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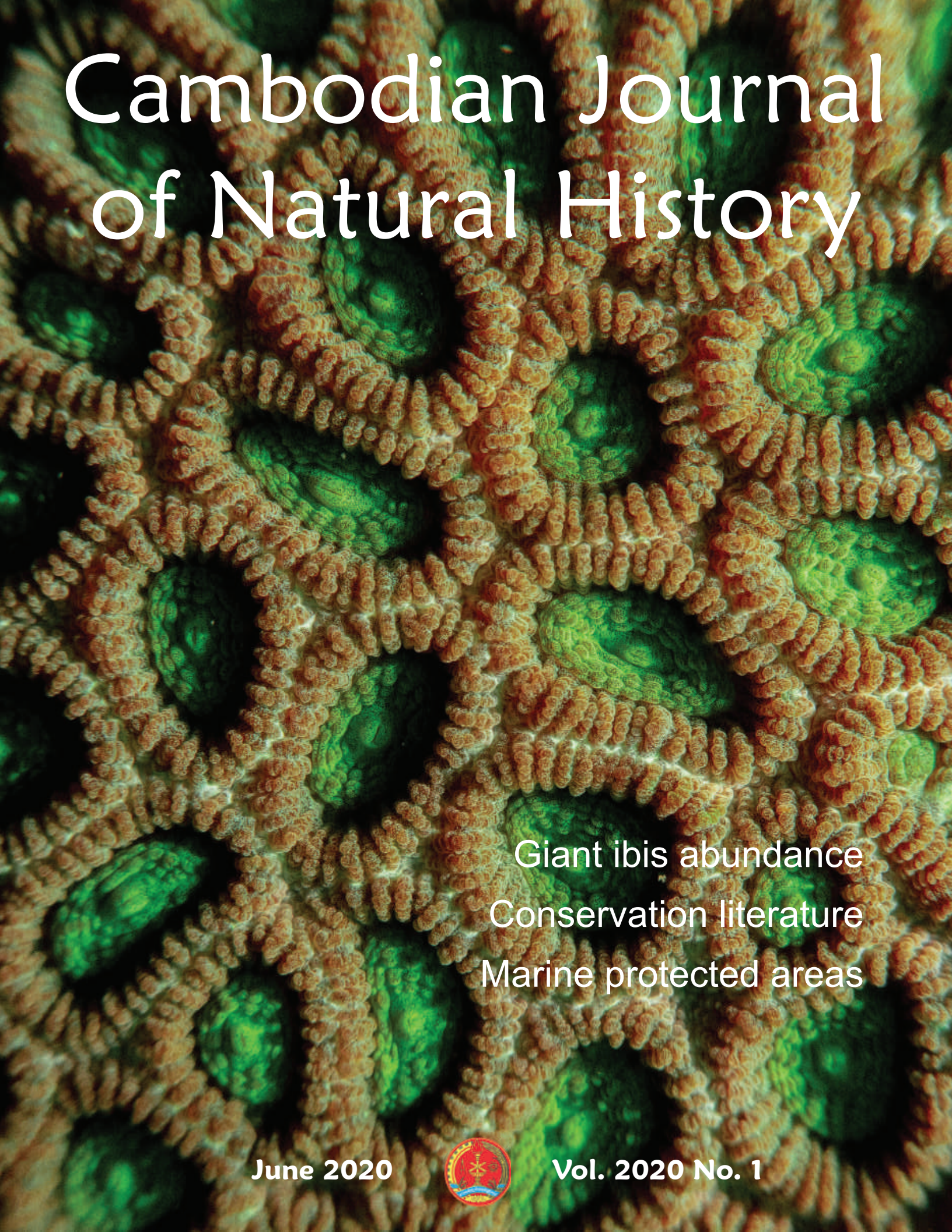

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Cover image: Coral polyps (*Favia* sp.) on the reefs of Koh Chan, Koh Sdach Archipelago, Koh Kong Province in June 2018 (© Matthew Glue/FFI).

Editorial—Marine protected areas in Cambodia: a call for collaborative action

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Cambodia's marine ecosystems underpin the country's growing coastal economy, food security and resilience of coastal communities. Connected habitats such as coral reefs, mangrove forests and seagrass meadows provide vital support to fishing and tourism industries, coastal communities and endangered wildlife but face mounting pressure from destructive and exploitative fishing, habitat degradation and coastal pollution (Selig & Bruno, 2010; Boulton *et al*., 2016; Hughes *et al*., 2017; Thaung *et al*., 2017). These challenges are compounded by increasing demands for seafood, a rapidly growing coastal tourism industry, poorly regulated coastal development and climate change impacts such as rising ocean temperatures, sea level rise and ocean acidification (Rizvi & Singer, 2011; van Bochove *et al*., 2011; Mulligan & Longhurst, 2014). The present pandemic could potentially exacerbate these issues by shifting fishing effort and altering market trends.

