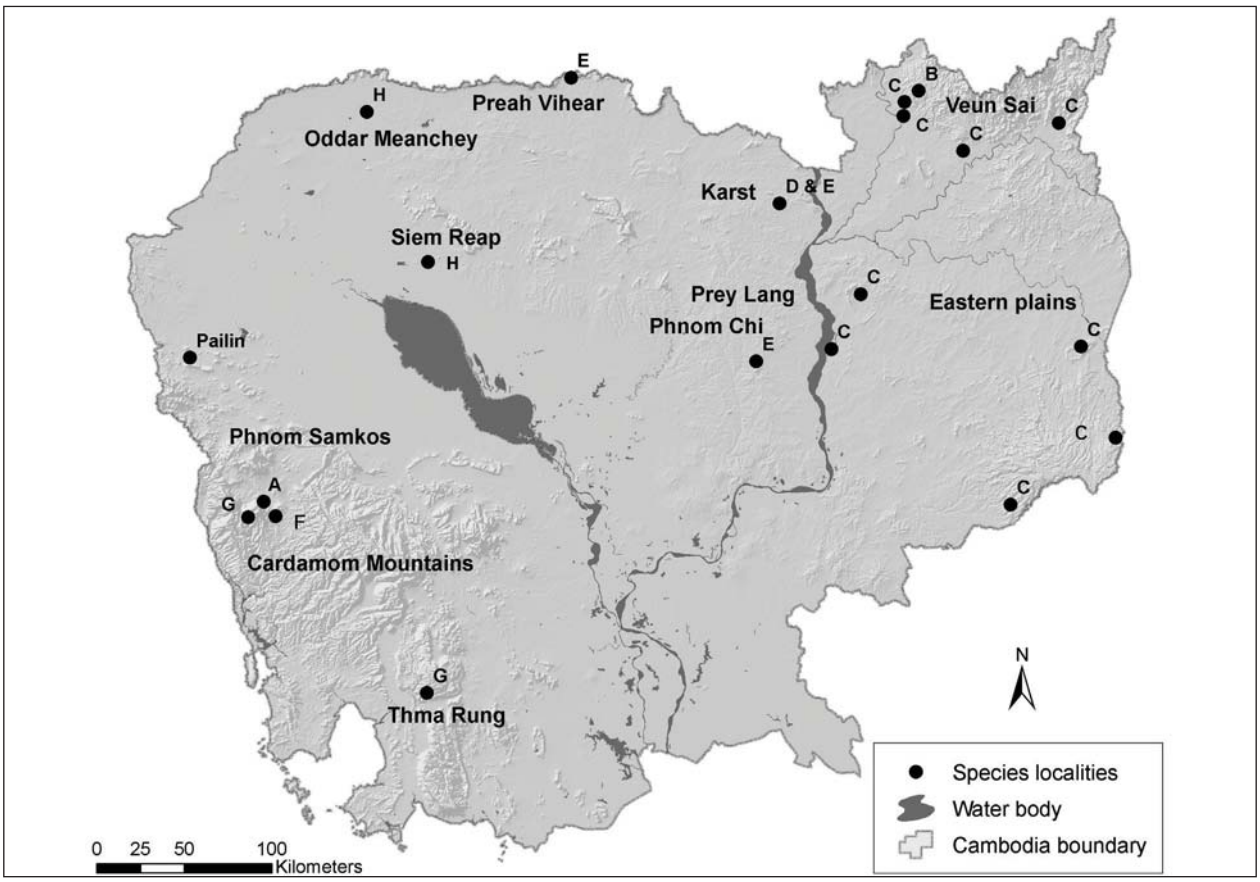

Fig. 1 Survey areas and localities of a) *Rhacophorus maximus*, b) *R. robertingeri*, c) *Calotes bachae*, d) *C. mystaceus* (easternmost locality), e) *Gekko petricolus*, f) *Dendrelaphis ngansonensis*, g) *Gongylosoma scriptum*, h) *Daboia siamensis*.

upper green surface and cream (yellowish)-pink ventral surface.

Ecological notes: The specimen was found in the morning around 09:00 hrs in leaf litter on the side of a forest trail about 10 m from a stream containing still water in lowland semi-evergreen forest after a light overnight rain during the dry season. The infrequent records of this large tree frog is perhaps due to its cryptic green coloration and canopy-dwelling nature. It may also behave cryptically because no call of this species has been reported.

Distribution: *Rhacophorus maximus* ranges from Nepal, to India, Bangladesh, southern China, Vietnam and western Thailand (Chan-ard, 2003; Wildenhues *et al.*, 2010; Hecht *et al.,* 2013). The discovery of this species in Cambodia fills a biogeographic gap in the southern part of the Indo-Burmese and Indochinese regions, and suggests it also may occur in southeastern Thailand, southern Vietnam and northeastern Cambodia (the species has recently been reported in Laos by Luu *et al.,* 2014).

Remarks: *Rhacophorus maximus* is very similar morphologically to *R. dennysi*. However, in a recent revision Yu *et al.* (2009) placed *R. dennysi* in a sister taxon to the clade of *R. maximus*, *R. nigropunctatus*, *R. chenfui*, *R. feae*, *R. taronensis*, *R. pingbianensis*, *R. omeimontis*, *R. dugritei*, *R. minimus* and *R. hui* which indicates that these two species are distinct. Yu *et al.* (2009) also indicated that the similarity in the full webbing between fingers (at least between the third and fourth finger) is a plesiomorphy. Our specimen diagnosis is based on the distinct white stripe extending along edge of the lower jaw through axilla to flank, groin and hind legs, separating between upper green surface and cream- or yellowish-pink ventral surface. Biogeographical data also supports our diagnosis: *R. dennysi* occurs from central Laos to northern Vietnam, China and northern Myanmar (Stuart *et al.,* 2005; Nguyen *et al.,* 2009) whereas *R. maximus* has a wider range in the southern region. The southernmost known record of *R. maximus* was recorded from western Thailand (Chan-ard, 2003), the closest locality to the Cambodian specimen. Our record of *R. maximus* from Cambodia

thus extends its known range to the south-easternmost regions of Indo-Burma.

***Rhacophorus robertingeri* Orlov, Poyarkos, Vassilieva, Ananjeva, Nguyen, Nguyen & Geissler, 2012** (Figs 3.1 –3.3)

Material examined: CBC 02488–92, adult males, collected by Neang Thy and Phan Channa, 12 July 2014, 14°19′18.4″N, 106°31′17.2″E, O'Kacheur, western portion of Virachey National Park, Siem Pang District, Stung Treng Province, northeastern Cambodia.

Description: Five adult male specimens (SVL 33.5–38.8 mm) match the original description of Orlov *et al.* (2012) in having a combination of the following characters: head large; snout pointed, protruding beyond lower jaw, nostril closer to tip of snout than to eye; diameter of eye less than snout length; tympanum less than half diameter of eye; interorbital distance wider than upper eyelid. Tips of fingers and toes with enlarged discs, those of fingers larger than those of toes; inner metatarsal tubercle elongated, outer absent; dorsal skin smooth; throat finely granular; ventral surface, beginning at level of forearm to groin with egg-like granular; prominent dermal process along outer edges of forearm and tarsus; supra-anal ridge present and numerous tubercles below vent with a pair of prominent rounded tubercles; nuptial pad present on dorsal surface of first metacarpal. This species is highly variable in colouration. CBC 02488 (Figure 3.1) has reddish-brown dorsum and limbs with sparse orange spots. CBC 02489, CBC 02491–92 (Figure 3.2) has a light-yellowish brown dorsum with scattered dark brown spots. CBC 02490 (Figure 3.3) has a dark yellowish-brown dorsum with a dark brown V-shape on forehead, dark brown transverse lines on the interorbital and occipital region, and interrupted lines on the dorsum and limbs. All specimens have an anal ridge and a pair of prominent white tubercles. The ventral surface is yellowish.

Ecological notes: All specimens were found at night during light rain in evergreen forest mixed with bamboo. They were calling from perches on bamboo, vines, palms and tree branches, 0.8–5 m above ground and 1–2 m from a 4–5 m wide sandy, fast-flowing stream.

Distribution: The species is known from the Annamite Mountains of Vietnam. Our record confirms a range extension of approximately 200 km for this species from central Vietnam in a westerly direction.

Remarks: The Cambodian specimens of *R. robertingeri* agree well with the description of Orlov *et al.* (2012), except that all our specimens exhibit an elongated inner metatarsal tubercle (vs. oval) and show slight differences in colouration, indicating additional variation in the colour of this species. Moreover, our five male specimens are slightly smaller in lower marginal size (33.5–38.8 mm) than males from Vietnam (36.04–43.55 mm). The lack of female specimens from Cambodia highlights a need for additional field work to gain a better understanding of variation between populations of this species.

***Calotes bachae* Hartmann, Geissler, Poyarkos, Ihlow, Galyan, Rödder & Böhme, 2013** (Fig. 4)

Material examined: CBC 02495, sub-adult male, collected by Neang Thy and Phan Channa, 10 July 2014, 14°12′12.0″N, 106°26′05.4″E, 90 m a.s.l., western part of Virachey National Park; CBC 02496, gravid female, 14°15′57.8″N, 106°26′34.7″E, 114 m a.s.l., same collectors, locality and date as above; CBC 02544, juvenile male, collected by Neang Thy, 25 October 2014, 13°16′47.0″N, 106°17′16.4″E, Kratie Province.

Description: Our sub-adult male (SVL 82.7 mm), a gravid female (SVL 83.5 mm) and one juvenile (55.1 mm) correspond well with the diagnostic characters of this species from southern Vietnam in having a combination of the following characters: body large, compressed; scales and spines on body small; mid-body scale rows (53 in males, 48 in female); vertebral scales 47 in males, 44 in female; one short spine above tympanum, a longer spine on occiput, mid-way between tympanum and nuchal crest; lack of spines above the orbit; skin fold in front of forelimb insertion distinct; bluish to turquoise colour on head, nuchal crest region, throat and upper arms; distinct yellow stripe from below eye crossing tympanum to end of head; large black blotch on shoulder; absent or indistinct dark rusty brown blotches on upper flanks (Hartmann *et al.*, 2013a).

Ecological notes: The sub-adult male (CBC 02495) was found sitting on the twig of a tree, 0.7 m above the ground and the gravid female (CBC 02496) was found on a tree trunk 0.5 m above the ground, both at the edge of a new logging road in evergreen forest during the day. A third uncaptured female was observed resting on the base of tree during the day in relatively undisturbed evergreen forest. The juvenile specimen (CBC 02544) was encountered 0.5 m above ground on a small tree branch in scrub in an agricultural area.

Distribution: *Calotes bachae* was first discovered in southern Vietnam (Hartmann *et al.*, 2013a) and our record extends its range to the extreme northwestern boundary for the species, which lies immediately to the east of the Mekong River (see below).

Remarks: Due to their morphological similarity, specimens of this species were previously treated

as *Calotes mystaceus* (Stuart *et al.,* 2006; Bezuijen *et al.,* 2009). One male photographed by Barney Long in 2000 in mixed deciduous forest in Mondulkiri Protected Forest (13°00′08.6″N, 107°22′16.8″E) matches *C. bachae*. Specimens reported by Stuart *et al.* (2006), from eastern Cambodia as *C. mystaceus* also represent *C. bachae*. Their subsequent identification was confirmed by examination of photographs in dorsal and lateral views of FMNH 262685, FMNH 262686, FMNH 262966–67 and FMNH 262969–70, which do not possess rusty dorsal blotch patterns, in contrast to FMNH 262681–84 of *C. mystaceus* from the Cardamom Mountains (Stuart & Emmett, 2006). Photographs taken by Gabor Csorba on 26 February 2010 and by Jackson Frechette on 28 April 2012 in semi-evergreen forest (near 14°00′56.2″N, 106°45′08.1″E) in Veun-Sai Proposed Protected Forest of Ratanakiri Province in northeastern Cambodia also match the typical colour pattern of *C. bachae*. All three specimens examined by us are located east of Mekong River (Figure 1c). We agree with Hartmann *et al.* (2012) that the photograph by Bezuijen *et al.* (2009: Figure 18, p. 156) from Koh Khlap, an island along the eastern side of the Mekong River, matches *C. bachae*. This may represent the westernmost range of *C. bachae*. The easternmost range of *C. mystaceus* known was confirmed by a photograph of a specimen with a blue throat, head, upper arms and a white stripe on the upper lip and rusty dorsal blotches. This was taken by Ben Hayes near a karst area in northern Prey Lang (13°44′49.7″N, 105°46′29.7″E), west of Mekong (Figure 1d, 1e), and the Mekong River is most likely the biogeographical barrier (Bain & Hurley, 2011; Geissler *et al.,* 2015) that separates *C. mystaceus* in the West and *C. bachae* in the East (Hartmann *et al.,* 2013a). Our analysis revises the status of previous specimens of *C. mystaceus* from east of the Mekong and documents *C. bachae* from Cambodia for the first time.

***Gekko petricolus* Taylor, 1962** (Fig. 5. 1–5.2)

Material examined: CBC 01220, CBC 01283, CBC 01267, adult males; CBC 01281, CBC 01270, females, collected by Kha Haur, 9 June 2014, 14°23′24.8″N, 104°40′48.5″E, 564 m a.s.l., foot of Preah Vihear temple; CBC 02416, adult female and CBC 02420, adult male, collected by Neang Thy and Hun Seiha, 23 June 2014, 12°56′09.5″N, 105°39′47.2″E, 320 m a.s.l., Phnom Chi, Prey Lang, San Dan District, Kampong Thom Province; CBC 02423, adult male, collected by Neang Thy and Hun Seiha, 25 July 2014, 13°44′53.6″N, 105°46′30.1″E, 124 m a.s.l., karst, Thalaborivath District, Stung Treng Province.

Description: Our five adult males (SVL 82.3–103.8 mm) and three adult females (SVL 83.2–86.1 mm) match well the description of Taylor (1963) as follows: nostril edged with rostral, supranasal, two divided posterior nasals and first supralabial; lacking web between digits and claws in inner digit; having body and dorsal surface of hind limbs covered with fine granules intermixed with scattered enlarged tubercles; subdigital lamellae undivided; subcaudal enlarged; 8–10 precloacal pores in males, absent in females; femoral pores absent in both sexes; relatively thick, depressed tail. Colour in life, males are yellow from shoulder to the tip of tail; forehead to shoulder and limbs grey; yellow spots on yellow background in males (Figure 5.1), the remaining parts are whitish grey spots as in females (Figure 5.2); ventral surface white with dark segments.

Ecological notes: These sandstone-adapted lizards were commonly encountered on boulders, rock faces and walls, between large rocks, at the entrance of karst caves, under rock ceilings and on house walls and columns, both during the day and night in disturbed, dry deciduous dipterocarp and semi-evergreen forest.

Distribution: This species has been reported in Thailand (Taylor, 1963), Laos (Stuart, 1999) and Cambodia (Harbing, 2006). In Cambodia, *G. petricolus* is found from the Preah Vihear temple in Preah Vihear Province to karsts in Stung Treng Province and as far south to areas with small granite hills near Phnom Chi in Kampong Thom Province, which may represent the southernmost extent of the species (Figure 1e). Our record is the second for the species in Cambodia.

***Dendrelaphis ngansonensis* (Bourrett, 1935)** (Fig. 6)

Material examined: CBC 01462, adult female, collected by Neang Thy, 18 February 2011, 12°07′55.3″N, 103°07′48.0″E, 522 m a.s.l., Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, Pursat Province, Southwest Cambodia.

Description: Our single female (SVL 864 mm) matches well the morphological characters of this species, described by Ziegler & Vogel (1999) as follows: 1 loreal; 1 preocular; 2 postocular; 9 supralabials (SL), SL 4th–6th in contact with orbit; 10 infralabials; 15 dorsal scale row at midbody; 187 ventral scale; 131 subcaudal scales; anal plate divided. In life, the specimen has greyish bronze colouration on dorsum; reddish bronze on head and flanks; absence of a light lateral stripe along flank; blue between scales; paler brown on posterior ventral surface and first scale row; yellowish on chin, supralabials and anterior part of venters; large distinct black temporal stripe from behind eye extending posteriorly to neck at the distance of head length and fading away. In preserva-

Fig. 2 Colour in life of a female *Rhacophorus maximus* (LSUHC 12231) from Phnom Samkos Wildlife Sanctuary in the Cardamom Mountains, Southwest Cambodia (© Neang Thy).

Fig. 3.1 Colour variation in life of *Rhacophorus robertingeri* (CBC 02488) from northeastern Cambodia (© Neang Thy).

Fig. 3.2 Colour variation in life of *Rhacophorus robertingeri* (CBC 02489) from northeastern Cambodia (© Neang Thy).

Fig. 3.3 Colour variation in life of *Rhacophorus robertingeri* (CBC 02490) from northeastern Cambodia (© Neang Thy).

Fig. 4 Colour in life of a female *Calotes bachae* (CBC 02496) from northeastern Cambodia (© Neang Thy).

Fig. 5.1 Colour in life of *Gekko petricolus* (CBC 01220) from Preah Vihear Province (© Neang Thy).

Fig. 5.2 Colour in life of a female *Gekko petricolus* (not collected) from Stung Treng Province, south of Preah Vihear (© Neang Thy).

Fig. 6 Colour in life of *Dendrelaphis ngansonensis* (CBC 01462) from Phnom Samkos Wildlife Sanctuary in the Cardamom Mountains, Southwest Cambodia (© Neang Thy).

Fig. 7 Colour in life of *Gongylosoma scriptum* (CBC 01365) from Phnom Samkos Wildlife Sanctuary in the Cardamom Mountains, Southwest Cambodia (© Neang Thy).

Fig. 8 Dorsal view of *Daboia siamensis* from Oddar Meanchey Province (© Shinya Otake).

tive, the specimens are bronze-brown on dorsum; blue between scales and underneath scales when removed; chin yellowish; ventral surface grey.

Ecological notes: Our specimen of this diurnal species was found moving rapidly along an old logging road during the day in hill evergreen forest.

Distribution: *Dendrelaphis ngansonensis* has been found in central and North Vietnam, Laos (Ziegler & Vogel, 1999; Nguyen *et al.*, 2009; Le *et al.*, 2014) and Cambodia (this paper).

Remarks: *Dendrelaphis ngansonensis* is similar to *D. cyanochloris,* but differs in that the former has a bronze-brown flank (vs. a more distinct bluish flank in the latter) (Ziegler & Vogel, 1999). This is the first record for Cambodia. On the basis of its currently known range the species is also expected to occur in northeastern Cambodia.

***Gongylosoma scriptum* Theobald, 1868** (Fig. 7)

Material examined: CBC 01365, adult female, collected by Neang Thy, 18 December 2010, 12°07′33.2″N, 102°59′32.9″E, 974 m a.s.l. in the Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, Pursat Province, Southwest Cambodia; CBC 02543, adult male, collected by Neang Thy, 11 March 2015, 11°13′24.4 N, 103°56′02.1″E, 290 m a.s.l., Thma Rung area, O'Bak-rotes Commune, Kampong Seila District, Preah Sihanouk Province.

Description: An adult male and one adult female match the description of this species by Smith (1943),

Taylor (1965) and Grismer *et al.* (2003) in having small size, SVL 252.2 mm (256.1 mm); TaL 172.2 mm (145.6 mm); 122 (138) ventral scales; 101 (93) subcaudal scales (female characters in brackets); 13–13–13 dorsal scale rows; single large preocular; 2 postoculars; 8 supralabials, 3–5th contacting orbit; 8 infralabials; (1+2) temporal in both sides, anterior almost twice the length of the posterior; anal plate divided. Large greenish olive occipital band, covering three to four scales long, bordered anteriorly and posteriorly by distinct transverse light crossbars; a distinct elongated light black-edged spot on each parietal; preocular and postocular with distinct vertical white bars. Our specimens have anterior dorsal surface and flanks with light-olive brown, becoming reddish-brown in the middle and dark olive grey on the rest of posterior portion of the body continuing to the end of the tail; one scale wide faint vertebral olive-brown stripe, reddish-brown along mid-body part and greyish-brown posteriorly extending to the end of the tail; sparse, black, paravertebral spots, more distinct anteriorly, extending to mid-body and fading away posteriorly; indistinct dark grey lateral stripe running between the second and third scale row.

Ecological notes: The female specimen was found during the day in the middle of a forest path under a relatively closed canopy in hill evergreen forest. The male specimen was encountered among leaf litter along an old forest road during the day in the dry season in semi-evergreen forest mixed with bamboo.

Distribution: *Gongylosoma scriptum* is reported from Myanmar, Thailand (Smith, 1943; Taylor, 1965; Grismer *et al.,* 2003; Uetz & Hošek, 2015) and Cambodia (this paper).

Remarks: *Gongylosoma* Fitzinger 1843 was listed as the genus *Liopeltis* by Smith (1943) and Taylor (1965). Leviton (1964) provided a significant review which separated *Liopeltis* from *Gongylosoma* and Grismer *et al.* (2003) commented on the latter nomenclature which we follow here. Our record confirms the occurrence of this genus and species for the first time in Cambodia.

***Daboia siamensis* (Smith, 1917)** (Fig. 8)

Material examined: Two photographs of a dead snake in dorsal and ventral views were taken by Dani Jump, 18 January 2015 in Pradak Village (approximately 13°26′37.37″N, 103°55′52.61″E, Bantey Srey District, Siem Reap Province (Figure 1h); One photograph of another dead snake in dorsal view (Figure 8), taken by Shinya Otake, 10 February 2015, Tropeang Tung Village 14°13′13.6″N, 103°35′23.9″E, Bansay Reak Commune, Samroang District, Oddar Meanchey Province (Figure 1h).

Description: Our photographs match the diagnostic characters of this species described by Taylor (1965), Saint Girons (1972) and Thorpe *et al.* (2007) as follows: robust body, slender neck, short tail; grey background on dorsum and flanks; solid, dark, elongated, separated dorsal and lateral blotches with darker edges, which are surrounded by white scales; small, thin, dark, elongated, blotches, locating between dorsal and lateral blotch series; creamy ventral surface with dark scales in form of half circle running along middle of venter and darker ventrolateral scales.

Ecological notes: Little is known about the ecology of this species. Two individuals of this highly venomous snake were found and killed in villages. The species is likely to be found in disturbed habitat, agricultural areas and near villages.

Distribution: This species has a disjunct distribution including from Myanmar to Thailand, Cambodia, Lesser Sundas, Java and China (Thorpe *et al.,* 2007). In Cambodia, *D. siamensis* was previously known only from a single specimen from Pailin, along the western border with Thailand (Saint Girons, 1972; Thorpe *et al.,* 2007). Our records extend the range of the species to the northeast into the Oddar Meanchey and Siem Reap provinces and suggest that it may also occur as far as the Cardamom Mountains and the central low-lying part of the Prey Lang area in Cambodia (see Figure 1a–h for species distributions).

Remarks: Russell's pit viper is one of many well-known highly venomous snakes in Southeast Asia, and two morphologically distinct and geographically separated species occur: *D. russelii*, west of the Bay of Bengal, and *D. siamensis*, east of the Bay of Bengal, including Cambodia (Thorpe *et al.,* 2007). This venomous snake is likely killed when encountered in Cambodia due to fear. Our record extends the known range of this species in Cambodia by 150–180 km to the East and Northeast.

Discussion

Research on amphibians and reptiles in Cambodia has intensified in recent years and many studies have found new species to science (Daltry & Wüster, 2002; Ohler *et al.,* 2002; Stuart *et al.,* 2006; Grismer *et al.,* 2007b, 2010; David *et al.,* 2008a,b; Rowley *et al.,* 2010; Wood *et al.,* 2010; Geissler *et al.,* 2012; Neang *et al.,* 2011, 2012, 2014) and new records to the country (Stuart & Emmett, 2006; Grismer *et al.,* 2008a,b; Stuart *et al.,* 2010; Neang *et al.,* 2010; Hartmann *et al.,* 2009, 2010, 2011, 2012, 2014 and reference

herein). This paper documents five new records for Cambodia which collectively represent significant additional biodiversity value for the country.

All of the new records were found in the Cardamom Mountains and the Eastern Plains, suggesting that herpetofaunal knowledge of these areas remains incomplete. The low-lying area of Prey Lang between the area west of Mekong River and east of Tonle Sap Lake also remains poorly studied as many new records have been reported from this area (Hartmann *et al.*, 2009, 2010, 2011, 2012, 2014). The biogeography of the latter appears to be linked to Cardamom Mountains through the occurrence of such species as *Hylarana mortenseni*, *Siebenrockiella crassicollis*, *C. mystaceus*, *Scincella melanosticta* and *Sphenomorphus stellatus* (Stuart & Emmett, 2006; Hartmann *et al.*, 2013a; Neang & Hun, unpublished data) and with the Eastern Plains through the occurrence of *Limnonectes dabanus*, *Pelochylax lateralis* and *Leiolepis rubritaeniata* (Hartmann *et al.*, 2013b; Neang & Hun, unpublished data).

It is uncertain how long it will take to fully elucidate the species composition and biogeography of Cambodia's herpetofauna. Following their scientific discovery, it took two to three years to prove the existence of *R. robertingeri* and *C. bachae* in Cambodia, six years for *D. ngansonensis* and over 100 years for *R. maximus* and *G. scriptum*. The latter two species were first described from Nepal in 1858 and from Myanmar in 1868, respectively (Gunther, 1858; Taylor, 1965). Contemporary land use changes in Cambodia have likely also altered the natural species richness and distribution of herpetofauna and other taxa in the country, particularly of endemic and rare species that occupy smaller ecological niches. There is therefore an urgent need for further field research to fill the gaps in current understanding and guide the prioritisation of areas for conservation attention.

Acknowledgements

We are grateful to His Excellency Mok Mareth, former Minister of Environment and His Excellency Chay Samith, General Department of Administration for Nature Conservation and Protection of the Ministry of Environment for providing field permissions. We are also grateful to Neil Furey for facilitating field work in 2010; Alan Reseter and John Murphy for providing photographs of *C. mystaceus* and *C. bachae* from the Field Museum of Natural History, Chicago; Kha Hour for specimens of *G. petricolus* from Preah Vihear; Gabor Csorba and Jackson Frechette for photographs of *C. bachae* from Ratanakiri; Barney Long for photographs of *C. bachae* from Mondulkiri; Ben Hayes for photographs of *C. mystaceus* from Prey Lang; Dani Jump and Shinya Otake for photographs of *D. siamensis* from Siem Reap and Oddar Meanchey; Anita Malhortra for her advice on the record of *D. siamensis*, amd Truong Quang Nguyen and Thomas Ziegler for providing papers. Our research was made possible by grants provided to Neang Thy by the Rufford Small Grants Foundation (Ref: 08.01.10), the Zoological Parks and Gardens Board of Victoria (Australia), Darwin Initiative (DEFRA, UK: EIDPO028), and the John D. and Catherine D. MacArthur Foundation (US: 09-92411-000-GSS). For supporting our surveys in Prey Lang, we thank the Forestry Administration, Conservation International, and Winrock, particularly Keo Omaliss, Tracy Farell, La Pengly and Kheng Sokorn. We also thank our three peer reviewers for their constructive comments and Jackson Frechette for his editorial assistance.

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Recent Master's Theses

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

Evaluation of the Thai Department of Fisheries monitoring method in the Srepok and the Sesan rivers, Northeast Cambodia

CHAN Bunyeth

មូលន័យសង្ខេប

ប្រភេទត្រីជាច្រើននៅទន្លេសេសាន និងស្រែពក បានត្រូវកំពុងរងការគំរាមកំហែងដោយសារ គំរោងស្នើសុំការីអគ្គិសនីសេសាន ក្រោម២។ ត្រីគឺជាប្រភពអាហារចំបងនិងចំណូលសំខាន់សម្រាប់ ប្រជាជនដែលរស់នៅក្នុងតំបន់នេះ។ ការសិក្សាស្រាវជ្រាវនេះមាន គោលបំណង ទី១៖ ធ្វើការសិក្សាតេស្តសាកល្បងទៅលើបច្ចេកទេសការត្រួតពិនិត្យស្តង់ដារមងដែលប្រើប្រាស់ដោយ ការិយាល័យ ជលផលប្រទេសថៃ ទី២៖ ប្រៀបធៀបភាពសំបូរបែបនៃប្រភេទត្រីនៅទន្លេសេសាន និងទន្លេស្រែពក ប្រទេសកម្ពុជា ជាមួយតំបន់ពីរ កន្លែងនៃទន្លេមេគង្គប្រទេសថៃ ទី៣៖ វិភាគទៅលើកំណត់ត្រារបស់ប្រភេទត្រីទៅតាមបំរែបំរួលនៃរដូវ ទី៤៖ ប្រៀបធៀបបំរែបំរួល ប្រភេទត្រីដែលចាប់បានដោយប្រើប្រាស់មងជាមួយទំហំមងផ្សេងគ្នា។ មងសរុបចំនួន ២៣៥ ត្រូវបានដាក់នៅទីតាំង៦កន្លែង នៅតាម ទន្លេសេសាន និងស្រែពក ប៉ុន្តែមានតែមងចំនួន ១១៣ប៉ុណ្ណោះដែលជាប់ត្រី។ មងក្រលា ៣ហ៊ុនគឺជាមងដែលជាប់ត្រីច្រើនជាងគេ។ ក្នុងចំណោម ត្រី៨៨ប្រភេទដែលបានកត់ត្រា មានត្រីចំនួន២ប្រភេទជាត្រីកំពុងរងគ្រោះជាសាកល ៦ប្រភេទងាយទទួលរងគ្រោះ និង ៦ប្រភេទទៀតជិតរងគ្រោះ។ ត្រី១០ប្រភេទត្រូវបានកត់ត្រា នៅទីតាំងទាំង៦នៅទន្លេសេសាននិងទន្លេស្រែពក។ ការវិភាគលើភាព ស្រដៀងគ្នា(ANOSIM) រកឃើញថាវាមានភាពខុសគ្នាតាមស្ថិតិប៉ុន្តែវាមានភាពខុសតិចតួចប៉ុណ្ណោះរវាងទីកន្លែង ទន្លេ និងទំហំមង (R^2 = 0.082; R^2 = 0.076; R^2 = 0.271 តាមលំដាប់ ,ប៉ាន់ម៉ែត្រទាំងអស់មានតំលៃ P < 0.01ដូចគ្នា)។ ត្រីទាំងអស់ចំនួន ២៨ប្រភេទត្រូវបានរកឃើញមានភាពដូចគ្នារវាងទន្លេនៅប្រទេសកម្ពុជានិងប្រទេសថៃ ប៉ុន្តែត្រីទាំងអស់គ្មានកំណត់ត្រានៅទីតាំង សិក្សាទាំង៨កន្លែងនោះទេ។ លទ្ធផលចង្អុលបង្ហាញឲ្យឃើញថាទន្លេសេសាននិងស្រែពកមានភាពសំបូរបែបនៃប្រភេទត្រី ហើយ វិធីសាស្ត្រត្រួតពិនិត្យរបស់ប្រទេសថៃអាចប្រើប្រាស់សម្រាប់ការវាស់វែងទៅលើភាពសំបូរបែបរបស់ប្រភេទអោយមានភាពប្រសើរតា មរយៈការប្រើប្រាស់ឧបករណ៍នេសាទបន្ថែមដូចជា ខ្សែសន្ទូច និងសំណាញ់។

Abstract

Many fish species in the Sesan and Srepok rivers are believed to be threatened by the proposed construction of the Lower Sesan 2 hydroelectric dam. Fish are one of the main sources of food and income for people living in this area. This study aimed to: (1) test in Cambodia the standard gill net monitoring protocol used by Thailand's Department of Fisheries, (2) compare fish species diversity in Cambodia's Sesan River and Srepok River with two sites in the Thai Mekong River, (3) analyse seasonal variation in the fish species recorded, and (4) compare variation in fish species caught using gill nets with different mesh sizes. A total of 235 gill nets were set at six sites along the Sesan and Srepok rivers, but only 113 gill nets caught fish successfully. The 3-cm mesh size was the most productive. Out of the 88 species of fish recorded, two were Endangered, six Vulnerable and six Near Threatened. Ten species were found in all six sites on the Sesan and Srepok rivers. Analyses of similarity (ANOSIM) found statistically significant, but only minor differences between sites, rivers, and mesh sizes (R^2 = 0.082; R^2 = 0.076; R^2 = 0.271 respectively, all p < 0.01). A total of 28 species were shared between the rivers sampled in both Cambodia and Thailand, but none occurred in all eight sites surveyed. Results indicate that the Srepok and Sesan rivers hold a rich fish fauna and that the Thai monitoring method could be improved in measuring species diversity through the use of additional fishing gear, including line hooks and cast nets.

CITATION: Chan B. (2015) Evaluation of the Thai Department of Fisheries monitoring method in the Srepok and the Sesan rivers, Northeast Cambodia. *Cambodian Journal of Natural History*, **2015**, 183.

Monitoring of **fi**sh in the 3S rivers network in Ratanakiri and Stung Treng provinces, Cambodia

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ប្រព័ន្ធទន្លេ៣ស (ទន្លេ សេសាន សេកុង និងស្រែពក) គឺជាដែនទន្លេមេគង្គដែលហូរកាត់ ខេត្តរតនគិរី និងស្ទឹងត្រែងនៅប្រទេសកម្ពុជា។ ប្រជាជននៅ តំបន់ទាំងនេះគឺពឹងពាក់ចំបងទៅលើត្រីសម្រាប់ជាប្រភពអាហារនិងចំណូល។ បណ្តាញទន្លេ៣ស កំពុងទទួលរងការគំរាមកំហែងពីការសាងសង់ទំនប់វារីអគ្គិសនីផ្នែកខាងលើនៅប្រទេសវៀតណាមនិងឡាវ។ ការត្រួតពិនិត្យអាចបង្ហាញពីស្ថានភាពអេកូឡូស៊ី និងការអភិរក្សរបស់ប៉ូពុយឡាស្យុងរបស់ត្រី។ ទីតាំងចំនួន៦កន្លែងត្រូវបានយកមកសិក្សាដើម្បីប្រៀបធៀបចំនួនត្រី និងភាពសំបូរបែបដោយប្រើប្រាស់ឧបករណ៍នេសាទផ្សេងៗគ្នាដូចជា៖ មងស្តង់ដា(ក្រឡា ១០ហ៊ុន) សំណាញ់ (ក្រឡា ៣ហ៊ុន) និងខ្សែសន្ទូច។ ត្រីសរុបចំនួន ២២៨២ ក្បាលចាប់បាន។ ភាពសំបូរបែបមានចន្លោះពី ៧ ទៅ៤៣ ប្រភេទត្រីដែលបាននៅតំបន់មួយៗ។ ក្នុងចំណោម ត្រី៧៥ប្រភេទ (២ប្រភេទងាយរងគ្រោះ និង៥ប្រភេទជិតរងគ្រោះ) មានតែមួយប្រភេទប៉ុណ្ណោះដែលកត់ត្រាគ្រប់ទីកន្លែងសិក្សា គឺត្រីស្រកាក្តាមក្រហម។ ភាពសំបូរបែបនៃប្រភេទនិងចំនួននៃប្រភេទ មានទំនាក់ទំនងតិចតួចទៅនឹងទន្លេ (R^2= 0.108; P < 0.01) និងឧបករណ៍នេសាទ (R^2= 0.073; P < 0.01) ។ ប្រភេទដែលមានច្រើនលើសលប់គឺត្រីរៀលដែលជាប្រភេទសំខាន់នៅក្នុងប្រព័ន្ធអេកូឡូស៊ីតំបន់នេះ និងប្រជាជនកម្ពុជាភាគច្រើនប្រើប្រាស់ត្រីរៀលជាត្រីប្រហុក។ លទ្ធផលទាំងនេះបានលើកឡើងថាទន្លេ ៣ស មានប្រភេទត្រីសំបូរបែបច្រើនលើសលប់ដែលប្រើប្រាស់ជំរកផ្សេងៗគ្នាជាច្រើន។ ការត្រួតពិនិត្យទៅលើប្រភេទត្រីវាមានភាពត្រឹមត្រូវពេលដែលវិធីសាស្ត្រនេសាទមួយចំនួនត្រូវបានប្រើប្រាស់។

Abstract

The "3S rivers" (Sesan, Sekong and Srepok rivers) are tributaries of the Mekong River that flow through Ratanakiri and Stung Treng provinces in Cambodia. People in this area are highly dependent on fish for food and income. The 3S rivers network is currently under threat from the construction of hydropower dams upstream in Vietnam and Laos. Monitoring can reveal the ecological health and conservation status of fish populations. Six sites were surveyed to compare fish abundance and diversity using several types of fishing gear: standard gill nets (10 mesh sizes), cast nets (three sizes) and hook lines. A total of 2,282 individuals were caught. Diversity ranged from 7 to 43 species of fish caught per site. Out of the total of 75 species (of which two were Vulnerable and five Near Threatened), only one species was recorded in every site: *Labiobarbus leptocheilus*. Species composition was weakly correlated with the river (R^2 = 0.108; p < 0.01) and the gear used (R^2 = 0.073; p < 0.01). The most abundant species was *Gymnostomus lobatus*, a keystone species of this ecosystem, and traditionally consumed by Cambodians in the form of the fish paste *prahoc*. These results suggest that the 3S rivers have a highly diverse fish fauna making differential use of the large variety of habitats available. Fish monitoring proved to be most accurate when several fishing methods were applied.