Despite recent progress in protecting marine ecosystems and improving fisheries management in Cambodia, capacity for coastal management remains limited and investments in marine conservation and sustainability initiatives have been disjointed. With a short coastline just 435 km in length, the increasingly complex nature of coastal resource management in the country necessitates stronger collaborative action. To ensure effective management and efficient investments, an unprecedented coalition is needed between government and non-government agencies, coastal communities and private and tourism sectors. In this article, we review recent developments in marine conservation and management in Cambodia, highlight the importance of cross-sector participation and dialogue and stress the need for greater inter-ministerial collaboration.

Progress towards marine protection

Recent progress has been realised through advances in small-scale fisheries management and increased attention to ecosystem-based approaches such as marine protected areas (MPAs). MPAs are management tools which aim to conserve marine biodiversity, manage dwindling fish stocks, promote sustainable tourism and protect coastal ecosystem integrity (Lubchenco, 2013; Edgar *et al*., 2014). While the global coverage of MPAs has expanded rapidly in the past two decades, their effectiveness is subject to continued debate (Pendleton et al., 2018). Nonetheless, as a relatively new actor on the MPA stage, Cambodia has a unique opportunity to learn from global experiences in MPA effectiveness and best practices (Selig & Bruno, 2010; Gill *et al*., 2017).

The first coastal protected areas in Cambodia were developed between 1993 and 1999 and include Peam Krasop Wildlife Sanctuary, Ream National Park, Botum Sakor National Park and the Koh Kapik Ramsar Site (Fig. 1), which are under the authority of the Ministry of Environment. Until recently, these sites have had limited formal management and focused on terrestrial and wetland habitats, with no zoning, monitoring or active protection of marine habitats (Ministry of Environment, 2017, 2018).

The designation of the Koh Rong Archipelago Marine Fisheries Management Area in 2016 was a landmark for marine protection in Cambodia (Ministry of Agriculture, Forestry and Fisheries, 2016) (Fig. 1). This was the nation's first large-scale and dedicated MPA and was created to protect marine biodiversity and ecosystem services that support fisheries and tourism. The 405 km^2 of coastal waters comprise conservation areas where no resource extraction is allowed, fishery refugia for seasonal stock recovery, recreational areas for tourism activities and community fishery areas that allow regulated family-

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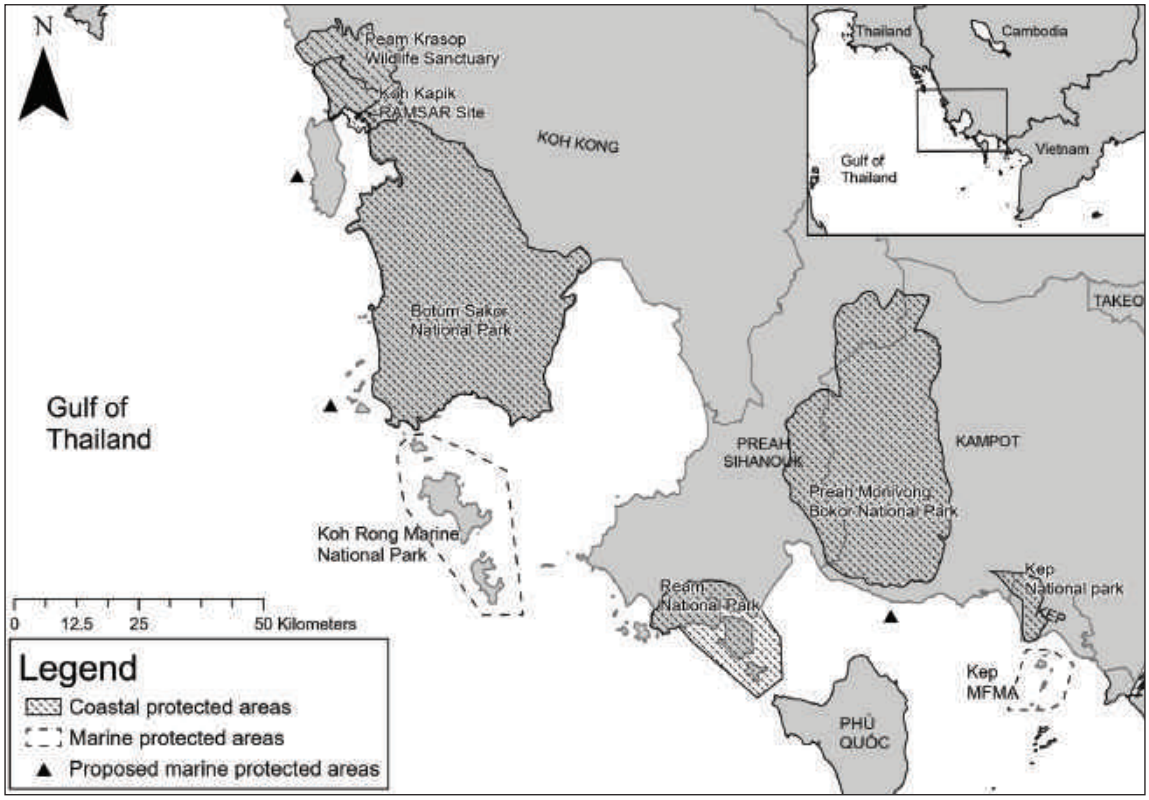

Fig. 1 Coastal and marine protected areas in Cambodia.

scale fishing (Fisheries Administration, 2016). These multiple-use areas are collaboratively managed and patrolled by community fishery teams and local government, with support from NGOs. This approach was replicated and adapted with the designation of the Kep Marine Fisheries Management Area (117 km^2) in 2018 (IUCN, 2018) (Fig. 1) and development of two additional marine fisheries management areas is now underway in Kampot Province and the Koh Sdach Archipelago in Koh Kong Province.