CITATION: Gnim S. (2015) Monitoring of fish in the 3S rivers network in Ratanakiri and Stung Treng provinces, Cambodia. *Cambodian Journal of Natural History*, **2015**, 184.

Diet and reproductive phenology of the cave nectar bat *Eonycteris spelaea* in Cambodia and its conservation implications

HOEM Thavry

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នៅប្រទេសកម្ពុជា សត្វប្រចៀវ របបអាហារ បាតុភូតវិទ្យានៃការបន្តពូជ និង ស្ថានភាពនៃការអភិរក្សរបស់វាត្រូវបានស្គាល់តិចតួចនៅឡើយ។ នេះជាការសិក្សាពីរបបអាហាររបស់ប្រចៀវក្របលំអងផ្កា *(Eonycteris spelaea)* មួយក្រុមនៅក្នុងល្អាងបាតខ្នះភ្នំឈ្មោក (ខេត្តកំពតភាគខាងត្បូងនៃប្រទេសកម្ពុជា)។ ការប្រមូលទិន្នន័យមានរយៈពេល ៦ ខែ គឺចាប់ផ្តើមពីខែកុម្ភៈ ដល់ខែកក្កដា ឆ្នាំ ២០១៤។ សម្ភារៈនិង វិធីសាស្ត្រត្រូវបានប្រើប្រាស់ដូចខាងក្រោម៖ (១) ការប្រើមងចាប់ប្រចៀវ ដើម្បីកំណត់បម្រែបម្រួលស្ថានភាពនៃការបន្តពូជវាពីពេលមួយទៅពេលមួយ។ (២) ការប្រមូលគំរូសំណាកលាមករបស់ប្រចៀវក្របលំអងផ្កា ដើម្បីកំណត់ប្រភេទរុក្ខជាតិ ដែលវាក្របតាមរយៈគ្រាប់លំអងរបស់ផ្កា។ (៣) ការអង្កេតផ្ទាល់ និង ការសម្ភាសន៍ដើម្បីកំណត់ផលប៉ះពាល់នៃមនុស្សចំពោះក្រុមប្រចៀវក្របលំអងផ្កា។ រុក្ខជាតិ ១៨ ប្រភេទត្រូវបានរកឃើញថាជារបបអាហាររបស់ប្រចៀវក្របលំអងផ្កានៅប្រទេសកម្ពុជា ដែលច្រើនជាងរបបអាហាររបស់ប្រចៀវប្រភេទដូចគ្នានៅភាគខាងត្បូងប្រទេសថៃ។ ប្រភេទរុក្ខជាតិដែលជាអាហារសំខាន់បំផុតគឺ: កោងកាង *Sonneratia alba* (44.8% ក្នុងមួយខែ) កន្ទុំថេត *Parkia speciosa* (41.2% ក្នុងមួយខែ) និង ចេក *Musa truncata* (35.6%)។ ការសិក្សាលើបាតុភូតវិទ្យានៃការបន្តពូជបង្ហាញថា នៅប្រទេសកម្ពុជា *E. spelaea* ផ្តល់កំណើតកូននៅខែមករា និង ខែឧសភាដល់ខែមិថុនា នេះផ្ទុយពីប្រទេសវៀតណាមខាងជើងដែលការផ្តល់កំណើតកូនខ្ពស់បំផុតនៅខែមីនាដល់ខែមេសា និង ខែ សីហាដល់កញ្ញា។ នៅខេត្តកំពត *E. spelaea* ត្រូវបានគម្រាមកំហែងដោយការបរបាញ់យកសាច់ជាអាហារ យកឈាមធ្វើថ្នាំ និង រំខានពីការប្រមូលលាមកប្រចៀវក្នុងល្អាង។ ការគម្រាមកំហែងនេះកើនឡើងនៅអំឡុងពេលថ្ងៃចូលឆ្នាំខ្មែរ (ខែមេសា)។ ការពង្រឹងការអនុវត្តន៍ច្បាប់ និង លើកកម្ពស់ការប្រមូលលាមកប្រចៀវដោយនិរន្តរភាពអាចកាត់បន្ថយផលប៉ះពាល់ការគម្រាមកំហែងទាំងនេះដល់ចំនួនសត្វប្រចៀវ។

Abstract

Cambodian bats and their diet, reproductive phenology and conservation status are poorly known. These aspects were investigated for a single colony of cave nectar bat *Eonycteris spelaea* in Bat Khteas cave in Phnom Chhngauk (Kampot Province, southern Cambodia). Field data were collected for six months, from February to July, 2014, using the following approaches: (1) Live-trapping using mist nets to determine changes in reproductive status over time; (2) Faecal sample collection from the cave to identify the plant species consumed by their pollen; (3) Direct observations and interviews to determine human impacts on the bat colony. The diet of *E. spelaea* in Cambodia was found to include at least 18 plant species: a broader diet than that known for the same species in southern Thailand. The most important food species were: mangrove apples *Sonneratia alba* (up to 44.8% per month), petai *Parkia speciosa* (up to 41.2%) and bananas *Musa truncata* (up to 35.6%). Investigation of reproductive phenology suggested that *E. spelaea* gives birth mainly in January and May–June in Cambodia, in contrast to North Vietnam where birth peaks occur in March–April and August–September. *Eonycteris spelaea* is threatened by hunting for bushmeat and disturbance from guano collection in Kampot Province, and these threats increase during the Khmer new year period (April). Improved law enforcement and promotion of sustainable harvesting would reduce the impact of these threats on bat populations.

CITATION: Hoem T. (2015) Diet and reproductive phenology of the cave nectar bat *Eonycteris spelaea* in Cambodia and its conservation implications. *Cambodian Journal of Natural History*, **2015**, 185.

Diet of a Lyle's **fl**ying fox *Pteropus lylei* population in Kandal Province, Cambodia

HOK Visal

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សត្វជ្រាំង និង រុក្ខជាតិដែលវាស៊ីមានអន្តរកម្មនិងគ្នា។ ជ្រាំងប្រភេទ *Pteropus lylei* មានដើមកំណើតនៅឥណ្ឌូចិន និង ត្រូវបានចាត់ថ្នាក់ជាសត្វងាយរងគ្រោះ ដែលកំពុងរងការគម្រាមកំហែងដោយការបំផ្លាញជម្រក និង ការបរបាញ់។ ជ្រាំងស៊ីផ្លែឈើដែលជាដំណាំកសិកម្មសេដ្ឋកិច្ចសំខាន់ៗក្នុងបរិមាណយ៉ាងច្រើន និង វាជាភ្នាក់ងារដឹកនាំគ្រាប់លំអងដ៏សំខាន់។ ប៉ុន្តែជ្រាំងអាចបង្កគ្រោះថ្នាក់ដល់សុខភាពមនុស្សផងដែរ ព្រោះវាអាចផ្ទុកវីរុស Nipah (ដែលអាចចម្លងនៅពេលមានសត្វជ្រូកជាវិចទ័រប៉ុណ្ណោះ)។ ការសិក្សានេះបង្ហាញពីរបបអាហាររបស់ប៉ូពុយឡាស្យុងសត្វជ្រាំងប្រភេទ *P. lylei* នៅខេត្តកណ្តាលនៃប្រទេសកម្ពុជា។ ទំនាក់ទំនងរវាងភាពសម្បូរនៃផ្លែឈើជាអាហារជាមួយពេលវេលាមុន និង ក្រោយកំណើតកូនរបស់ជ្រាំង និង ពេលដែលការចម្លងវីរុស Nipah កើនឡើង។ របបអាហារត្រូវបានកំណត់ដោយប្រើប្រាស់គំរូសំណាកលាមកជ្រាំងចំនួន ៤២០។ ការប្រមូលគំរូសំណាកលាមកមានរយៈពេល ៧ ខែគឺចាប់ពីខែធ្នូ ២០១៣ ដល់ខែមិថុនា ២០១៤។ ភាពសំបូរនៃអាហារត្រូវបានវាយតម្លៃដោយការអង្កេតផ្ទាល់ និង ការសម្ភាសកសិករ។ ការជំរឿនទ្រនំរួមបញ្ចូលទាំងកំណត់ត្រារដ្ឋមានជ្រាំងមិនទាន់ពេញវ័យ។ ជ្រាំងស៊ីរុក្ខជាតិ ៨ ប្រភេទក្នុងសមាមាត្រប្រែប្រួល។ ល្មុត *Manilkara zapota* ជារបបអាហារមានចំនួនច្រើនជាងគេ ដែលមានវត្តមានក្នុងលាមករៀងរាល់ខែ និង មាន 78% ក្នុងគំរូសំណាកលាមកនៅខែមិថុនា។ ទីពីរ ផ្កាជំពូ *Syzygium malaccense* ត្រូវបានប្រទះឃើញច្រើនក្នុងខែមីនា (62% នៃគំរូសំណាកលាមក)។ សមាសធាតុក្នុងរបបអាហារប្រចាំខែ និង ទិសដៅនៃការហើរចេញរកអាហារឆ្លើយតបនិងភាពសម្បូរនៃរុក្ខជាតិដែលជាអាហាររបស់ជ្រាំង។ ជ្រាំងមិនទាន់ពេញវ័យមានវត្តមាននៅខែមេសា ដល់ខែឧសភា (រយៈពេលនៃការផ្តល់កំណើត) និង ថយចុះទៅវិញនៅខែមិថុនា (រយៈពេលក្រោយការផ្តល់កំណើត)។ ដោយសត្វជ្រាំងអាស្រ័យលើដំណាំល្មុតនេះជាអំឡុងពេលគ្រោះថ្នាក់គួរតែមានសេចក្តីជូនដំណឹងឲ្យមានការប្រុងប្រយ័ត្នចំពោះការចម្លងវីរុសនៅតំបន់ជុំវិញកសិដ្ឋានមានសត្វវិចទ័ររបស់វីរុស Nipah។

Abstract

Fruit bats and the plants they feed on are interdependent. Lyle's flying fox *Pteropus lylei* is native to Indochina and classified as Vulnerable, being threatened by habitat destruction and hunting. The bats feed heavily on economically important farmed fruits and are valuable pollinators, but also pose a potential danger to human health because they are reservoirs of Nipah virus (transmissible only through vectors such as pigs). This study characterised the diet of a *P. lylei* population in Kandal Province, Cambodia, in relation to fruit availability and with regard to birthing and post-birthing periods, when the risk of Nipah virus transmission increases. Diet was quantified using 420 faecal samples collected over seven months, from December 2013 to June 2014. Food availability was evaluated through direct observation and farmer interviews. Roost censuses included recording the presence of any juveniles. The bats fed on eight plant species in changing proportions. Sapodilla *Manilkara zapota* was the dominant food item, present in faeces every month and occurring in 78% of the faeces sampled in June. Second were Malay apple *Syzygium malaccense* flowers, most commonly consumed in March (62% of faeces). Monthly diet composition and foraging flight direction corresponded with the documented plant availability. Juveniles appeared in April–May (birthing period), decreasing by June (post-birthing period). Reliance on farmed sapodilla during these critical periods may call for increased caution around farms, particularly with potential Nipah virus vector animals.

CITATION: Hok V. (2015) Diet of a Lyle's flying fox *Pteropus lylei* population in Kandal Province, Cambodia. *Cambodian Journal of Natural History*, **2015**, 186.

Does boat traffic affect behaviour of Irrawaddy dolphins *Orcaella brevirostris* in the Mekong River?

HONG SeangAun

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ប៉ូពុយឡាស្យុងរងផ្សោតទឹកសាប ក្បាលត្រឡោក (Irrawaddy *Orcaella brevirostris*) នៃទន្លេមេគង្គបាននឹងកំពុងរងការគម្រាមកំហែងធ្ងន់ធ្ងរ។ តាមការប៉ាន់ស្មាន ប្រភេទនេះនៅសល់តិចជាង៧០ក្បាលរស់នៅតាមបណ្តោយទន្លេមេគង្គ លាតសន្ធឹង១៩០ គម. ចាប់ពីខេត្តក្រចេះ (ប្រទេសកម្ពុជា) រហូតដល់ល្បាក់ខោន (Khone Falls) ផ្នែកខាងលើនៃទន្លេ និងជាព្រំប្រទល់រវាងប្រទេស ឡាវ និងកម្ពុជា។ អន្លង់កាំពីក្នុងខេត្តក្រចេះជាជំរកដ៏សំខាន់សម្រាប់ផ្សោត ប៉ុន្តែផលប៉ះពាល់ពីកំណើនភ្ញៀវទេសចរណ៍មើលផ្សោតលើអាកប្បកិរិយារបស់ផ្សោត ការជួយថែរក្សា និងការអភិរក្សនៅមិនទាន់ត្រូវបានគេសិក្សានៅឡើយ។ ក្នុងកំឡុងពេលសិក្សានេះ ក្រុមផ្សោតសំខាន់ៗមួយចំនួនត្រូវបានតាមដានដោយប្រើទូក និងដោយសង្កេតពីឆ្នេរទន្លេដើម្បីស្វែងយល់ពីឥទ្ធិពលទូកទេសចរណ៍លើអាកប្បកិរិយារបស់ផ្សោត។ អាកប្បកិរិយាស៊ីចំណីរបស់ផ្សោតទាំងអស់ដែលបានកត់ត្រាពីលើទូកថយចុះស្របពេលដែលចំនួនទូកកើនឡើង (slope = -0.05, R^2 = 0.80, P = 0.039)។ កំណើនចំនួនទូកក៏ជះឥទ្ធិពលលើចំនួនក្រុមផ្សោតដែរ (slope = -0.11, R^2 = 0.93, P = 0.008) លើសពីនេះវាក៏រំខានដល់អាកប្បកិរិយាស៊ីណីរបស់មេបណ្តើរកូនផងដែរ ទោះក្នុងកម្រិតទាបក៏ដោយ (slope = -0.166, R^2 = 0.82, P = 0.09)។ វិធីសាស្ត្រសង្កេតនៅលើដី បង្ហាញថាវត្តមានរបស់ផ្សោត និងទូកមានទំនាក់ទំនងគ្នា យ៉ាងជិតស្និត (χ^2 = 10.793, df = 1, P = 0.001)។ ការរំខានដល់អាកប្បកិរិយាស៊ីចំណីប្រហែលជាអាចជះឥទ្ធិពលអាក្រក់ដល់ សុខភាព ការបន្តពូជ និងភាពរស់រានមានជីវិតរបស់ផ្សោត។ មគ្គុទេសក៍ស្តីពីចំនួនទូកទេសចរណ៍ និងសន្ធិសញ្ញាការពារផ្សោតអាចជាយុទ្ធសាស្ត្រចាំបាច់ដើម្បីអភិរក្សប្រភេទដ៏កម្រនេះ ក៏ដូចជាសកម្មភាពដើម្បីការពារដែនជំរកដែលបាននឹងកំពុងបាត់បង់បន្តិចម្តងៗ។

Abstract

The Mekong river subpopulation of freshwater Irrawaddy dolphins *Orcaella brevirostris* is Critically Endangered. Fewer than 70 individuals are estimated to remain along a 190 km stretch from Kratie (Cambodia) to the Khone Falls, upstream of the Laos/Cambodia border. Kampi pool in Kratie Province is a vital stronghold for the dolphins, but the effects of increasing dolphin-watching tourism on their behaviour, welfare and conservation needs had not been investigated. During this study, focal groups of dolphins were followed by boat and observed from the riverbank to understand the effects that motorized tourist boats have on their behaviour. The feeding behaviour of all dolphins, recorded from a boat, significantly decreased with increasing numbers of boats (slope = -0.05, R^2 = 0.80, p = 0.039). An increased number of boats also affected the dolphin groups (slope = -0.11, R^2 = 0.93, p = 0.008) and, though not statistically significant, appeared to disturb the feeding behaviour of mother–calf pairs (slope = -0.166, R^2 = 0.82, p = 0.09). Land-based observations showed that dolphin presence and boat presence on consecutive time-steps were strongly associated (χ^2 = 10.793, df = 1, p = 0.001). Disturbance of feeding behaviour may be having damaging consequences on dolphin fitness, reproductive success and survival. Guidelines on tourist boat numbers and dolphin approach protocols may be necessary to conserve this rare species, as well as actions to protect their shrinking habitat.

CITATION: Hong S. (2015) Does boat traffic affect behaviour of Irrawaddy dolphins *Orcaella brevirostris* in the Mekong River? *Cambodian Journal of Natural History*, **2015**, 187.