Following the creation of the Department of Marine and Coastal Zone Conservation within the Ministry of Environment in 2016, the nation's first marine national park was established around the Koh Rong Archipelago in 2018 (Royal Government of Cambodia, 2018) (Fig. 1). This new form of designation incorporates terrestrial (53 km^2) and marine (471 km^2) habitats across two provinces and supersedes and expands upon the Koh Rong Marine Fisheries Management Area declared in 2016. Given plans to create additional marine national parks in priority areas such as Koh Kong, further expansion of Cambodia's MPA network is imminent.

There has also been progress beyond the designation coastal and marine protected areas. Active management plans now exist for the Koh Rong Marine Fisheries Management Area (Fisheries Administration, 2016) and Peam Krasop Wildlife Sanctuary (Ministry of Environment, 2018) and a management plan was recently approved for the Kep Marine Fisheries Management Area. Community groups and conservation organisations along the coastline are actively protecting and restoring coastal habitats, and socioeconomic and ecological monitoring programmes are underway. While there is continued evidence of over-exploitation and environmental damage, there are also initial signs of ecological stability and recovery in MPAs (Roig-Boixeda *et al*., 2017; Reid *et al*., 2019; Glue & Teoh, 2020). Additionally, the crucial role of community memsbers and local fishers in effective marine management has been recognised and community networks and exchange programmes now exist along the coastline (Savage, 2017; Barter, 2018).

Cross-sectoral coordination and dialogue has also improved through the Technical Working Group for Fisheries and the Cambodian Coral Reef Monitoring Network (established in 2019), which provide forums for government, academic institutions, development agencies, NGOs, and private sector representatives to interact. In the case of the technical working group for the Koh

Rong MPA, such groups can also provide a platform for community representatives to participate in coastal resource management and decision-making (Preah Sihanouk Provincial Hall, 2014). These developments are collectively promising, although marine conservation efforts in Cambodia are still at a relatively early stage.

Control of illegal & unsustainable fishing

Illegal, unreported and unregulated (IUU) fishing arguably poses one of the greatest threats to Cambodian marine resources due to over-exploitation of fish populations and degradation of marine habitats from destructive fishing practices (Fisheries Administration, 2018; Reid *et al*., 2019). IUU fishing is often associated with humanitarian crimes in the region (Sylwester, 2014; Mutaqin, 2018). It also undermines national fisheries management and conservation efforts, discriminates against and demotivates fishers who act responsibly, and destabilises food and job security (Teh *et al*., 2017). As a consequence, increased surveillance and enforcement capacity is critical to achieving successful fisheries management and conservation in Cambodia. For example, management of the Koh Rong MPA is limited by the capacity of community-led patrol teams who cannot confront large fishing vessels operated by outsiders or issue penalties for infractions unless accompanied by fisheries enforcement officers (Roig-Boixeda *et al*., 2018). These community patrols are important and effective management and awareness-raising measures for MPAs. However, they cannot address shifts in fishing effort to less patrolled areas and are insufficient to deter offshore and large-scale fishing which often occurs at night (Roig-Boixeda *et al*., 2018; Glue & Teoh, 2020).

Remote sensing technologies that are being explored can potentially address some of these issues and improve the detection capacity of enforcement efforts. In addition, the Fisheries Administration is also developing national plans to address identified governance needs for fisheries. These include a national plan for fisheries conservation, a national plan to deter and eliminate IUU marine fishing (Fisheries Administration, 2018), and a national plan for control and inspection in the marine sector. Provided community fisheries continue to be strengthened and marine fisheries management areas and fisheries refugia are well designed, collaboratively managed and actively enforced, further advances in marine fisheries management can be expected in the coming years.

Governance of MPAs & fisheries

Fisheries management and food security cannot be decoupled from marine conservation and coastal management in a Cambodian context. Marine environments are often open access and coastal communities and fishing industries rely on their biodiversity. As such, MPAs in the country will need to integrate fisheries management objectives with biodiversity conservation objectives to achieve their social, environmental and economic goals. Because Cambodia is highly dependent on fish protein and generates significant revenue from fish exports, innovative management approaches must be considered in the design and management of MPAs.