Cave selection and reproductive phenology of insectivorous bats in southern Cambodian karst and their conservation implications

LIM Thona

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ប្រចៀវជាសត្វឆ្អឹងកងតែមួយគត់ ដែលប្រើប្រាស់ស្អាងយ៉ាងទូលំទូលាយ។ ប៉ុន្តែនៅប្រទេសកម្ពុជា អេកូឡូស៊ីនៃទ្រនំរបស់វា ត្រូវបានស្គាល់តិចតួចនៅឡើយ។ គោលបំណងនៃការសិក្សានេះដើម្បីវាយតម្លៃទ្រនំដែលបានជ្រើសរើស និង បាតុភូតវិទ្យានៃការបន្តពូជរបស់សត្វប្រចៀវស៊ីសត្វល្អិតដែលរស់នៅក្នុងស្អាងថ្មកំបោរនៅភ្នំឈ្មោក (ខេត្តកំពត ភាគខាងត្បូងនៃប្រទេសកម្ពុជា) និង ដើម្បីកំណត់ការគម្រាមកំហែងដល់ការរស់នៅរបស់សត្វប្រចៀវ។ ស្អាងទាំងបី និង សត្វប្រចៀវដែលរស់នៅក្នុងនោះត្រូវបានប្រៀបធៀបទាំងរចនាសម្ព័ន្ធ ខាងក្នុង និងបរិស្ថានខាងក្រៅស្អាង អថេរនៃសមាសភាគចូលរួមរបស់ប្រភេទប្រចាំខែ ចំនួនសត្វប្រចៀវ និង ការបត់បែនក្នុងការហើរ។ ការសិក្សានេះចាប់ផ្តើមពីខែកុម្ភៈ ដល់ ខែកក្កដា ២០១៤។ បាតុភូតវិទ្យានៃការបន្តពូជត្រូវបានអង្កេតដោយការដាក់មងនៅមុខស្អាងដើម្បីចាប់សត្វប្រចៀវ។ ការគម្រាមកំហែងដល់ការអភិរក្សត្រូវបានកំណត់អត្តសញ្ញាណដោយប្រើទិន្នន័យភ្ញៀវទេសចរណ៍ចូលមកលេងក្នុងស្អាង ការសម្ភាសជាមួយអ្នកប្រមូលលាមកប្រចៀវ និង ការអង្កេតផ្ទាល់។ ស្អាងបាតខ្ទះមានចំនួន និង ប្រភេទប្រចៀវ (ប្រចៀវ ៩ ប្រភេទ) ច្រើនជាងស្អាងវិហារទុកបុណ្យ និង ស្អាងត្រែលក្ខណ៍ (ប្រចៀវ ៥ ប្រភេទ) ព្រោះ ទំហំធំរបស់ស្អាង និង ភាពសាំញ៉ាំរបស់ស្អាងដែលផ្តល់បរិស្ថានសមស្របសម្រាប់ប្រចៀវជាច្រើនប្រភេទផ្សេងៗគ្នា។ ចំពោះប្រចៀវពីរប្រភេទ *Taphozous melanopogon* និង *Hipposideros larvatus* ប្រែកង់នៃចំនួនការចាប់បានប្រចៀវញីមានទឹកដោះមានទំនាក់ទំនងវិជ្ជមានជាមួយកម្រិតទឹកភ្លៀងប្រចាំឆ្នាំ។ នេះដោយសារនៅរដូវវស្សាសំបូរអាហារ (សត្វល្អិត)។ ការរំខានដោយភ្ញៀវទេសចរណ៍ចូលទៅមើលស្អាង និង អ្នកគោរពសាសនា បានប៉ះពាល់យ៉ាងខ្លាំងដល់សត្វប្រចៀវនៅស្អាងវិហារទុកបុណ្យ ទន្ទឹមការបរបាញ់ និងការប្រមូលលាមកប្រចៀវយ៉ាងអនាធិបតេយ្យបានគម្រាមកំហែងសត្វប្រចៀវទាំងអស់នៅក្នុងស្អាងទាំងបី។ ការពង្រឹងការអនុវត្តច្បាប់ ការអប់រំប្រជាជន និងការធ្វើឲ្យប្រសើរក្នុងការប្រមូលលាមកប្រចៀវតាមវិធីសាស្ត្រប្រកបដោយនិរន្តរភាពចាំបាច់ក្នុងការអភិរក្សសត្វប្រចៀវនៅក្នុងស្អាងភ្នំឈ្មោក។

Abstract

Bats are the only vertebrates to have widely exploited caves, but their roosting ecology is poorly known in Cambodia. The aim of this study was to evaluate roost selection and reproductive phenology of insectivorous bats inhabiting three limestone caves in Chhngauk Mountain (Kampot Province, southern Cambodia) and to identify threats to their survival. The three caves and their bat faunas were compared in terms of their internal structure and external environments, monthly variation in species composition, relative abundance and manoeuvrability in flight, from February to July 2014. Reproductive phenology was investigated by sampling the bats with mist-nets at the cave entrances. Conservation threats were identified from cave visitor data, interviews with bat guano collectors, and direct observations. Bat Khteas cave had larger numbers of bats and species (nine species) than the Vihear Tuk-Bonn and Trai Lak caves (five species apiece) because its larger size and greater complexity provide a wider range of environmental niches for different bat species. The frequency of lactating female bats was significantly positively correlated with rainfall in two bat species (*Taphozous melanopogon* and *Hipposideros larvatus*), putatively due to the increased availability of food (insects) during the wet season. Disturbance from tourists and religious visitors strongly affected bats in Vihear Tuk-Bonn cave, while hunting and unregulated guano-collection threatened all three caves. Improved law enforcement, public education and promotion of sustainable guano collection techniques are needed to conserve the cave-dwelling bats of Chhngauk Mountain.

CITATION: Lim T. (2015) Cave selection and reproductive phenology of insectivorous bats in southern Cambodian karst and their conservation implications. *Cambodian Journal of Natural History*, **2015**, 188.

Dry-season habitat use of the Critically Endangered white-shouldered ibis *Pseudibis davisoni* in the Mekong **fl**ooded forest landscape in Kratie Province, Northeast Cambodia

MAO Khean

មូលន័យសង្ខេប

បក្សីរងគ្រោះ (Critically Endangered) ត្រយ៉ងចង្កឹកស (white-shouldered ibis: *Pseudibis davisoni*) គឺជាប្រភេទដែលមានដែនជំរកស្ទើតែទាំងស្រុងស្ថិតក្នុងប្រទេសកម្ពុជា វាត្រូវបានរងការគម្រាមកំហែងដោយការបំផ្លាញទីជំរកតាមរយៈសម្បទានដី ការសង់លំនៅដ្ឋាន ផ្លូវថ្នល់ ក៏ដូចជាការបរបាញ់ ការនេសាទ និងការចាប់កង្កែបនៅតាមបឹង ការបោះបង់សំបុក និងផលប៉ះពាល់ដោយប្រយោលនៃបំរែបំរួលអាកាសធាតុ។ ការសិក្សានេះគឺដើម្បីស្វែងយល់ពីដែនជំរករបស់ត្រយ៉ងចំកំកសនៅតាមព្រៃលិចទឹកទន្លេមេគង្គ (ភាគឥសាន្តនៃប្រទេសកម្ពុជា) នៅចុងរដូវប្រាំង។ សកម្មភាពរកចំណីត្រូវបានវាយតម្លៃតាមការសិក្សាស្នាមចំពុះក្នុង quadrats ដែលបានដាក់នៅក្នុងត្រពាំងចំនួនប្រាំមួយនៅលើកោះមួយ និងត្រពាំងប្រាំបួនផ្សេងទៀតនៅលើដីទ្វីប។ របាយរបស់ត្រយ៉ងក៏ត្រូវបានវាយតម្លៃតាមរយៈមើលឃើញដោយផ្ទាល់ ដោយសង្កេតតាមបណ្តោយផ្លូវប្រវែង១៥០ គម. ក្នុងទីជំរកដោយកាត់តាមមជ្ឈដ្ឋានផ្សេងៗគ្នារួមមាន ព្រៃពាក់កណ្តាលស្រោង (semi-evergreen forest) ព្រៃរបោះ(dry dipterocarp) វាលស្មៅ និងវាលស្រែ (ទាំងដីប្រើប្រាស់ និងមិនប្រើប្រាស់)។ ឥទ្ធិពលនៃចម្ងាយផ្លូវ ចម្ងាយភូមិ និងទំហំរបស់ត្រពាំងទៅលើសកម្មភាពរកចំណីត្រយ៉ងត្រូវបានវិភាគតាម linear regressions និង general linear mixed-effects models។ ស្លាកស្នាមសកម្មភាពរកចំណីកាន់តែកើនឡើងនៅលើទីតាំងដែលកាន់តែឆ្ងាយពីផ្លូវ (slope = 1.6132; R^2 = 0.44; P < 0.01) នេះបង្ហាញឲ្យឃើញថា វាអាចបណ្តាលមកពីការរំខាននៃយានជំនិះ ឬការរីករាលដាលនៃលំនៅដ្ឋានរបស់មនុស្ស។ នៅក្នុងបរិស្ថាន គេច្រើនប្រទះឃើញត្រយ៉ងនៅក្នុងដីស្រែប្រើប្រាស់ជាប្រចាំ និងបន្ទាប់មកក្នុងដីស្រែមិនប្រើប្រាស់ និងព្រៃរបោះ។ ត្រពាំងក្នុងតំបន់ព្រៃលិចទឹកមិនត្រូវបានរងការបំផ្លាញធ្ងន់ធ្ងរដោយអ្នកភូមិតាមរយៈការនេសាទត្រី និងរកកង្កែបទេ។ ត្រយ៉ងចំកំកសហាក់ដូចជាស៊ាំក្នុងកម្រិតណាមួយទៅនឹងសកម្មភាពរំខានរបស់មនុស្ស រាប់បញ្ចូលទាំងសកម្មភាពកសិកម្មតាមបែបប្រពៃណី។

Abstract

The Critically Endangered white-shouldered ibis *Pseudibis davisoni* is mostly restricted to Cambodia and threatened by habitat destruction due to land concessions, settlements and roads, as well as hunting, fishing and frog harvesting in water holes (trapeang in Khmer), nest failures, and indirect impacts from climate change. This study examined habitat use by white-shouldered ibis in the Mekong flooded forest landscape (northeastern Cambodia) in the late dry season. Foraging activity was assessed by studying beak marks in quadrats placed in six water holes on an island and nine water holes on the mainland. Ibis distribution was also evaluated by recording sightings along 150 km of tracks across several landscapes: semi-evergreen and dry dipterocarp forests, grasslands (veal in Khmer), and both used and unused rice fields. The influence of distance to roads and villages, and trapaeng size on ibis foraging activity was analysed using linear regressions and general linear mixed-effects models. Signs of foraging activity significantly increased away from roads (slope = 1.6132; R^2 = 0.44; p < 0.01), which may be due to disturbance by vehicles or the presence of dispersed human settlements. On the landscape scale, ibises were most often encountered in active rice fields, followed by unused rice fields and dry dipterocarp forest. Water holes around the flooded forests were not heavily disturbed by villagers fishing or frog harvesting. White-shouldered ibises seem to tolerate some level of anthropogenic activity, including traditional, low-intensity agriculture.

CITATION: Mao K. (2015) Dry-season habitat use of the Critically Endangered white-shouldered ibis *Pseudibis davisoni* in the Mekong flooded forest landscape in Kratie Province, Northeast Cambodia. *Cambodian Journal of Natural History*, **2015**, 189.

Livelihoods in the Monks' Community Forest, Oddar Meanchey, Cambodia

MEAS Chenda

មូលន័យសង្ខេប

ការសិក្សានេះអង្កេតលើរបរចិញ្ចឹមជីវិតរបស់ប្រជាសហគមន៍ដែលពឹងផ្អែកលើអនុផលព្រៃឈើនៅព្រៃសហគមន៍សង្ឃរុក្ខាវ័ន្តនៅខេត្តឧត្តរមានជ័យនៃប្រទេសកម្ពុជា។ ប្រាក់ចំណូលប្រចាំឆ្នាំបានពីអនុផលព្រៃឈើ និង បានពីប្រភពផ្សេងទៀត (ដំណាំស្រូវ ដំឡូងមី ការលក់ដូរ ការនេសាទ និង ការចិញ្ចឹមសត្វ) ក្នុងភូមិចំនួន បួនគឺ ភូមិឈូកមាស ភូមិបាក់នឹម ភូមិថ្មី និង ភូមិទំនប់ថ្មី ត្រូវបានវាយតម្លៃ និងប្រៀបធៀប។ ឥរិយាបទប្រជាសហគមន៍ក្នុងការគ្រប់គ្រងព្រៃឈើសហគមន៍ក៏ត្រូវបានសិក្សាផងដែរ។ វិធីសាស្ត្របី ត្រូវបានប្រើប្រាស់ក្នុងការសិក្សាស្រាវជ្រាវពីរបរចិញ្ចឹមជីវិតរបស់ប្រជាសហគមន៍គឺ: ការសិក្សាស្រាវជ្រាវពីគ្រួសារប្រជាសហគមន៍ (៨៩ នាក់) ការពិភាក្សាក្រុមគោលដៅ (២០ នាក់) និង ការសម្ភាសជនបង្គោល (១១ នាក់)។ អនុផលព្រៃឈើ ៦ ប្រភេទជាប្រភពចំណូលសំខាន់សម្រាប់ប្រជាជនក្នុងភូមិទាំងនេះរួមមាន: ជ័រទឹក ជ័រចុង ទំពាំង ផ្សិត ខ្លាយ និង ក្របៅ។ លទ្ធផលនៃការសិក្សាបង្ហាញថាប្រាក់ចំណូលបានពីការលក់អនុផលព្រៃឈើខ្ពស់ជាងប្រាក់ចំណូលបានពីប្រភពដទៃទៀតគឺ: ភូមិថ្មីមានប្រាក់ចំណូលប្រចាំឆ្នាំចំនួន 60.8% ភូមិឈូកមាសមានចំនួន 59.9% ភូមិបាក់នឹមចំនួន 45.8% និង ភូមិទំនប់ថ្មីចំនួន 41.6%។ អនុផលព្រៃឈើត្រូវបានលក់ក្នុងតម្លៃខុសៗ គ្នាអាស្រ័យលើភាពសំបូរ ចម្ងាយពីភូមិទៅព្រៃ និង កម្រិតនៃភាពចាំបាច់របស់វាចំពោះប្រជាជនក្នុងភូមិនីមួយៗ ដែលការប្រមូលផលក្នុងរដូវខុសៗគ្នា។ តាមរយៈការប្រមូលពត៌មានបង្ហាញថា ការគ្រប់គ្រងអនុផលព្រៃឈើមានប្រសិទ្ធភាពបានលើកកម្ពស់ការអភិរក្សធនធានធម្មជាតិ ដោយសារមានការបន្តសហការវាងព្រះតេជគុណ ប៊ុន សាឡុត (ប្រធានព្រៃសហគមន៍សង្ឃរុក្ខាវ័ន្តខេត្តឧត្តរមានជ័យ) ជាមួយអ្នកពាក់ព័ន្ធផ្សេងៗដូចជា ប្រជាសហគមន៍ និង អង្គការក្រៅរដ្ឋាភិបាលក្នុងការការពារព្រៃឈើ។

Abstract

This study investigated community livelihood dependence on non-timber forest products (NTFPs) in the Monks' Community Forest (MCF), Oddar Meanchey Province, Cambodia. Annual income from NTFPs and from other resources (rice and cassava crops, direct sales, fishing and animal husbandry) was assessed and compared in four villages: Chhok Meas, Bak Nem, Thmey and Thomnob Thmey. Attitudes towards community forest management were also investigated. Three community livelihood research methods were applied: household surveys (89 respondents), focus group discussions (20 respondents) and key informant interviews (11 interviewees). Six types of NTFPs brought significant income to these villages: liquid resin, solid resin, bamboo shoots, mushrooms, finger roots and kra-bao. Results showed that the annual income generated by the villages from selling NTFPs was higher than the income from other sources: 60.8% of mean annual household income in Thmey, 59.9% in Chhok Meas, 45.8% in Bak Nem and 41.6% in Tomnob Thmey. Depending on their availability in the nearby forests, NTFPs had different levels of importance in each village, were collected during different months, and sold at different prices. The information gathered suggested that effective management of NTFPs in MCF has led to improved resource conservation, mostly due to the continued cooperation between stakeholders Venerable Bun Saluth (Head of MFC), local communities and NGOs in protecting the forest.

CITATION: Meas C. (2015) Livelihoods in the Monks' Community Forest, Oddar Meanchey, Cambodia. *Cambodian Journal of Natural History*, **2015**, 190.