Effective MPAs are especially important in protecting marine habitat and fisheries stock where conventional fisheries management is weak (Edgar *et al*., 2014). Marine management often sits at the nexus between competing government ministries and frequently straddles fisheries, environmental and sometimes economic divides. There are examples globally where different government agencies found ways to successfully co-manage marine resources, but these are complex approaches reliant on compromise and communication. In Guinea-Bissau for example, a country similar to Cambodia in its high resource exploitation and limited financial resources, shared responsibilities and collaborations between fisheries and protected area agencies have helped to reconcile conservation and fisheries objectives within its MPAs (Weigel *et al*., 2014). Given Cambodia's creation and expansion of marine national parks in sites with high incidences of IUU fishing, fisheries-dependent coastal communities and marine waters under existing fisheries management, unprecedented collaborations will be required between the Fisheries Administration and the Ministry of Environment to ensure their social, governance and biodiversity goals can be met. As such, ongoing dialogue between these two agencies will be key to the future success of national marine and fisheries management through MPAs.

Governments worldwide are under pressure to increase the coverage of marine protected areas and this has often resulted in opportunistic rather than systematic designations (Toropova *et al*., 2010; Hansen *et al*., 2011). The continued creation of marine fisheries management areas by the Fisheries Administration and the development of marine national parks by the Ministry of Environment will expand the coverage of MPAs in Cambodia and this momentum is commendable. However, without effective collaboration between government agencies, overlapping jurisdictions and unclear mandates for management will hamper action on the ground (Souter *et al*., 2016). Once an MPA has been designed and established, the ongoing management effort is significant. Large-scale boundary demarcation and awareness efforts on land and at sea must be undertaken to ensure basic

levels of understanding and compliance in areas which are often undergoing rapid development for tourism and other purposes. Coastal habitats and offshore waters must be regularly patrolled and conservation and fishery regulations must be effectively enforced. Terrestrial, in-water and fisheries monitoring must also be undertaken to assess progress towards ecological, socio-economic and other management goals. Given these requirements, collaborative management between government agencies should not be regarded as an aspirational ideal to strive towards, but as a prerequisite for efficiently managing complex coastal and marine sites.

Participatory design & management of MPAs

Allied to the need for collaborative management, successful MPAs rely on strong support, engagement and leadership from local communities (Giakoumi *et al*., 2018). Participatory approaches to MPA zoning and design are critical for local compliance, especially where the capacity for regulation and enforcement is low. These were employed in the design of the Koh Rong MPA for example (Boon *et al*., 2014), where subsequent studies reported high levels of voluntary compliance and perceived decreases in illegal fishing activities (Hamilton, 2012; Roig-Boixeda *et al*., 2017, 2018). Roig-Boixeda *et al*. (2017) also indicated high levels of local awareness of the MPA (88%) and its rules (80%), with most respondents (92%) reporting that the MPA benefited their village. These findings were attributed to the perceived legitimacy of the MPA and collaborative approach taken in its design and management. Notably however, Roig-Boixeda *et al*. (2017, 2018) also found low awareness within the private and tourism sectors and low compliance among outsiders. The latter was attributed to a lack of law enforcement capacity and absence of effective boundary demarcation.

While the ecological benefits of strict no-take MPAs are well documented (e.g., Lester & Halpern, 2008), MPAs are not closed ecological systems. Marine systems are inherently connected by the migration of fish species across habitats and long-distance dispersal of marine organisms (Luo *et al*., 2009; Hughes *et al*., 2010). Further, while integrated approaches for coastal management are well known in Cambodia, the land-sea interface is often ignored in MPA planning (Lyngby *et al*., 2017; Prak *et al*., 2018). Because ineffective management actions on land negatively influence marine systems, this discrepancy needs to be addressed in management plans and policies to ensure the resilience of marine systems. Significant collaborations between government agencies, land developers and the tourism sector will be required to this end.

Mobilising support for marine conservation

Although the number of conservation organisations active in Cambodia's marine environment remains relatively small, several large projects have begun in recent years that consider integrated approaches to coastal management. Recognising the critical need for such approaches, several international development agencies and organisations are now engaged in or exploring investment opportunities for sustainable management of coastal and marine resources[1]. Collaborations between these projects have begun, and if successful and sustained, these could amplify benefits for coastal livelihoods, industries and the ecosystems upon which they rely. They may also catalyse meaningful engagement with coastal stakeholders from the tourism sector, land and infrastructure developers, marine defence sector and inter-agency government committees[2].

A strong desire for environmental action exists in much of the private sector in coastal Cambodia, especially in the tourism industry whose revenue relies on healthy and attractive coastal ecosystems. However, businesses and developers are often ill-informed about existing initiatives and working groups, and resource management measures are not designed in a way that engages these fast-paced sectors. Mobilising private sector support will be crucial going forward (Barter, 2018). Moreover, engaging the private sector in collaborative coastal and marine management can generate additional funding opportunities. For example, a collaborative manage-

[1] Relevant programmes include: The 'South China Sea Fisheries Refugia Project' of the Southeast Asian Fisheries Development Centre, United Nations Environment Programme and Global Environment Facility aims to improve management of fisheries and fisheries refugia. The European Union funded 'CAPFISH' project will provide direct support to the Cambodian fisheries sector and support monitoring and enforcement in marine fisheries. The 'CamAdapt' project led by the Food and Agriculture Organisation of the United Nations will support coastal communities in adapting and improving resilience to climate change. A project led by Fauna & Flora International and a consortium of local partners aims to strengthen a network of marine protected areas that support biodiversity and livelihoods across the Cambodian coastline. The World Bank is conducting assessments to inform investments in integrated coastal zone management and blue economy development, and a forthcoming project of the Asian Development Bank will support inclusive development of coastal and marine fisheries value chains and sustainable tourism.

[2] Examples of inter-agency government committees include the National Committee on Management and Development of the Coastal Zones, the National Council for Sustainable Development and the National Committee on Maritime Security.

ment and financing mechanism has been proposed for the Koh Rong MPA to attract private investments alongside philanthropic and tourism capital. The intention of the mechanism is to boost the financial stability of MPA management and support local communities and site managers (Agulto *et al*., 2020) and its success will depend on collaborations between public agencies, private businesses, NGOs and local communities.

Conclusions

The stage is set for effective management of MPAs in Cambodia. However, to move MPAs beyond seemingly arbitrary lines on a map, participatory and evidence-based approaches to their design and ongoing management must be adopted to enhance community compliance and balance social equity. Focused efforts will also be required to facilitate collaborative management between sectors and direct much-needed investments and technical support to managing marine resources and securing long-term conservation gains.

An ambitious coalition is needed to facilitate links and dialogue between the many stakeholders in coastal Cambodia, including local communities, the private sector, NGOs and a range of government agencies. Forums for open dialogue between these stakeholders can be created and MPA planning should be embedded in broader plans for fisheries and coastal development. Enhanced leadership from government will be crucial to navigating these exciting but uncharted waters.

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The first population assessment of the Critically Endangered giant ibis *Thaumatibis gigantea* in Lomphat Wildlife Sanctuary, Cambodia

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មូលន័យសង្ខេប

សត្វត្រយ៉ងយក្ស *Thaumatibis gigantea* ដែលជាបក្សីជំនាញរស់នៅក្នុងព្រៃល្បោះស្ងួត មានការថយចុះខ្លាំង និងគួរឱ្យកត់សម្គាល់ទាំងចំនួន និងទីរបស់វា ដោយសារកត្តាបាត់បង់ទីជម្រក ការរំខាន និងការបរបាញ់។ ក្នុងពេលបច្ចុប្បន្នចំនួនសត្វត្រយ៉ងយក្សពេញវ័យមានមិនដល់២០០ក្បាលផង ហើយការស្វែងយល់ពីចំនួនប្រជាសាស្ត្ររបស់សត្វត្រយ៉ងយក្សដែលនៅសេសសល់នេះ គឺមានសារៈសំខាន់ខ្លាំងដើម្បីធ្វើការអភិរក្សពូកវា។ យើងបង្ហាញពីការប៉ាន់ប្រមាណនូវចំនួនប្រជាសាស្ត្រនៃត្រយ៉ងនេះនៅក្នុងដែនជម្រកសត្វព្រៃលំផាត់ជាលើកដំបូងតាមរយៈការអង្កេតតាមដានសំបុករបស់វានៅកំឡុងរដូវបន្តពូជចាប់ពីឆ្នាំ២០១៥-២០១៨ និងការអង្កេតនៅតាមត្រពាំងទឹកនារដូវប្រាំងក្នុងឆ្នាំ២០១៩។ ជាទូទៅទាំងចំនួននៃការកត់ត្រាជារួម និងចំនួនរបស់សត្វត្រយ៉ងយក្សដែលគណនាពីការអង្កេតនៅតាមត្រពាំងមានកំរិតខ្ពស់នៅកំឡុងខែមករា និងកុម្ភៈ ហើយការកត់ត្រាតាមរយៈសំលេងវាមានការកើនឡើងនៅក្នុងខែកុម្ភៈ។ មានសំបុកសត្វត្រយ៉ងយក្ស សរុបចំនួន៣១ ត្រូវបានរកឃើញ និងអង្កេតតាមដាននៅក្នុងកំឡុងពេលនៃរដូវបន្តពូជរវាងឆ្នាំ២០១៥-២០១៨។ អត្រាញាស់ជោគជ័យមានប្រមាណ៩០% ជាមួយនឹងចំនួនកូនសត្វត្រយ៉ងយក្សញាស់ជាមធ្យម ១,៥៣ក្បាល/សំបុក ហើយចំនួនកូនសត្វត្រយ៉ងយក្សញាស់ជាមធ្យម ១០.២៥ក្បាល/ឆ្នាំ។ យ៉ាងហោចណាស់មានសត្វត្រយ៉ងយក្ស (ដែលរួមទាំងសត្វពេញវ័យ និងកូនសត្វដែលបានញាស់) ចំនួន១៣ក្បាល ៨ក្បាល ៣១ក្បាល និង៥១ក្បាល ត្រូវបានកត់ត្រានៅតាមសំបុកក្នុងពេលអង្កេតតាមដានក្នុងឆ្នាំ២០១៥ ឆ្នាំ២០១៦ ឆ្នាំ២០១៧ និងឆ្នាំ២០១៨រៀងៗខ្លួន ដែលឱ្យជាមធ្យមមានសត្វត្រយ៉ងយក្ស ចំនួន២៥.៧៥ក្បាល/រដូវបន្តពូជ។ សត្វត្រយ៉ងយក្សពេញវ័យមានចំនួនប្រហាក់ប្រហែលគ្នារវាងការអង្កេតនៅតាមត្រពាំងទឹក និងការអង្កេតតាមដានសំបុក។ លទ្ធផលបង្ហាញថា ការអង្កេតនៅតាមត្រពាំង និងការអង្កេតតាមដានសំបុក ជាវិធីសាស្ត្រមានសារៈសំខាន់ដែលអាចប្រើប្រាស់ដើម្បីប៉ាន់ប្រមាណចំនួនសត្វត្រយ៉ងយក្សបាន។ វិធីសាស្ត្រនេះអាចអនុវត្តបានលុះណាមានបុគ្គលិកទីវាលដែលមានបទពិសោធន៍ និងទទួលបានការបណ្តុះបណ្តាលគ្រប់គ្រាន់។