Assessment of **fi**sh monitoring methods in the 3S rivers system, Cambodia

MEN Sophatry

មូលន័យសង្ខេប

ទន្លេមេគង្គគឺជាទន្លេដែលវែងជាងគេលំដាប់ទី១២នៅលើពិភពលោកដែលផ្តត់ផ្តង់ត្រីសម្រាប់ប្រជាជនរាប់លាននាក់ ហើយមានទីជំរកធំទូលាយផ្សេងៗជាច្រើនដែលមានលក្ខណៈអចិន្ត្រៃយ៍និងតាមរដូវកាល។ ទន្លេសេសាន ស្រែពក និងសេកុង គឺជាដៃទន្លេនៃទន្លេមេគង្គដែលបង្កើតជាទំរង់ប្រព័ន្ធ ៣ទន្លេ នៃភាគល្អសានប្រទេសកម្ពុជាដែលនៅរយៈពេលប៉ុន្មានឆ្នាំចុងក្រោយនេះផលនេសាទត្រីមានការថយចុះជាលំដាប់ដោយសារការប្រើប្រាស់ឧបករណ៍នេសាទខុសច្បាប់ (ឧទាហរណ៍ ៖ ការគប់គ្រាប់បែក និងការប្រើប្រាស់ឧបករណ៍ឆក់ត្រីខុសច្បាប់) ។ ការត្រួតពិនិត្យគឺជាជំហានដំបូងដើម្បីទប់ស្កាត់ការថយចុះផលត្រី អោយនៅអប្បរិមាដោយការកត់ត្រាសមាសភាពប្រភេទត្រី និងចំនួនត្រី។ ការសិក្សានេះ គឺប្រៀបធៀបប្រសិទ្ធិភាពនៃការត្រួតពិនិត្យនៃស្តង់ដារបស់មង(ប្រើប្រាស់មងមានក្រលា ៦ប្រភេទទំហំផ្សេងៗគ្នា ពី ១ ទៅ ៥ ហ៊ុន) និង មងក្រឡាចម្រុះ នៅរដូវពីរគឺរដូវ ប្រាំងនិងរដូវវស្សានៅទីតាំង៦កន្លែងនៅតាមទន្លេទាំងបី។ វិធីសាស្ត្រប៉ាវ៉ាម៉ែត្រចម្រុះ(Multivariate)(metaMDS, SIMPER និង PERMANOVA) បង្ហាញពីភាពខុសគ្នានៃស្ថិតិដោយបង្ហាញពីភាពខុសគ្នាតិចតួចរវាងប្រភេទត្រីដែលចាប់បាននៅទន្លេ (R^2 = 0.077, P < 0.01) រវាងរដូវ(R^2 = 0.036, P < 0.01) និងវិធីសាស្ត្រក្នុងការនេសាទផ្សេងៗគ្នា(R^2 = 0.10, P < 0.01)។ លទ្ធផលទាំងនេះបង្ហាញអោយឃើញថាការត្រួតពិនិត្យត្រីគឺជាការសម្រេចបានដ៏ល្អបំផុតជាមួយហ្មឺងវិធីសាស្ត្រសមរម្យមួយ។ បណ្តាញទន្លេ ៣ សំបូរទៅធនធានជីវៈចម្រុះខ្ពស់ រួមមានពូកដែលបម្លាស់ទី និងប្រភេទដែលកំពុងរងគ្រោះ ដូច្នេះហើយទន្លេទាំងនេះ ត្រូវតែការពារពីការប្រើប្រាស់វិធីសាស្ត្រខុសច្បាប់ផ្សេងៗ។

Abstract

The Mekong River is the 12th longest river in the world, provides fish to millions of people, and has a wide range of permanent and seasonal habitats. The Sesan, Srepok and Sekong rivers are tributaries of the Mekong that form the "3S rivers" of Northeast Cambodia, where in the last few years fish catch has believed to have been declining due to the use of illegal fishing methods (e.g. explosives and electro-fishing). Monitoring is the first step to minimise fish decline by detecting changes in fish species composition and abundance. This study compared the effectiveness for monitoring purposes of standard gill nets (contiguous panels with six mesh sizes between 1 and 5 cm) and multiple nets (separate panels), during the dry and rainy season in six study sites on the 3S rivers. Multivariate methods (metaMDS, SIMPER and PERMANOVA) showed statistically significant by only minor differences in fish species caught in each river (R^2 = 0.077, p < 0.01), between seasons (R^2 = 0.036, p < 0.01) and using either method (R^2 = 0.10, p < 0.01). These results indicate fish monitoring is best accomplished with a suite of methods. The 3S rivers have high biodiversity, including migratory and endangered species, and should therefore be protected from illegal practices.

CITATION: Men S. (2015) Assessment of fish monitoring methods in the 3S rivers system, Cambodia. *Cambodian Journal of Natural History*, **2015**, 191.

Ecology and economic importance of resin trees in the Monks' Community Forest, Oddar Meanchey Province, Northwest Cambodia

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មូលន័យសង្ខេប

ព្រៃសហគមន៍សង្ឃរុក្ខាវ័ន្តស្ថិតនៅក្នុងខេត្តឧត្តរមានជ័យ គ្របដណ្តប់លើផ្ទៃដី ១៨៦២១ ហិចតា គឺជាព្រៃសហគមន៍ធំបំផុតក្នុងប្រទេសកម្ពុជាដែលមានកម្មវិធីការផ្តួចផ្តើម REDD+ (Reduced Emissions from Deforestation and Degradation)។ អនុផលព្រៃឈើរួមមាន ជ័រទឹក និង ជ័រចុង មានសារៈសំខាន់ចំពោះការចិញ្ចឹមជីវិតរបស់ប្រជាសហគមន៍។ គោលបំណងរបស់គម្រោងសិក្សានេះ ដើម្បីវាយតម្លៃអេកូឡូស៊ី និង សារៈសំខាន់នៃដើមឈើផ្តល់ជ័រក្នុងព្រៃសហគមន៍សង្ឃរុក្ខាវ័ន្ត រួមមាន (a) របាយ និង ជម្រកនៃដើមឈើផ្តល់ជ័រ ត្រូវបានវាយតម្លៃតាមរយៈការសិក្សាពីជីវសាស្ត្ររបស់ក្នុងប្លង់សិក្សាគម្រូចំនួន ៦០។ (b) សារៈសំខាន់នៃដើមឈើផ្តល់ជ័រចំពោះការចិញ្ចឹមជីវិតរបស់ប្រជាសហគមន៍ និង (c) ប្រព័ន្ធគ្រប់គ្រងដើមឈើផ្តល់ជ័រ ដែលត្រូវបានវាយតម្លៃតាមរយៈការសម្ភាសប្រជាជនចំនួន ៥០ គ្រួសារ ក្នុងភូមិចំនួនបួន។ ទំហំគ្រួសារ ប្រាក់ចំណូល និង ប្រាក់ចំនាយ មានការប្រែប្រួលយ៉ាងខ្លាំងក្នុងភូមិទាំងបួន (NMDS: R^2 = 0.155; P = 0.02; R^2 = 0.635; P < 0.01; R^2 = 0.565; P < 0.01)។ សកម្មភាពចំនួន ១០ (អនុផលព្រៃឈើចំនួន ៤ ប្រភេទ) ក្នុងការបង្កើតប្រាក់ចំណូលមានកម្រិតប្រែប្រួលក្នុងចំនោមភូមិទាំងបួន។ ការដុតយកជ័របង្កើតប្រាក់ចំណូលជាមធ្យម 500 ដុល្លាសហរដ្ឋអាមេរិចក្នុងមួយឆ្នាំ និង មានសារៈសំខាន់ខ្លាំងចំពោះប្រជាជនក្នុងភូមិថ្មី និង ភូមិទំនប់ថ្មី។ រុក្ខជាតិជ័រ ៤ ប្រភេទត្រូវបានដុតយកជ័រៈ ជ័រទឹក *Dipterocarpus alatus* Roxb. និង *D. intricatus* Dyer ចំណែកជ័រចុង *Shorea obtusa* Wall. និង *S. siamensis* Miq.។ តាមស្ថិតិវិភាគរុក្ខជាតិទាំងនេះដុះក្នុងជម្រកខុសៗគ្នា (R^2 = 0.11; P = 0.04)។ ប្រជាសហគមន៍បង្ហាញថាពួកគាត់មានឆន្ទៈក្នុងការចូលរួមបន្តទៀតក្នុងការគ្រប់គ្រងព្រៃសហគមន៍សង្ឃរុក្ខាវ័ន្ត ដើម្បីការពារព្រៃឈើ និង ធានានិរន្តរភាពនៃអនុផលព្រៃឈើ។

Abstract

The Monks' Community Forest (MCF) in Oddar Meanchey Province, covering 18,621 ha, is the largest area in the country within the REDD+ (Reduced Emissions from Deforestation and Degradation) initiative in Cambodia. Non-timber forest products (NFTPs), including liquid and solid resin, are essential to local community livelihoods. The aims of this project were to evaluate the ecology and importance of resin trees in MCF including: (a) the distribution and habitat of resin trees, assessed with a biological survey on 60 plots; (b) the importance of resin trees for local community livelihoods; and (c) resin tree management systems, evaluated by interviewing 50 families in four villages. Family size, income and expenditure varied significantly among the four villages (NMDS: R^2 = 0.155; p = 0.02; R^2 = 0.635; p < 0.01; R^2 = 0.565; p < 0.01 respectively). Ten activities (four NFTPs) varied in their levels of income generated among the villages. Resin tapping generated, on average, $500 per year, and was particularly important in Thmey and Tomnum Thmey. Four species were tapped: *Dipterocarpus alatus* Roxb. and *D. intricatus* Dyer for liquid resin and *Shorea obtusa* Wall. and *S. siamensis* Miq. for solid resin. These trees grow in statistically significantly different habitats (R^2 = 0.11; p = 0.04). The local communities indicated they were willing to become more involved in MCF management to protect the forest and ensure the sustainability of NFTPs.

CITATION: Meng N. (2015) Ecology and economic importance of resin trees in the Monks' Community Forest, Oddar Meanchey Province, Northwest Cambodia. *Cambodian Journal of Natural History*, **2015**, 192.

Socio-economic implications of proposed no-take zones in Koh Rong and Koh Rong Sanloem Archipelago, Cambodia

ON Chanthy

មូលន័យសង្ខេប

ធនធានសមុទ្រនៅជុំវិញប្រជុំកោះរុងត្រូវបានប្រើប្រាស់ដោយពុំមាននិរន្តរភាព និងកំពុងមានការបំផ្លាញ។ ការបង្កើតឡើងនូវតំបន់គ្រប់គ្រងជលផលសមុទ្រ (MFMA) ត្រូវបានស្នើរបង្កើតដើម្បីធ្វើការអភិរក្សជីវចម្រុះសមុទ្រ និរន្តរភាពនៃការនេសាទ ព្រមទាំងចូលរួមកាត់បន្ថយភាពក្រីក្រ។ តំបន់គ្រប់គ្រងជលផលសមុទ្រមានក្រលាផ្ទៃប្រមាណ ៣៤០គីឡូម៉ែត្រការ៉េ ដែលមានចំងាយ ៥គីឡូម៉ែត្រជុំវិញកោះ ព្រមទាំងមានតំបន់អភិរក្សចំនួន ១១កន្លែងផ្សេងគ្នា (តំបន់គ្មានការនេសាទ)។ ភូមិចំនួនបួនដែលស្ថិតនៅក្នុងតំបន់ដែលត្រូវបានស្នើរជាតំបន់ការពារជលផលសមុទ្រគឺជាភូមិដែលមានប្រជាជនពឹងផ្អែកលើការនេសាទ រួមមាន៖ ភូមិព្រែកស្វាយ ភូមិដើមក្លូវ ភូមិកោះរុងសន្លឹម និងភូមិសុខសាន្ត។ ការសិក្សានេះមានគោលបំណងដើម្បីស្វែងយល់អំពីរបៀបនៃការប្រើប្រាស់ធនធានសមុទ្ររបស់សហគមន៍មូលដ្ឋាន ព្រមទាំងការយល់ឃើញរបស់ពួកគាត់អំពីផលប៉ះពាល់ដល់ផ្នែកសេដ្ឋកិច្ចសង្គមពីការលើកឡើងនៃតំបន់អភិរក្សនេះឡើង ដែលអាចឈានទៅរកការសន្និដ្ឋានរួមមួយ ថាតើពួកគាត់នឹងគាំទ្រ ឬក៏បដិសេធទៅលើការបង្កើតតំបន់អភិរក្សនេះឡើង។ វិធីសាស្ត្រដែលបានប្រើប្រាស់រួមមាន៖ (១) ការបង្កើតផែនទីដោយមានការចូលរួមពីក្រុមសហគមន៍ (២) ការសំភាសប្រជាជន និង (៣) ការវិភាគទៅលើទិន្នន័យអំពីត្រីរបស់អង្គការអភិរក្សថ្កាថ្ម (Coral Cay Conservation) ដើម្បីធ្វើការប្រៀបធៀបចំនួនត្រីដែលមានវត្តមាននៅខាងក្នុង និងខាងក្រៅនៃតំបន់ស្នើបង្កើតតំបន់អភិរក្សនីមួយៗ។ ការធ្វើផែនទីជាក្រុមនេះបានបង្ហាញថាទីតាំងចំនួន៥ ក្នុងចំណោមទីតាំងជាអាទិភាពចំនួន១៩នៃការប្រមូលផលនេសាទគឺស្ថិតនៅខាងក្នុងតំបន់ស្នើបង្កើតតំបន់អភិរក្ស។ រីងដង់ស៊ីតេរបស់ត្រីនៅខាងក្នុង និងខាងក្រៅនៃតំបន់ស្នើបង្កើតជាតំបន់អភិរក្សពុំមានភាពខុសគ្នានៅក្នុងការវិភាគស្ថិតិឡើយ លើកលែងនៅទីតាំងសិក្សាចំនួនមួយកន្លែងដែលមានដង់ស៊ីតេរបស់ត្រីសេក (parrotfish) ខ្ពស់ជាងគេ ក៏ប៉ុន្តែវាមិនមែនជាត្រីជាទីនិយមរបស់ប្រជានេសាទសហគមន៍ឡើយ។ ប្រជាជនភាគច្រើនគាំទ្រគំនិតក្នុងការបង្កើតតំបន់អភិរក្សនេះ ហើយពួកគាត់យល់ស្របថាតំបន់អភិរក្សនេះនិងធ្វើអោយមានការកើនឡើងនូវនានាភាពនៃអាហារសមុទ្រ ចំនួនត្រីដែលចាប់បាន និងកំណើនសេដ្ឋកិច្ច។ ពួកគាត់ក៏បានជឿជាក់ផងដែរថា តំបន់អភិរក្សនេះអាចធ្វើអោយមានការដុះលូតលាស់បន្ថែមទៀតនៃថ្កាថ្ម កោងកាង និងស្មៅសមុទ្រ ហើយប្រហែលជាអាចអោយពួកគាត់ទទួលបានចំនួលបន្ថែមទៀតពីវិស័យទេសចរណ៍។

Abstract

Around Koh Rong Archipelago of Cambodia, marine resources have been used unsustainably and are declining. The establishment of a Marine Fisheries Management Area (MFMA) has been proposed to conserve marine biodiversity, maintain sustainable fishing, and contribute to poverty reduction. The MFMA would extend 340 km^2 including 5 km buffer zones and 11 conservation (no-take) zones. Four villages inside the proposed MFMA depend on marine fisheries: Prek Svay, Deam Thkov, Koh Rong Sanloem, and Sok San. This study aimed to understand resource use patterns of local people, their perception of the socio-economic impacts of the proposed conservation zones, and whether they will support their establishment. Methods used were: (1) group participatory mapping, (2) individual interviews, and (3) analysis of fish data from Coral Cay Conservation to compare fish abundance inside and outside each proposed conservation zone. Group mapping revealed that five of their 19 priority harvesting sites were inside the proposed conservation zones. Fish densities inside and outside the conservation zones was not significantly different, except for the higher density of parrotfish in one area, which was not amongst those species preferred by local fishers. Most people supported the idea of establishing conservation zones and agreed that they would increase seafood availability, fish catch, and income. They also believed that conservation zones would enhance the growth of coral, mangrove and seagrass, which could bring additional income from tourism.

CITATION: On C. (2015) Socio-economic implications of proposed no-take zones in Koh Rong and Koh Rong Sanloem Archipelago, Cambodia. *Cambodian Journal of Natural History*, **2015**, 193.

The effectiveness of artificial reefs (brush parks and plastic flowers) as fish shelters in Community Fishery Refuges in Pursat and Battambang, Cambodia

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ត្រីគឺជាប្រភពអាហារដ៏សំខាន់មួយសម្រាប់ប្រជាជនរាប់លាននាក់នៅលើពិភពលោក ហើយដោយសារការកើនឡើងនៃចំនួនប្រជាជនពិភពលោកបានធ្វើអោយតម្រូវការត្រីកើនឡើង។ ប្រទេសកម្ពុជាបាននឹងកំពុងតែធ្វើការយ៉ាងសកម្មដើម្បីបង្កើនផលិតភាពត្រីរបស់ខ្លួន តាមរយៈការធ្វើអោយមានភាពប្រសើរឡើងនូវផលិតភាពត្រីនៅតាមវាលស្រែជាដើម។ ការសិក្សាស្រាវជ្រាវនេះបានធ្វើការប្រៀបធៀបទៅលើប្រភេទត្រី និងបរិមាណត្រីនៃប្រភេទនីមួយៗដែលចាប់បានពីប្រភេទសម្រាស់ខុសៗគ្នាចំនួនបីប្រភេទដែលធ្វើឡើងពីរុក្ខជាតិគឺ ស្នាយ (*Streblus asper*) អំពិលទឹក (*Pithecellobium dulce*) និងដង្កៀបក្តាម (*Antidesma ghaesmbilla*) ព្រមទាំងផ្កាផ្លាស្ទិច (Plastic flower) ដែលធ្វើឡើងពីដបទឹកសុទ្ធដែលប្រើប្រាស់រួច និងឫស្សី។ បំរែបម្រួលគុណភាពទឹកក៏ត្រូវបានធ្វើការតាមដានផងដែរ។ ជម្រកសិប្បនិម្មិត្តត្រូវបានដាក់នៅក្នុងស្រះជម្រកត្រីសហគមន៍ចំនួនបីគឺ ស្រះជម្រកត្រីបឹងកន្ទួត ស្រះជម្រកត្រីបឹងរំលិច (នៅខេត្តពោធ៍សាត់) និងនៅស្រះជម្រកត្រីអន្លូសដូង (ខេត្តបាត់ដំបង) ដែលនៅក្នុងបឹងនីមួយៗមានបីទីតាំងនៃជម្រកសិប្បនិម្មិត្តិ និងមានរយៈពេលមួយខែ (មិថុនា ដល់កក្តដា ឆ្នាំ២០១៤)។ ប្រភេទត្រី នានាភាព និងឯកត្តៈនៃប្រភេទនីមួយៗមានភាពខុសគ្នាក្នុងការវិភាគស្ថិតិរវាងបឹងនីមួយៗ (PERMANOVA: R^2=0.40, p<0.01) ក៏ប៉ុន្តែត្រីដែលចាប់បានពីជម្រកសិប្បនិម្មិត្តិនីមួយៗមានចំនួនប្រភេទ និងចំនួនឯកត្តៈដូចៗគ្នា (R^2= 0.02, p= 0.01)។ ជម្រកសិប្បនិម្មិត្តិទាំងបួនប្រភេទមិនមានផលប៉ះពាល់ដល់គុណភាពទឹកឡើយ។ លទ្ធផលដែលបានមកពីការសិក្សានេះបង្ហាញថា ការប្រើប្រាស់ដបផ្លាស្ទិចឡើងវិញដើម្បីធ្វើជាជម្រកសិប្បនិម្មិត្តិអាចធ្វើអោយមានភាពប្រសើរឡើងនូវជម្រកត្រីនៅក្នុងស្រះជម្រកត្រីសហគមន៍ ព្រមទាំង ជួយបង្កើនទិន្នផលត្រីផងដែរ។ លើសពីនេះវាជួយក្នុងការបញ្ចៀសការកាប់ដើមឈើ និងចូលរួមជួយសំអាតបរិស្ថានជុំវិញ។

Abstract

Fish are an essential food source for millions of people around the world and as human populations increase, so too does the demand for fish. Cambodia is working to increase its fish production including improving the efficiency of rice field fisheries. This study compared the variation on fish species, diversity and abundance between different types of artificial reefs: brush parks (*samrah* in Khmer language) made from three tree species (*Streblus asper*, *Pithecellobium dulce*, and *Antidesma ghaesembilla*) and plastic flowers made from recycled bottles and bamboo. Water quality changes were also monitored. The artificial reefs were deployed in three Community Fishery Refuges in Boeng Kantout and Boeng Romlech (Pursat Province), and Anlos Dong (Battambang Province), in three sites per pond for one month (June–July 2014). Fish species, diversity, and abundance varied significantly between the ponds (PERMANOVA: $R^2 = 0.40$, $p < 0.01$), but every artificial reef had similar fish species and abundance ($R^2 = 0.02$, $p = 0.52$). The brush parks did not affect water quality. Results from this study suggest that recycling plastic bottles as artificial reefs would improve Community Fishery Refuge habitats and increase fish yield, with the added benefits of avoiding cutting down trees and helping to clean up the surrounding areas at no cost.

CITATION: Sak S. (2015) The effectiveness of artificial reefs (brush parks and plastic flowers) as fish shelters in Community Fishery Refuges in Pursat and Battambang, Cambodia. *Cambodian Journal of Natural History*, **2015**, 194.

Home range and habitat use of yellow-cheeked crested gibbons *Nomascus gabriellae* in the Seima Protected Forest, eastern Cambodia

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យល់ដឹងពីតម្រូវការមជ្ឈដ្ឋានរបស់សត្វទោចគឺជាកត្តាចាំបាច់សម្រាប់ការអភិរក្សប្រកបដោយប្រសិទ្ធភាព ប៉ុន្តែចំណេះដឹងទាំងនោះនៅមានកម្រិតនូវឡើយចំពោះប្រភេទរងគ្រោះទោចថ្ពាល់លឿង (yellow-cheeked crested gibbon *Nomascus gabriellae*)។ ការស្រាវជ្រាវលើការប្រើប្រាស់លំនៅដ្ឋានគឺនៅខ្សត់ខ្សោយនូវឡើយនៅក្នុងព្រៃការពារសីមា ខេត្តមណ្ឌលគីរី នៃប្រទេសកម្ពុជា ដែលនេះជាតំបន់ទ្រទ្រង់ប៉ូពុយឡាស្យុងទោចថ្ពាល់លឿងធំជាងគេបំផុតក្នុងពិភពលោក។ ការសិក្សានេះមានគោលបំណង (i) ប៉ាន់ប្រមាណពីទំហំដែនជំរករបស់ក្រុមគោលដៅមួយ (ii) ប៉ាន់ប្រមាណ និងប្រៀបធៀបលក្ខណៈទីជំរកនៅក្នុងដែនជំរកទៅនឹងតំបន់ជាប់ៗដែលមិនមែនជាលំនៅដ្ឋាន (iii) ធ្វើអត្តសញ្ញាណប្រភេទរុក្ខជាតិដែលប្រើប្រាស់ដោយសត្វទោច។ ទីតាំង និងលក្ខណៈដើមឈើដែលទោចយំត្រូវបានកំណត់ត្រា។ លក្ខណៈលំនៅដ្ឋាននៅក្នុង និងក្រៅដែនជំរកត្រូវបានប្រមូលពី៩១ទីតាំង។ មានដែនជំរកចំនួនបីត្រូវបានកំណត់ផ្អែកលើកំណត់ត្រាពី៣២ទីតាំង ដោយប្រើ Kernel methods: ១៤.៩ ហិចតា (៥0% contour) ៣៨.៦ហិចតា(៨៥%) និង៥៧.៨ហិចតា(៨៥%)។ លំនៅដ្ឋានដែលជ្រើសរើសដោយទោចមានដើមឈើធំៗជាង (ដើមឈើដែលមាន DBH ធំជាងគេចំនួន ប្រាំ) និងមានគំរបព្រៃក្រាស់ជាង។ ក្រៅពីដើមឈើប្រាំពីរប្រភេទដែលទោចយំ ដើមស្រឡៅ (*Lagerstroemia calyculata*) គឺជាប្រភេទឈើដែល ត្រូវបានប្រើញឹកញាប់បំផុត (៨១។១៨%)។ ដែនជំរកកំណត់ដោយ contour ៨៥% (៣៨.៦ ហិចតា) អាចជាការប៉ាន់ប្រមាណដែលមានកម្រិតត្រឹមត្រូវខ្ពស់ ដោយវាគ្របដណ្តប់លើតំបន់ដែលទោចប្រើប្រាស់ញឹកញាប់ជាងគេ និងតំបន់ជាយជុំវិញដែលមានវត្តមានទោច។ ដើមឈើខ្ពស់ៗ គម្របព្រៃក្រាស់ និងដើមស្រឡៅធំៗប្រហែលជាទីជំរកចាំបាច់ ដូច្នេះលក្ខណៈទាំងនេះអាចជាតំរុយសម្រាប់ការពារតំបន់ពិសេសណាមួយ (ឧ. ការគម្រាមកំហែងពីការកែប្រែដី) សម្រាប់ការអភិរក្សទោចថ្ពាល់លឿងក្នុង តំបន់ព្រៃការពារសីមា។

Abstract

Understanding the habitat requirements of gibbons is critical for their effective conservation, but there has been limited information on the Endangered yellow-cheeked crested gibbon *Nomascus gabriellae*. Habitat use research was notably lacking in Seima Protection Forest, Mondulkiri Province, Cambodia, which may support the largest population of *N. gabriellae* globally. This study aimed to: (1) estimate the home range size of one semi-habituated focal group; (2) assess and compare habitat characteristics within their home range to the adjacent, non-home range forest area; and (3) identify the tree species used by the gibbons. Point locations and characteristics of calling trees used were recorded. Habitat characteristics inside and outside the home range were assessed on 91 plots. Three home range size estimates emerged from 32 locality records using Kernel methods: 14.9 hectares (50% contour), 38.6 hectares (85%), and 57.8 hectares (95%). The habitat selected by the gibbons had significantly larger trees (DBH of the five largest trees) and a denser canopy cover. Out of seven calling-tree species, *Lagerstroemia calyculata* was the most frequently used (41.18%). The 85% contour (38.6 hectares) was considered the most accurate home range estimate, including the most frequently used areas and regularly observed outlier locations. Tall emergent trees, a dense canopy and large *L. calyculata* trees might be basic habitat requirements, and therefore could be indicators of areas to be especially protected (e.g. from land conversion threats) for *N. grabriellae* conservation in the Seima Protection Forest.

CITATION: Sok P. (2015) Home range and habitat use of yellow-cheeked crested gibbons *Nomascus gabriellae* in the Seima Protected Forest, eastern Cambodia. *Cambodian Journal of Natural History*, **2015**, 195.

Seasonal diversity of Monogononta rotifers in four rivers in northeastern Cambodia

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រ៉ូទីហ្វ៊ែរ ជាសត្វឥតឆ្អឹងកងទឹកតូចៗ ដែលមាននាទីសំខាន់ក្នុងប្រព័ន្ធអេកូឡូស៊ីទឹកសាប។ រ៉ូទីហ្វ៊ែរភ្ជាប់ច្រវ៉ាក់អាហាររវាងអ្នកផលិតបឋម (ឧទាហរណ៍ សារាយបៃតង) និង អ្នកប្រើប្រាស់ (ឧទាហរណ៍ ត្រីស៊ីប្លង់តុងសត្វ) និង ជាប្រភពអាហារចំបងរបស់សារពាង្គកាយជាច្រើនទៀត។ ការសិក្សានេះបានប្រៀបធៀបភាពសម្បូរបែបនៃសហគមន៍រ៉ូទីហ្វ៊ែរក្នុងរដូវកាលពីរ និង នៅទន្លេចំនួនបួន: ទន្លេមេគង្គ ទន្លេសេសាន ទន្លេស្រែពក និង ទន្លេសេកុង ដែលស្ថិតនៅភាគល្អសាននៃប្រទេសកម្ពុជា។ សំណាកគម្រូទឹកត្រូវបានប្រមូលពី តំបន់សិក្សាចំនួន ២១ ទាំងនៅដើមរដូវប្រាំង (13–17 ធ្នូ 2012) និង នៅចុងរដូវប្រាំង (18–22 មេសា 2012)។ រ៉ូទីហ្វ៊ែរចំនួន ៦០ ប្រភេទ នៅក្នុង ២៣ ពូក និង ១៦ អំបូរ ត្រូវបានកំណត់ប្រភេទ: ៤២ ប្រភេទនៅក្នុងសំណាកទឹកប្រមូលនៅដើមរដូវប្រាំង និង ៥៦ ប្រភេទនៅក្នុងសំណាកទឹកប្រមូលនៅចុងរដូវប្រាំង។ អំបូរ Lecanidae មានភាពសម្បូរបែបបំផុត (២២ ប្រភេទ) អំបូរ Brachionidae ជាអំបូរមានភាពសម្បូរបែបបន្ទាប់ (១៤ ប្រភេទ)។ *Keratella cochlearis* (78.6% នៃសំណាកគម្រូ) *Lecane curvicornis* និង *Cephalodella gibba* (ទាំងពីរប្រភេទមាន 71.4%) ជាប្រភេទដែលមានចំនួនច្រើនជាងគេ។ តាមស្ថិតិវិភាគ ភាពសម្បូរបែបរ៉ូទីហ្វ៊ែរមានភាពខុសគ្នាខ្លាំងរវាងរដូវកាលទាំងពីរ (PERMANOVA: $R^2 = 0.25$, $P = 0.01$) និង ទទួលឥទ្ធិពលតិចតួចពីអន្តរកម្មរវាងរដូវកាល និង ជម្រក ($R^2 = 0.14$, $P = 0.01$)។ ស្ថិតិវិភាគលើភាពស្រដៀងគ្នា (SIMPER) បង្ហាញនូវការកើនឡើងនៃការចូលរួមរបស់ប្រភេទដែលមានឥទ្ធិពលបំផុត ដែលត្រូវបានប្រទះឃើញចំពោះអថេរទាំងឡាយក្នុងរដូវកាលទាំងពីរ *Keratella cochlearis* (0.24) *Brachionus angularis* (0.43) និង *Lecane curvicornis* (0.58)។ រចនាសម្ព័ន្ធសហគមន៍រ៉ូទីហ្វ៊ែរស្រដៀងគ្នានៅទន្លេទាំងអស់ក្នុងរដូវកាលទាំងពីរ និង អថេរបរិស្ថានទាំងឡាយ (pH សីតុណ្ហភាព និង ចរន្តទឹក)។

Abstract

Rotifers are minute aquatic invertebrates that play vital roles in freshwater ecosystems. They link the food chain between primary producers (e.g. algae) and consumers (e.g. zooplanktivorous fish) and are a major food source for many organisms. This study compared rotifer community diversity between two seasons and four rivers: the Mekong, Sesan, Srepok, and Sekong rivers in Northeast Cambodia. Water samples were collected from 21 sites both in the early dry season (13–17 December 2012) and late dry season (18–22 April 2012). Sixty species in 23 genera and 16 families were identified: 42 in the early dry season and 56 in the late dry season. The Lecanidae was the most diverse family (22 species), followed by Brachionidae (14). The commonest species were *Keratella cochlearis* (78.6% of samples), *Lecane curvicornis* and *Cephalodella gibba* (both 71.4%). The difference in rotifer diversity was statistically significant between seasons (PERMANOVA: $R^2 = 0.25$, $p = 0.01$) and was weakly influenced by the interaction between season and habitat ($R^2 = 0.14$, $p = 0.01$). Similarity percentage analysis (SIMPER) provided cumulative contributions of the most influential species, which accounted for most of the variation between seasons: *K. cochlearis* (0.24), *Brachionus angularis* (0.43) and *L. curvicornis* (0.58). Rotifer community structure was similar between all rivers in both seasons, as were environmental variables (pH, temperature, and conductivity).

CITATION: Thoung B. (2015) Seasonal diversity of Monogononta rotifers in four rivers in northeastern Cambodia. *Cambodian Journal of Natural History*, **2015**, 196.

Effect of sedimentation on coral reef health around Koh Rong Sanloem, Cambodia

YIM Raksmey

មូលន័យសង្ខេប

ថ្ពាថ្មគឺជាទីជម្រកក្នុងសមុទ្រដ៏មានសារៈសំខាន់នៅតំបន់ត្រូពិច។ បច្ចុប្បន្ននេះថ្ពាថ្មទាំងអស់នេះបាននិងកំពុងទទួលរងការគំរាមកំហែងពីសកម្មភាពមនុស្ស និងធម្មជាតិ។ នៅក្នុងនោះដែរ កករត្រូវបានគេជឿជាក់ថាគឺជាកត្តាចំបងដែលជះឥទ្ធិពលទៅដល់សុខភាពរបស់ថ្ពាថ្ម។ ដូច្នេះហើយការសិក្សានេះនិងធ្វើការគណនាអត្រាកំណររបស់កករ ព្រមទាំងទំនាក់ទំនងរបស់វាជាមួយនិងចំងាយរវាងទីតាំងសិក្សាទៅនិងមាត់អូរ និងលំនៅស្ថានរបស់ប្រជាជន។ លើសពីនេះសុខភាពរបស់ថ្ពាថ្មនៅជុំវិញកោះរុងនៃប្រទេសកម្ពុជាក៏ត្រូវបានសិក្សាផងដែរ។ អត្រាកំណរបស់កកត្រូវបានគណនាដោយប្រើប្រាស់ឧបករណ៍សម្រាប់ត្រងយកកករ។ សត្វឆ្អឹងកងមួយចំនួនក៏ត្រូវបានប្រើប្រាស់ដើម្បីធ្វើការចង្អុលបង្ហាញអំពីសុខភាពរបស់ថ្ពាថ្ម។ ទីតាំងសិក្សាសរុបចំនួន ៥២កន្លែងត្រូវបានសិក្សាស្រាវជ្រាវដោយទីតាំងនីមួយៗមានប្រវែង ៩៥ម៉ែត្រ និងសិក្សានៅពីរផ្នែកផ្សេងគ្នាគឺនៅជំរៅទឹកជ្រៅ (៦-១២ម៉ែត្រ) និងនៅជំរៅទឹករាក់ (២-៦ម៉ែត្រ)។ ការសិក្សាស្រាវជ្រាវនេះចាប់ផ្តើមពីខែកុម្ភៈ ដល់ខែឧសភា ឆ្នាំ២០១៤។ ទិន្នន័យថ្ពាថ្មរបស់អង្គការអភិរក្សថ្ពាថ្ម (Coral Cay Conservation) នៅឆ្នាំ២០១០ក៏ត្រូវបានបញ្ចូលនៅក្នុងការវិភាគទិន្នន័យនេះផងដែរ។ លទ្ធផលនៃការសិក្សានេះបានបង្ហាញថាអត្រាកំណកកករជាមធ្យមគឺ ០.២៨ក្រាមក្នុងមួយថ្ងៃ។ រីឯអត្រាកំណរកកររមានទំនាក់ទនងជាអវិជ្ជមានតិចតួចជាមួយនិងនានាភាពរបស់ថ្ពាថ្ម (R^2=-0.38, p =0.44) និងចំងាយពីលំនៅស្ថានរបស់ប្រជាជន (R^2=-0.566, p =0.24)។ មធ្យមភាគរបស់គម្របថ្ពាថ្ម (នៅចន្លោះឆ្នាំ២០១០-២០១៤) មាន២៣.៥៦ភាគរយ ដែលបង្ហាញពីការថយចុះពី ៥០ភាគរយនៅឆ្នាំ១៩៩៨ (Wilkinson ២០០០)។ ភាពខ្សត់ខ្សត់ខ្សោយនៃចំនួនឯកត្តៈ និងប្រភេទរបស់សត្វឆ្អឹងកងមួយចំនួនបានបង្ហាញថានៅទីតាំងសិក្សាប្រហែលជាទទួលនូវផលប៉ះពាល់ពីសកម្មភាពមនុស្ស។ ដូចនេះហើយ ការកើនឡើងនៃកម្រិតកកររធ្វើអោយមានផលអវិជ្ជមានទៅដល់សុខភាពរបស់ថ្ពាថ្មនៅជុំវិញកោះរុងសន្លឹម ហើយកត្តាផ្សេងៗទៀតដូចជា ដំណើរឡើងពណ៌សនៃថ្ពាថ្ម (Coral bleaching) និងការកើនឡើងសីតុណ្ហភាពនៅក្នុងទឹកក៏មានផលអាក្រក់ទៅលើសុខភាពរបស់ថ្ពាថ្មដែរ។

Abstract

Corals form the most important marine habitats in shallow tropical seas. Currently, coral reefs are threatened by anthropogenic and natural impacts, of which sedimentation is believed to be a major problem for coral reef health. This study assessed the rate of sedimentation, its relationship with the distance to the river mouth and to human settlements, and coral reef health around the island Koh Rong Sanloem, Cambodia. Sedimentation rate was measured using sediment traps. Target invertebrates were used as indicators of coral reef health. Fifty-two sites were surveyed along 95 m long, deep transects (6–12 m) and shallow transects (2–6 m), from February to May, 2014. Coral Cay Conservation (CCC) data on coral cover in the area from 2010 were also included in the analysis. Results showed that the mean sedimentation rate was 0.28 g^{d-1}. Sedimentation rates were weakly negatively correlated with hard coral diversity (R^2 = -0.38, p = 0.44) and distance to human settlements (R^2 = -0.566, p = 0.24). Mean hard coral cover (2010–2014) was 23.56%, having decreased from 50% in 1998 (Wilkinson, 2000). Target invertebrates were low in abundance and diversity, indicating that the sites might be under pressure from anthropogenic impacts. Thus, sediment accumulation has had a negative effect on coral reef health around Koh Rong Sanloem, but other factors such as coral bleaching events and increase in water temperature might also be at play.