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Abstract

The Critically Endangered giant ibis *Thaumatibis gigantea* is a dry forest specialist whose range and population has declined dramatically due to habitat loss, human disturbance and hunting. Less than 200 mature individuals of the species are now thought to exist and understanding the status of remaining populations is crucial to their conservation management. We provide a first estimate for giant ibis populations in Lomphat Wildlife Sanctuary, based on nest monitoring during the 2015–2018 breeding seasons and waterhole surveys in 2019. Overall detections and numbers of individuals recorded at waterholes were high in January and February 2019, and most of our call detections occurred in the latter month. A total of 31 nests were found and monitored over the 2015–2018 breeding seasons. Nest success rates were high at 90% and on average, 1.53 chicks fledged per nest and 10.25 chicks fledged per year. At least 13, 8, 31 and 51 giant ibises (including adults and fledged chicks) were recorded at nests monitored in 2015, 2016, 2017 and 2018 respectively, giving an average of 25.75 giant ibises per breeding season. Numbers of mature giant ibises estimated from nest monitoring and waterhole surveys were comparable. Our results suggest that both survey methods can be used to estimate populations of the species, provided field surveyors have adequate training and experience.

Keywords Call detections, giant ibis, sight detections, waterholes.

Introduction

The Lower Mekong Ecoregion is one of the most important 200 ecoregions for global biodiversity (Olson & Dinerstein, 1998; Wikramanayake *et al*., 2002). The eastern and northern plains landscape of Cambodia supports the largest extent of lowland dry deciduous forest in Southeast Asia (Wikramanayake *et al*., 2002) and are recognized as having high value for biodiversity conservation (Tordoff *et al*., 2005). This landscape is home to a wide range of wildlife including globally threatened mammals and bird species (Gray *et al*., 2012; O'Kelly *et al*., 2012). During the dry season, water availability within the landscape is mainly limited to perennial rivers and waterholes ("trapeang" in Khmer). These water sources form an essential part of the dry deciduous forest and are used by several globally threatened large mammals and large birds (Keo, 2008; Wright *et al*., 2012a; Pin *et al*., 2018).

The national bird of Cambodia, the Critically Endangered giant ibis *Thaumatibis gigantea*, historically ranged across Thailand, Cambodia, Lao PDR and Vietnam but has declined dramatically in numbers and range due to habitat loss, disturbance, and poaching (Thewlis & Timmins, 1996). The remaining global population is estimated to be around 190 mature individuals (BirdLife International, 2018) and confined to the eastern and northern plains of Cambodia (Keo, 2008; Gray *et al*., 2014; Ty *et al*., 2016; Pin *et al*., 2018). A few individuals may also remain in Vietnam and Lao PDR, but the species is considered extinct in Thailand (BirdLife International, 2018).

The Critically Endangered status and lack of knowledge of giant ibis have prompted several studies in recent years. These include studies of its ecology, conservation (Keo, 2008; Wright *et al*., 2012a) and behaviour (Pin *et al*., 2018). All of the remaining populations known are in protected areas. The first study to determine the size of such a population occurred in the Prey Siem Pang Khang Lech Wildlife Sanctuary in Stung Treng Province (Ty *et al*., 2016), which estimated 49.5 ± 10 mature birds remained at the site. Using the waterhole survey methodology developed by Ty *et al*. (2016), combined with nest monitoring, the aim of our study was to determine the population of giant ibises in Lomphat Wildlife Sanctuary in Ratanakiri Province.