CITATION: Yim R. (2015) Effect of sedimentation on coral reef health around Koh Rong Sanloem, Cambodia. *Cambodian Journal of Natural History*, **2015**, 197.

Recent literature from Cambodia

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

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

New species and taxonomic reviews

Bayarsaikhan, U. & Bae, Y.S. (2015) Three new species of *Stictane* Hampson, 1900 (Erebidae, Arctiinae) from Cambodia, with checklist of *Stictane*. *Zootaxa*, **3981**, 241–252.

A review of the genus *Stictane* in Cambodia, including systematic revisions and descriptions of three species new to science: *S. cambodiensis* sp. nov., *S. khmerensis* sp. nov. and *S. bokorensis* sp. nov. Author: uug228@yahoo.com

Cho, J.-L., Kry M. & Chhenh K. (2015) A new giant parabathynellid from Cambodia (Syncarida: Bathynellacea). *Journal of Crustacean Biology*, **35**, 559–569.

A new genus, *Kampucheabathynellan* gen. nov., is erected for a new species, *K. khaeiptouka* sp. nov., collected in the Mekong Basin of Cambodia. Illustrated descriptions of the new genus and the new species are provided. The new genus is distinguished from other representatives of the Parabathynellidae by a variety of morphological features. Author: joolae@korea.kr

Ith, S., Bumrungsri, S., Furey, N.M., Bates, P.J.J., Wonglapsuwan, M., Khan, F.A.A., Vu D.T., Soisook, P., Satasook, C. & Thomas, N.M. (2015) Taxonomic implications of geographical variation in *Rhinolophus affinis* (Chiroptera: Rhinolophidae) in mainland Southeast Asia. *Zoological studies*, **54**, 31.

Morphological, acoustic and genetic data suggest that at least three forms of the intermediate horseshoe bat *Rhinolophus affinis* occur in mainland Southeast Asia (including *R. a. macrurus* in Cambodia), two of which concur with previously recognised taxa and one which appears to be new to science. Author: pheaveng@gmail.com

Kosterin, O.E. (2015) *Risiophlebia guentheri* sp. nov. (Odonata, Libellulidae) from southeastern Indochina. *Zootaxa*, **3964**, 138–145.

A new and second species of dragonfly in the genus *Risiophlebia* is described from Mondulkiri Province. The new species is likely separated from its only congener by a 1,000 km gap in the range of the genus in Thailand and most of Cambodia. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2015) *Prodasineura hoffmanni* sp. nov. (Odonata, Platycnemididae, Disparoneurinae) from eastern Cambodia. *Zootaxa*, **4027,** 565–577.

A new species of dragonfly is described from the Annamese Mountains of eastern Cambodia: *Prodasineura hoffmanni* sp. nov. A female of *P. doisuthepensis* is also described and the following synonymy proposed: *P. fujianensis* Xu, 2006 = *P. huai* Zhou et Zhou, 2007, syn. n. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2015) Taxonomical notes on *Indolestes* Fraser, 1922 (Lestidae, Zygoptera). 1. *Indolestes gracilis expressior* ssp. nov. from eastern Cambodia. *Journal of the International Dragonfly Fund*, **81**, 1–11.

A new subspecies of dragonfly *Indolestes gracilis expressior* ssp. nov. is described from Mondulkiri Province. The new subspecies is thought to range over the plateau of eastern Cambodia and southern Laos, but is very rare. Author: kosterin@bionet.nsc.ru

Kosterin, O.E., Karube, H. & Futahashi, R. (2015) Two new subspecies of *Hemicordulia tenera* Lieftinck, 1930 (Corduliidae) from Cambodia and Thailand. *Journal of the International Dragonfly Fund*, **82**, 1–19.

Two new subspecies of dragonfly are described, including *Hemicordulia tenera vikhrevi* ssp. nov. from Koh Kong Province in Cambodia. Author: kosterin@bionet.nsc.ru

Kosterin, O.E. (2015) Taxonomic and faunal notes on *Macromia* Rambur, 1842 from Cambodia (Odonata: Macromiidae). *Odonatologica*, **44**, 117–151.

This study reviews five species of *Macromia* dragonflies recently collected in Cambodia, including one, *M. aculeata*, not collected since its original description in 1927. Diagnostic characters, variation and the taxonomy of related species are discussed. Author: kosterin@bionet.nsc.ru

Leblanc, L., San Jose, M. & Rubinoff, D. (2015) Description of a new species and new country distribution records of *Bactrocera*. *Zootaxa*, **4012**, 593–600.

The authors describe a new species of fly from Koh Kong Province (*Batrocera kohkongiae* sp. nov.) and document new records for Cambodia of 22 species within the genus *Bactrocera*. Author: leblanc@hawaii.edu

Lis, J.A., Lis, B., Ziaja, D.J. & Nakatani, Y. (2014) Towards resolving a problem of the identity of the *Aethus* species (Hemiptera: Heteroptera: Cydnidae) occurring in Cambodia. *Zootaxa*, **3895**, 446–450.

It has been unclear to date which species of the bug genus *Aethus* occurs in Cambodia. This paper documents the occurrence of *A. pseudindicus* in Siem Reap, as opposed to *A. indicus* which was reported from the same area 50 years ago. Author: cydnus@uni.opole.pl

McHone, E., Won, H. & Livshultz, T. (2015) *Sarcolobus cambogensis* (Marsdenieae, Asclepiadoideae, Apocynaceae): A new rheophytic shrub from Cambodia. *Phytotaxa*, **197**, 45–53.

The authors describe a new plant from the Central Cardamom Mountains of Koh Kong Province: *Sarcolobus cambogensis* sp. nov. Specimens of the new species differ from the related *S. luzonensis* and *S. borneensis* in having broader leaves, larger corona, and wider caudicles. Author: tl534@drexel.edu

Neang T., Hartmann, T., Hun S., Souter, N.J. & Furey, N.M. (2014) A new species of wolf snake (Colubridae: *Lycodon* Fitzinger, 1826) from Phnom Samkos Wildlife Sanctuary, Cardamom Mountains, Southwest Cambodia. *Zootaxa*, **3814**, 68–80.

A new species of wolfsnake *Lycodon zoosvictoriae* sp. nov. is described. Due to the submontane nature of the type locality, the new species may be endemic to the Cardamom Mountains (Southwest Cambodia and probably Southeast Thailand). Author: thy.neang@fauna-flora.org

Neang T., Morawska, D. & Nut M. (2015) First record of *Lygosoma angeli* (Smith, 1937) (Squamata: Scincidae) from eastern Cambodia. *Herpetology Notes*, **8**, 321–322.

The first record of the lizard *Lygosoma angeli* is documented from Seima Protected Forest in Mondulkiri Province. The species is also predicted to occur in the Cardamom Mountains of Southwest Cambodia. Author: thy.neang@fauna-flora.org

Pham H.-T., Lee, Y.J. & Constant, J. (2015) Cicada genus *Pomponia* Stål, 1866 (Hemiptera: Cicadidae) from Vietnam and Cambodia, with a new species, a new record,and a key to the species. *Zootaxa*, **3925**, 562–572.

The authors review taxa within the genus *Pomponia* from Vietnam and Cambodia, adding one new record to the Cambodian fauna (*P. backanensis*) and providing a key to the seven species currently known from the two countries. Author: phamthai@vnmn.vast.vn

Peeters, C. & De Greef, S. (2015) Predation on large millipedes and self-assembling chains in *Leptogenys* ants from Cambodia. *Insectes Sociaux*, **62**, 471–477.

Various ants can link their bodies in chains or other structures, a striking example of cooperation. The authors document chain behaviour in an undescribed *Leptogenys* species, which facilitates the collective transport of large millipedes. Author: christian.peeters@upmc.fr

Qi, M.-J. & Bae, Y.-S. (2015) New genus of Phycitinae (Lepidoptera: Pyralidae) with description of a new species from Cambodia. *Entomological Research*, **45**, 158–161.

Samkosia gen. nov. and its type species, *Samkosia cambodiensis* sp. nov., are described and illustrated from Cambodia. A new combination *S. rufimaculella* (Yamanaka, 1993) comb. n. is proposed. Author: baeys@inu.ac.kr

Qi, M.-J. & Bae, Y.-S. (2015) Taxonomic study of the genus *Epicrocis* Zeller (Lepidoptera, Pyralidae, Phycitinae) in Cambodia, with description of a new species. *Journal of Asia-Pacific Entomology*, **18**, 577–581.

The authors revise species in the genus from Cambodia. Among these, *E. pramaoyensis* sp. nov., is described as new to science, and *E. hilarella* (Ragonot, 1888) and *E. oegnusalis* (Walker, 1859) are documented as new records for the country. A key to the Cambodian species of the *Epicrocis* genus is also provided. Author: qimujie@163.com

Shi, H., Qian, Z., Wang, X., Liu, D., Zhang, Y., Ye, X., Harada, H. & Wang, L. (2015) The genus *Letrouitia* (Letrouitiaceae: Lichenized Ascomycota) new to Cambodia. *Mycobiology*, **43**, 163–165.

The fungus genus *Letrouitia* is newly recorded for Cambodia, including four species: *L. domingensis*, *L. leprolytoides*, *L. sayeri* and *L. subvulpina*. Brief descriptions and illustrations are provided. Author: wanglisong@kib.ac.cn

Seong-Hyun, C., Jung-Hoon, L., Hyosig, W., Chhang P. & Young-Dong, K.(2015) *Sonerila bokorense* (Melastomataceae), a new species from Cambodia. *Phytotaxa*, **222**, 295–299.

The authors describe a new plant species from Bokor National Park, Kampot Province: *Sonerila bokorense* sp. nov. The new species is distinguishable from the related *S. calophylla* by several features. Author: dricetea@hallym.ac.kr

Tagane, S., Toyama, H., Chhang P., Nagamasu, H. & Yahara, T. (2015) Flora of Bokor National Park, Cambodia I: thirteen new species and one change in status. *Acta Phytotaxonomica et Geobotanica*, **66**, 95–135.

Paper not seen. Author: stagane29@gmail.com

Biodiversity inventories

Goes, F. (2011) *Cambodia Quarterly Bird Reports, January–March 2014.* Http://www.samveasna.org/userfiles/recent_bird_reports_2014a.pdf [accessed 9 October 2015].

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

Hayes, B., Eang H.K., Neang T., Furey, N., Chhin S., Holden, J., Hun S., Phen S., La P. & Simpson, V. (2015) *Biodiversity Assessment of Prey Lang: Kratie, Kampong Thom, Stung Treng and Preah Vihear Provinces*. Forestry Administration, USAID, Winrock International and Conservation International, Cambodia.

The findings of vegetation, mammal (including bats), bird, amphibian and reptile surveys conducted the Prey Lang landscape between 2014 and 2015. Prey Lang is one of largest remaining forest areas outside the official protected area system in Cambodia and ranks as one of the more significant areas of lowland evergreen forest in the Indo-Burma Region. Online: https://www.winrock.org/sites/default/files/publications/attachments/Final%20English%20PL%20Biodiversity%20Assessment%20Report.pdf

Likhitrakarn, N., Golovatch, S.I. & Panha P. (2015) A checklist of the millipedes (Diplopoda) of Cambodia. *Zootaxa*, **3973**, 175–84.

Only 19 species of millipede are currently documented for Cambodia. This figure lags behind the known diversity of neighbouring and other Asian countries even at the ordinal level, demonstrating that more collecting effort is required to amass a representative body of material for inventory studies. Author: sgolovatch@yandex.ru

Wiesner, J. (2014) Records of tiger beetles collected in Cambodia III (Coleoptera, Cicindelidae) (120th contribution towards the knowledge of Cicindelidae). *Lambillionea CXIV*, **2**, 144–146.

Presents new records of tiger beetles for Kampong Speu Province and a distributional table of all Cambodian species in several Cambodian provinces and adjacent countries. Author: uergen.wiesner@wolfsburg.de

Vikhrev, N.E. (2014) Taxonomic notes on *Lispe* (Diptera, Muscidae). Parts 1–9. *Amurian Zoological Journal*, **7**, 147–170.

A detailed taxonomic review of the dipteran genus *Lispe*, including records of three species from Cambodia: *L. leucospila*, *L. bivittata* and *L. kowarzi pallitarsis.* Author: nikita6510@ya.ru

Species ecology and status

Gray, T.N.E., McShea, W.J., Koehncke, A., Prum S. & Wright, M. (2015) Artificial deepening of seasonal waterholes in eastern Cambodia: impact on water retention and use by large ungulates and water birds. *Journal of Threatened Taxa*, **7**, 7189–7195.

An account of an experimental study that deepened six waterholes (trapaengs) in Mondulkiri Province. Following modification, five of the six waterholes held water at the end of the subsequent dry season (April) and camera trapping revealed the presence of 23 mammal species, including two Critically Endangered species (banteng *Bos javanicus* and Eld's deer *Rucervus eldii*), and two Critically Endangered birds (giant ibis *Thaumatibis gigantea* and white-shouldered ibis *Pseudibis davisoni*).

van Zalinge, R. & Triet T. (2014) *Census of Non-Breeding Sarus Cranes in Cambodia and Vietnam, 2014: Summary Report*. Research Institute for the Environment and Livelihoods, Charles Darwin University and International Crane Foundation—Southeast Asia Program.

Report not seen. Author: robertvanzalinge@yahoo.com

Guides and monographs

Leti, M., Hul S., Fouché, J., Cheng S.K. & David, B. (2013) *Flore Photographique du Cambodge*. Éditions Privat, Toulouse, France.

Detailed descriptions and over 2000 photographs in the wild of 524 plant species in Cambodia, including two new species to science and six new records for the country.

Eames, J.C.E. (2014) *Western Siem Pang: Hidden Natural Wonder of Cambodia*. Privately published, Condé-sur-Noireau, France.

A lavishly illustrated account of the wildlife, landscapes and people of a remote district in northern Cambodia that supports some rare and little known birds and mammals. Creates a compelling case for conservation of the area. Author: jonathan.eames@birdlife.org

Save Cambodia's Wildlife (2014) *Atlas of Cambodia: Maps on Socio-economic Development and Environment*. Save Cambodia's Wildlife, Phnom Penh, Cambodia.

A revised, updated and large format edition of the *2006 Atlas of Cambodia: National Poverty and Environment Maps*. The atlas contains a wealth of maps, graphs and text on various aspects of its physical and human geography, forests, fish resources, biodiversity, agriculture and other sectors.

Coasts, wetlands and aquatic resources

Bond, N. (2015) *Examining adaptations to changing fish populations of Tonle Sap Lake in Cambodia: a case study of Pursat Province, Cambodia*. MA thesis, University of Guelph, Canada.

This study explores livelihoods in the Pursat Province portion of Tonle Sap Lake and the extent to which fishers perceive their livelihoods are changing. Results suggest results suggest that: (i) fish catches are broadly perceived to have remained stable but fish size and species diversity have decreased; (ii) most fishing households are resistant to changing their livelihood strategies and are 'locked' into fishing.

Hoy S.R. (2014) Assessment of sand extraction and use in coastal fishery communities of Cambodia. *Journal of the Marine Biological Association of India*, **56**, 96–102.

Coastal resources need to be maintained to support the well-being of coastal resource-dependent communities and a balanced suite of ecosystem goods and services. However, a variety of infrastructure projects, sand extraction and other activities have negatively affected the coastal environment. This article explores these issues and documents a number of contributing factors. Author: reasey@mail.com

Loeung K., Schmidt-Vogt, D. & Shivakoti, G.P. (2015) Economic value of wild aquatic resources in the Ang Trapeang Thmor Sarus Crane Reserve, North-western Cambodia. *Wetlands Ecology and Management*, **23**, 467–480.

Wild aquatic resources are important for the livelihoods of rural communities in the Greater Mekong. This study assesses the economic value of wild aquatic animals and plants to the annual incomes of households in Ang Trapaeng Thmor. The authors conclude that families that fish full time are more dependent on aquatic resources than non-fishing households or households that fish part-time. Author: schmidt-vogt@mail.kib.ac.cn

Mak S. (2015) The governance of wetlands in the Tonle Sap Lake, Cambodia. *Journal of Environmental Science and Engineering B*, **4**, 331–346.

Although much research has been done on 'wise use' and its utility in wetland management, its application in the Tonle Sap Lake remains challenged. This study employs a literature review and case-study to analyse wetland governance in the Tonle Sap Lake and the implications for human well-being and ecosystem services. Author: mak.sithirith@rupp.edu.kh

Nagumo, N., Sugai, T. & Kubo, S. (2015) Fluvial geomorphology and characteristics of modern channel bars in the Lower Stung Sen River, Cambodia. *Geographical Review of Japan Series B*, **87**, 115–121.

Tributaries of the Tonle Sap Lake are strongly influenced by seasonal changes in water levels in the lake and discharge of the Mekong River. Using aerial photography, satellite imagery and bankside surveys, this study documents the fluvial geomorphology of the Stung Sen, a tributary of Tonle Sap Lake. The riverine environment differs greatly from that of the floodplain, where sediment is deposited from suspension during periods of inundation. Author: n-nagumo55@pwri.go.jp

Sovann C., Irvine, K.N. Suthipong, S., Kok S. & Chea E. (2015) Dynamic modeling to assess natural wetlands treatment of wastewater in Phnom Penh, Cambodia: towards an eco-city planning tool. *British Journal of Environment and Climate Change*, **5**, 104–115.