Methods

Study area

Lomphat Wildlife Sanctuary (LWS) covers 2,525 km^2 and is located in the eastern plains landscape of Cambodia (centred on 13.2°N, 106.5°E) (Fig. 1). Despite designation as a wildlife sanctuary, the landscape of LWS has been degraded by an economic land concession for agricultural development, and by illegal land encroachment (Hor *et al*., 2014; Chanrith *et al*., 2016). The sanctuary borders Srepok Wildlife Sanctuary to the southeast and O'Yadav National Park to the east and largely supports deciduous dipterocarp forests dominated by Dipterocarpaceae, mostly comprising *Shorea siamenis*, *S. obtusa*, *Dipterocarpus tuberculatus*, *D. obtusifolius* and *D. intricatus* (McShea *et al*., 2011). The area experiences a monsoon tropical climate with two distinct seasons: a rainy season with most rainfall occurring between May to October, and a dry season from November to April (Thoeun, 2015). During the dry season, the area experiences frequent

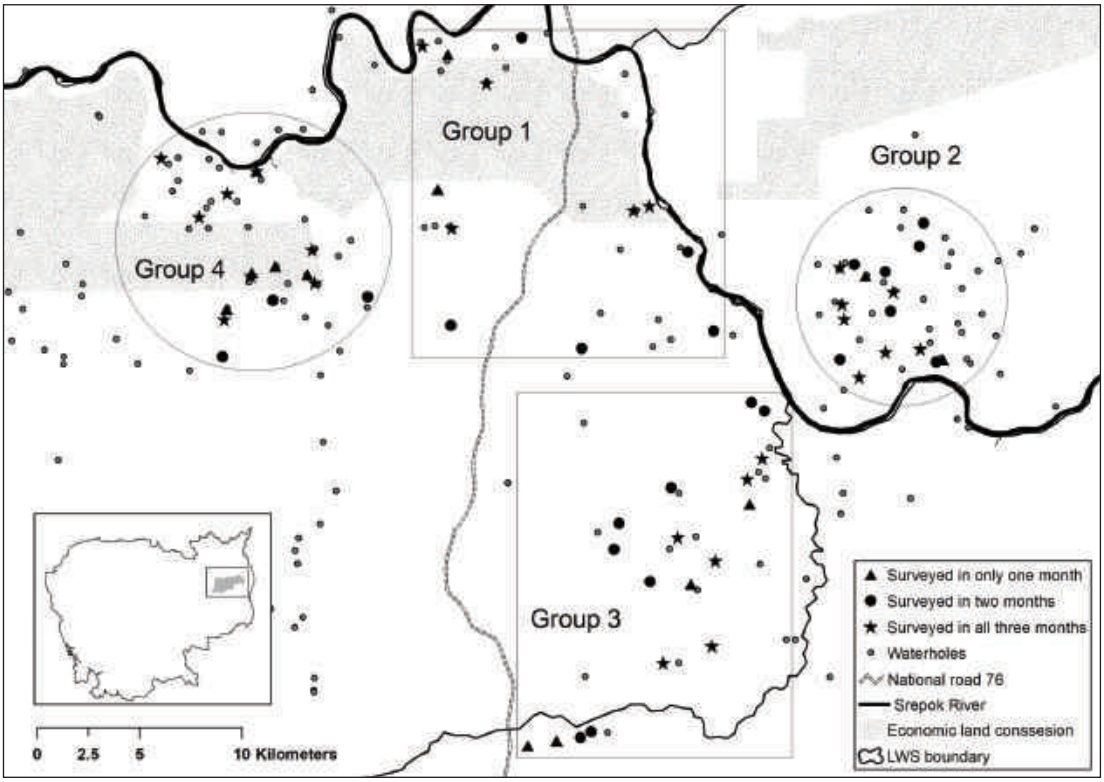

Fig. 1 Waterhole groups selected for giant ibis surveys in Lomphat Wildlife Sanctuary during the 2019 dry season (January–March). The inset shows the location of the wildlife sanctuary in Cambodia.

forest fires which create an open understory and reduce canopy cover (McShea *et al*., 2011; Ratnam *et al*., 2016).

Lomphat Wildlife Sanctuary supports a suite of globally threatened species including mammals such as banteng *Bos javanicus*, gaur *B. gaurus*, Asian elephant *Elephas maximus*, Eld's deer *Rucervus eldii*, sambar *Rusa unicolor*, and large-bodied birds such as red-headed vulture *Sarcogyps calvus*, giant ibis, white-shouldered ibis *Pseudibis davisoni*, sarus crane *Antigone antigone*, lesser adjutant *Leptoptilos javanicus* and Asian woolly-neck *Ciconia episcopus* (BirdLife International Cambodia Programme, unpublished data; Tordoff *et al*., 2005; Goes, 2009; Sum *et al*., 2011; Gray *et al*., 2012; Wright *et al*., 2012b; Clements *et al*., 2013; Wright *et al*., 2013b).

Waterhole surveys

The giant ibis is a large-bodied dry forest specialist which forages extensively at waterholes, abandoned paddy fields, and occasionally at rivers during the dry season (Keo, 2008; Wright *et al*., 2012a; Pin *et al*., 2018). As such, we decided to conduct our surveys for giant ibis at waterholes.

All of our team members were trained in data collection prior to the waterhole survey, including the use of GPS devices and compasses (to record bearings to giant ibises seen and heard), and in filling out the datasheets. We also played audio recordings of calls of giant ibis and other bird species to ensure team members could accurately distinguish giant ibis calls. Recorded distances between observers and calling giant ibises were based on the presumption and experience of each listener, rather than formal measurement.