The authors modelled a natural wastewater treatment wetland in Phnom Penh with a view to developing a tool for evaluating future urban development or climate change scenarios. They conclude that their method is a useful planning tool and that the natural wetland treatment system in Phnom Penh is effective and fits well with the concepts of green infrastructure and eco-cities. Author: chansopheaktra@gmail.com

Sor R., Meas S., Wong, K.K.Y., Min M. & Segers, H. (2015) Diversity of Monogononta rotifer species among standing waterbodies in northern Cambodia. *Journal of Limnology*, **74**, 192–204.

The authors report the presence and abundance of 107 rotifer species in the upper part of the Cambodian Mekong River Basin, including 25 new species records for the country. No significant difference was found in species richness between habitats or seasons at regional and local scales. Much of the high rotifer diversity found at sampling sites could not be attributed to "nestedness" or to the environmental variables measured and each habitat type and season supported substantially different rotifer communities. The number of rotifer species recorded from Cambodia has now reached 306, although the true number present is estimated to be nearer 400. Author: sorsim.ratha@gmail.com

Forests and forest resources

Anonymous (2015) *Conversion Timber, Forest Monitoring, and Land-Use Governance in Cambodia*. Forest Trends Report Series, Forest Trends, London, UK.

This study presents an overview of national patterns and practices of forest land clearance during the 2012–2013 dry season, and maps and describes the geography of forest land allocations in relation to major forest formations, land concessions, protected areas, the national forest estate, and reported concession ownership. It identifies many serious problems in the management of

Cambodia's forests, and criticises the economic land concessions as "an unlawful instrument to rapidly exhaust the remaining timber resources of the country". The report sets out a number of recommendations, and considers both FLEGT and REDD+ as having potential to help improve the current situation. Http://forest-trends.org/releases/uploads/Cambodia%20Concessions%20Report%20small%20size.pdf

Chheng K., Mizoue, N., Khorn S., Kao, D. & Sasaki, N. (2015) Tree-based approach to evaluate size dependence of residual tree damage caused by selective logging: case study in tropical semi-evergreen forests of Cambodia. *Forest Ecology and Management*, doi: 10.1016/j.foreco.2015.06.031

Damage to the trees left behind after logging is fundamental to evaluating the sustainability of selective logging in terms of timber production, carbon retention and biodiversity conservation. The authors quantified the relationship between such damage and the sizes of the residual and felled trees, and conclude that taking tree size into account would increase the accuracy of logging damage estimation and aid comparisons across different types of tropical forests. Author: mizouenn@gmail.com

Clements, T., Seng S., Wilkie, D.S. & Milner-Gulland, E.J. (2014) Impacts of protected areas on local livelihoods in Cambodia. *World Development*, **64**, 125–134.

A study of the effect of protected areas on poverty and livelihoods in Cambodia. Compared with controls, no evidence was found that protected areas exacerbated local poverty or reduced agricultural harvests. Households bordering protected areas were better off due to greater access to markets and services, whereas non-timber forest product collectors inside the protected areas were better off than controls and had greater rice harvests because they had more secure access to land and forest resources. Author: tclements@wcs.org

Davis, K.F., Yu, K., Rulli, M.C., Pichdara, L. & D'Odorico, P. (2015) Accelerated deforestation driven by large-scale land acquisitions in Cambodia. *Nature Geoscience*, **8**, 772–775. doi:10.1038/ngeo2540

More than two million hectares have been leased as economic land concessions in Cambodia to date, sparking debate over the consequences for local communities and the environment. The authors combined official records on concession locations with a high-resolution data set on forest cover changes to quantify the contribution of land concessions to deforestation between 2000 and 2012. Nearly half of the area where concessions were granted between 2000 and 2012 had been forested in 2000, and annual rates of forest loss were 29–105% higher than comparable areas outside concessions. Most of the deforestation occurred after the contract date. Whether the investor was domestic or foreign had no effect on deforestation rates.

Hor S., Saizen, I., Tsutsumida, N., Watanabe, T. & Kobayashi, S. (2014) The impact of agricultural expansion on forest cover in Ratanakiri Province, Cambodia. *Journal of Agricultural Science*, **6**, 46–59.

Agricultural expansion has had a significant impact on forest cover in Ratanakiri Province. This study investigated the dynamics of landscape transformation using remote sensing data and ethnographic and qualitative research. Results indicate that three 'triggers' are actively changing local forest landscapes: (1) indigenous people moving from swidden farming to mono-cropping without external support and agricultural market information; (2) a chaotic property market created by migrants purchasing existing farms or forest lands from indigenous people via land brokers; and (3) introduction of land concessions by government via the 2001 Land Law, which allows agricultural cooperation to develop plantations. Author: hor.sanara.24s@st.kyoto-u.ac.jp

Kurashima, T., Matsuura, T., Miyamoto, A., Sano, M. & Chann S. (2015) Considering the practical rationality of experimental operation in developing countries: reality and challenges under a rigid community forestry system in Cambodia. *Forests*, **6**, 3087–3108.

Though conventional scientific forest management plans for community forestry (CF) have constraints, some developing countries continue to use rigid, complex and high-cost plans and regulations. The authors examine the development of a rigid CF system in Kampong Thom Province, review negative factors influencing the upland forested area, clarify unfavourable situations arising from these factors and discuss likely problems associated with the CF management system. They suggest development and funding of a functional network of CF management committees might be a practical solution to these issues, rather than the adoption of an entirely new, alternative system. Authors: kurashima @asafas.kyoto-u.ac.jp

Michinaka, T. Matsumoto, Miyamoto, M., Yokota, Y., Sokh H., Lao S., Tsukada, N., Matsurra, T. & Ma, V. (2015) Forecasting forest areas and carbon stocks in Cambodia based on socio-economic factors. *International Forestry Review*, **17**, 66–75.

Establishment of forest reference emission levels and/or forest reference levels is important for countries considering taking part in the REDD+ scheme under the UNFCCC, especially those experiencing corresponding economic development with land use changes. This study forecasts Cambodia's forest areas and forest carbon stocks from 2011 to 2018 for use in establishing forest reference emission levels in the country. Author: michinaka.t@affrc.go.jp

Møller, L.R. & Jacobsen, J.B. (2014) Benefits of interrelationships between climate change mitigation and adaptation: a case study of replanting mangrove forests in Cambodia. *Scandinavian Forest Economics*, **45**, 191.

This paper investigates the welfare benefits of climate change mitigation and adaptation using a case study of mangrove forest replanting in the coastal wetland areas of Peam Krasaob Wildlife Sanctuary. It concludes that this provides benefits in climate change mitigation and adaptation, and no extra investment is needed to identify such benefits. Online: http://curis.ku.dk/ws/files/132144549/Scandinavian_Forest_Economics_No_45.pdf

Toyama, H., Kajisa, T., Tagane, S., Mase, K., Chhang P., Samreth V., Ma, V., Sokh, H., Ichihashi, R., Onoda, Y., Mizoue, N. & Yahara, T. (2015) Effects of logging and recruitment on community phylogenetic structure in 32 permanent forest plots of Kampong Thom, Cambodia. *Philosophical Transactions B. Biological Sciences*, **370**, doi: 10.1098/rstb.2014.0008.

Ecological communities, including tropical rainforest, are rapidly changing due to disturbance from human activity, particularly illegal logging and clear-felling for agriculture. This study investigates the effect of tree logging, mortality and recruitment on phylogenetic community structure. Within such communities, logging decreased phylogenetic diversity, and increased overall phylogenetic clustering and terminal phylogenetic evenness. Between communities, logging increased phylogenetic similarity between evergreen and deciduous plots. Recruitment had opposite effects within and between communities. These patterns are attributed to environmental homogenization under logging. Author: htohy-scb@kyushu-u.org

Wallace, P. (2015) Forest, livelihoods and biodiversity: a case study from Phnom Kulen National Park, Cambodia. *Journal of the MSc in Primate Conservation*, *Canopy*, **15**, 4–7.

Habitat quality is declining due to overexploitation in Phnom Kulen National Park. This study assessed livelihood strategies and forest use through interviews and found that while local villagers do not rely heavily on natural resources for income, these are very important for household consumption nonetheless. Conflicts between humans and wildlife were also found in the form of crop raiding by pig-tailed macaques *Macaca leonina*. Author: pennyywallace@hotmail.com

Singh, M., Evans, D., Tan S.T. & Nin, C.S. (2015) Mapping and characterising selected canopy tree species at the Angkor World Heritage Site in Cambodia using aerial data. *PloS ONE*, doi: 10.1371/journal.pone.0121558

An assessment of several methods of aerial imagery analysis for the characterization of tree height and crown width. Author: ms2127@cam.ac.uk

Singh, M., Evans, D., Friess, D.A., Tan S.T. & Nin, C.S. (2015) Mapping above ground biomass in a tropical forest in Cambodia using canopy textures derived from Google Earth. *Remote Sensing*, **7**, 5057–5076.

The authors present a modelling framework for using very high-resolution aerial imagery to monitor above-ground biomass stocks in tropical forest. Their findings demonstrate that an array of texture-based techniques with Google Earth imagery can support the wider use of free imagery for low-cost, fine-resolution monitoring of forest parameters at the landscape scale. Author: ms2127@cam.ac.uk

Yem D., Top N. & Lic V. (2015) Rubber plantation development in Cambodia: a cost-benefit analysis. In *Cost-Benefit Studies of Natural Resource Management in Southeast Asia* (eds D. James & H.T. Francisco), pp. 137–156. Springer, Singapore.

This study focuses on several new policy instruments introduced by the Government of Cambodia to encourage changes in land use; in particular a shift towards smallholder rubber plantations. Results of cost-benefit analysis show that conversions from crop production (maize, soybean, cassava and cashew) to smallholder rubber plantation provide the largest benefit to farmers involved in these schemes, whereas conversion of forestland into large-scale rubber plantation ranks last in economic terms. Author: dararath@online.com.kh

Payments for conservation services, including carbon

Baird, I.G. (2014) Reduced emissions from deforestation and forest degradation (REDD) and access and exclusion: obstacles and opportunities in Cambodia and Laos. *Southeast Asian Studies*, **3**, 643–668.

Concerns have been raised regarding the potential for the REDD framework to "re-centralize" forest management, potentially hampering localized, decentralized forms of natural resource management. This article considers access to land and natural resources in the context of three REDD projects in Cambodia and Laos and argues that it is possible to envision REDD being used to encourage decentralized forest tenure. Author: ibaird@wisc.edu

Chapman, S., Wilder, M., Millar, I., Dibley, A., Yeang D., Heffernan, J., Sherchan, K., Maguire, R., Wanjiku Kago, C., Kamunde-Aquino, N., Kiguatha, L., Nana Afua Idun, Y., Doshi, M., Engbring, G. & Dooley, E. (2015) A legal perspective of carbon rights and benefit sharing under REDD+: a conceptual framework and examples from Cambodia and Kenya. *Carbon and Climate Law Review*, **9**, 143–155.

This article discusses two issues in REDD+ design and implementation at the national level: carbon rights and benefit sharing. The authors use a conceptual framework derived from legal analysis to consider cases in Cambodia and Kenya, and discuss challenges such countries might encounter when considering how to manage carbon rights and benefit sharing in the context of REDD+ implementation.

Clements, T. & Milner-Gulland, E.J. (2015) Impact of payments for environmental services and protected areas on local livelihoods and forest conservation in northern Cambodia. *Conservation Biology*, **29**, 78–87.

A study of the impacts on forests and human well-being of three payments for ecosystem services (PES) programmes in two protected areas in northern Cambodia. Both PES and the protected areas delivered additional environmental outcomes, and impacts of PES on household wellbeing were related to the size of payments provided. Two higher paying market-linked PES programmes had significant positive impacts, whereas a lower paying programme that targeted biodiversity protection had no detectable effect on livelihoods, despite its positive environmental outcomes. Author: tclements@wcs.org

Environmental policy and practice

Chanthy S. & Grünbühela, C.M. (2015) Critical challenges to consultants in pursuing quality of Environmental and Social Impact Assessments (ESIA) in Cambodia. *Impact Assessment and Project Appraisal*, **33**, 226–232.

Despite the progress made since its introduction to Cambodia in 1996, ESIA practice and the role of stakeholders remain inconsistent, resulting in assessment reports that omit critical information. The authors identify several shortcomings and issues for resolution to improve the quality of ESIA nationally.

Hok, L., de Moraes Sác, J.C., Boulakia, S., Reyes, M., Leng V., Kong, R., Tivet, F.E., Briedis, C., Hartman, D., Ferreira, L.A., Magno, T. & Pheav S. (2015) Short-term conservation agriculture and biomass-C input impacts on soil C dynamics in a savanna ecosystem in Cambodia. *Agriculture, Ecosystems & Environment*, **214**, 54–67.

"Conservation agriculture" is an effective tool in increasing soil carbon sequestration and enhancing soil quality and productivity, but empirical evidence from Southeast Asia is still scarce. This study documents the impacts of different soil management and cropping systems on soil organic carbon, soil total nitrogen, particulate organic carbon and mineral-associated organic carbon over five years. Author: jcmsa@uepg.br

Milne, S. & Mahanty, S. (2015) *Conservation and Development in Cambodia: Exploring Frontiers of Change in Nature, State and Society*. Routledge, UK & USA.

Cambodia has experienced an economic transformation in the last decade, with growth averaging nearly 10% per year. This has heralded tremendous social and environmental changes which, although positive in some aspects, have led to rising inequality and profound shifts in the condition, ownership and management of natural resources. This treatment explores the social and political dimensions of these environmental changes, and efforts to intervene in and improve conservation and development in Cambodia. Author: sarah.milne@anu.edu.au

Sun H. (2014) *Cardamom landscape management to sustain biodiversity and economic returns in Cambodia*. PhD Thesis, University of Minnesota, USA.

Preservation of large landscapes for biodiversity conservation is especially difficult in developing countries, where population growth is high and land is in great demand. This study investigated three different management scenarios to explore how the Central Cardamoms landscape could be developed in an environmentally sound and economically efficient manner: (1) "strong development"; (2) "strong conservation"; and (3) "mixed conservation and development", based on current government policy, development pressure, and donor community and NGO arguments. Results suggest that the "strong conservation" scenario would provide the greatest economic return while sustaining biodiversity in the landscape.

Climate change

Barrett, S. (2015) *Costs and Values of TAMD in Cambodia*. IIED Working Paper, International Institute for Environment and Development, London, UK.

The Tracking Adaptation and Measuring Development (TAMD) monitoring and evaluation framework can enable public authorities to assess climate risk management processes and contributions from adaptation/climate resilient development policy. Little is known about the pros and cons of applying TAMD in Cambodia, and whether it could improve the effectiveness of investments. This study examines the additional costs and benefits of implementing the TAMD framework. Online: http://pubs.iied.org/10130IIED

Va D., Bajracharya, B., Lebel, L., Regan, M. & Taplin, R. (2015) Narrowing gaps between research and policy development in climate change adaptation work in the water resources and agriculture sectors of Cambodia, *Climate Policy*, doi: 10.1080/14693062.2014.1003523

This article investigates stakeholder opinions as to how gaps between research and policy development can be bridged within the Cambodian water resources and agriculture sectors. A number of challenges and barriers to narrowing these gaps are identified, including: limited effectiveness of governmental policies and planning, lack of relevant information required to promote evidence-based planning and policy development, and communication barriers. Engaging policy stakeholders in research to build adaptation knowledge, and introducing knowledge intermediaries, are suggested to narrow current gaps between research and policy development. Author: dva@bond.edu.au

Davies, G.I., McIver, L., Kim, Y., Hashizume, M., Iddings, S. & Chan V. (2015) Water-borne diseases and extreme weather events in Cambodia: review of impacts and implications of climate change. *International Journal of Environmental Research and Public Health*, **12**, 191–213.

Cambodia is prone to extreme weather events, especially floods, droughts and typhoons, and climate change is predicted to increase their frequency and intensity. This study reveals that waterborne diseases are of particular concern in Cambodia in this context, due to a high pre-existing burden of diseases such as diarrhoeal illness and a lack of sanitation infrastructure in rural areas. Addressing such weaknesses is vital to building health resilience and strengthening capacity to adapt to extreme weather events and climate change. Author: gidav2@student.monash.edu

Mao C., Yamada, Y. & Matsuoka, T. (2014) A preliminary assessment of geological CO_2 storage in Cambodia. *International Journal of Greenhouse Gas Control*, **30**, 19–33.

This study screens and ranks sedimentary basins in Cambodia in terms of their containment, capacity and feasibility for geological storage of CO_2. Results indicate that the Khmer Basin is the most suitable basin, followed by the Kampong Saom and Tonle Sap basins. A combination of their initial suitabilities and estimates of their prospective matched storage capacity suggest that these basins could provide a solution to the problem of reducing future atmospheric emissions. Author: maochanrithyrouth@gmail.com

Human history

Forestier, H., Heng S., Puaud, P., Celiberti, V., Frère, S., Zeitoun, V., Mourer-Chauviré, C., Mourer, R., Heng T. & Billault, L. (2015) The Hoabinhian from Laang Spean Cave in its stratigraphic, chronological, typo-technological and environmental context (Cambodia, Battambang Province). *Journal of Archaeological Science: Reports*, **3**, 194–206.

Cambodia's Palaeolithic history has received less attention than the Angkorian period and is little known. This study details the results of excavations since 2009 at Laang Spean Cave in Battambang Province and presents new stratigraphic, chronocultural and archaeozoological data concerning the Hoabinhian techno-complex, dated at the site between 11,000 and 5,000 years BP. Author: hubforestier@gmail.com

The Recent Literature section was compiled by Neil M. Furey, with additional contributions from Fredéric Goes and Oleg Kosterin. All Internet addresses were correct at the time of publication. Please send contributions (published or grey literature, including project technical reports and conference abstracts not more than 18 months old) by email to: Editor.CJNH@gmail.com

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

The following are examples of house style:

Papers:

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

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

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

Books and chapters:

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

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

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

Reports:

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

Theses:

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

Netherlands.

Websites:

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

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The Editors are grateful to our reviewers and to Dr Ith Saveng, Pheng Sokline and Vanessa Herranz Munoz for their kind assistance with the production of this issue.

Cambodian Journal of Natural History

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