Our study was conducted over three months from January to March 2019. Counts were undertaken between the 21st and 26th days of each month. We employed the survey method developed by Ty *et al*. (2016) to ensure our data set would be comparable. This method combines visual and auditory detections at waterholes. As giant ibis generally produces loud, long, and well-patterned calls, we were able to record auditory detections. Auditory detections were records of any giant ibis calls (beyond visual detections) made during survey hours, including calls made at roost sites while preparing to fly to foraging sites and call produced while traveling.

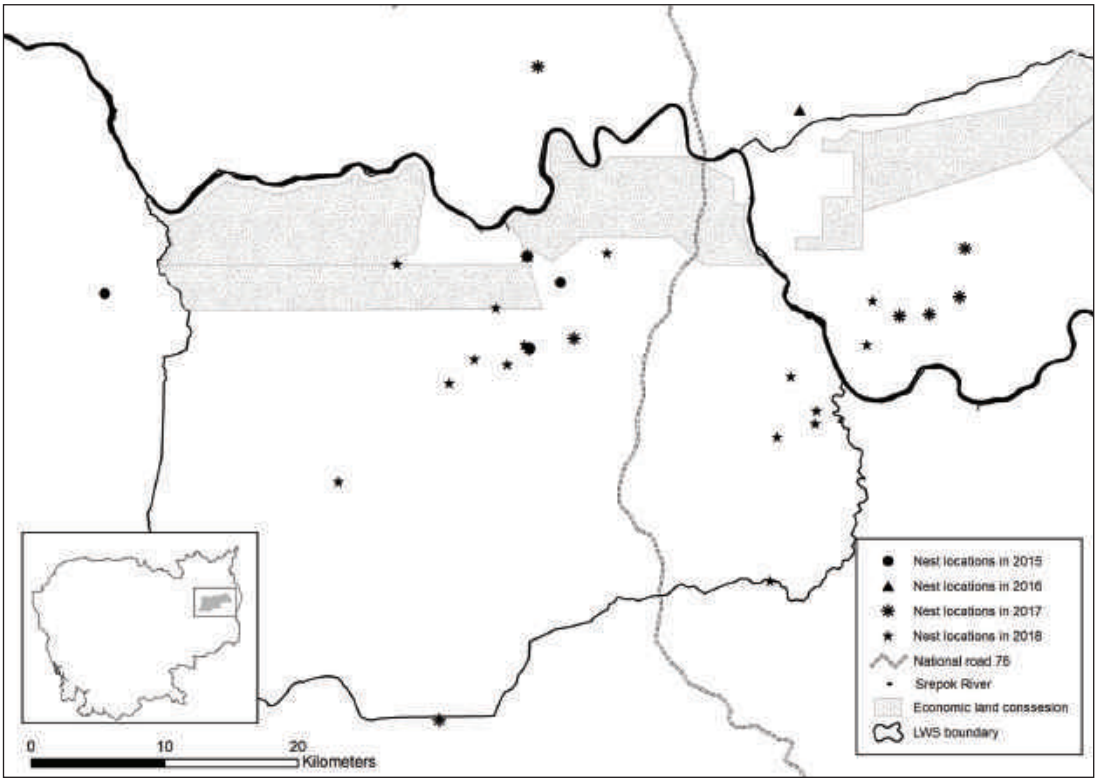

Fig. 2 Locations of giant ibis nests monitored in Lomphat Wildlife Sanctuary during the 2015-2018 breeding seasons.

To maximize detections of giant ibis, we focused on surveying waterholes that had been used by the species in previous years and recent months. These were identified using information and incidental encounters generated by field staff and local community members and accounted for ≈25% of all known waterholes in LWS (49 of ≈200). Our survey team comprised 14 people (six community members and eight BirdLife International staff). Due to personnel limitations, our study waterholes were divided into four groups which were surveyed on different days by dedicated surveyors (Fig 1). To maximise the number of waterholes surveyed simultaneously, one or two team members were assigned to survey a given waterhole at a time. We surveyed 41 waterholes in January, 49 waterholes in February and 48 waterholes in March. As the distance between each group of waterholes was greater than 4 km (Fig. 1), we assumed that giant ibis detections in different waterhole groups were independent of one another. The average distance between nearest-neighbour waterholes was 1,510 m (range 151–6,483 m). Each waterhole was surveyed once per day by surveyors who waited in concealed positions to avoid disturbing the birds. The survey was conducted between 05:00 and 08:00 hrs each day and the distance and bearing to each giant ibis detected was recorded.

Nest monitoring

Monitoring and protection of bird nests from poaching and predation is an important method for improving the reproduction success of birds, especially globally threatened species (Clements *et al*., 2009; Clements *et al*., 2013; Wright *et al*., 2013a). Monitoring of giant ibis nests in LWS began in 2015 and continued as of early 2020.

Nest searches were undertaken to determine the reproductive success of giant ibises in LWS and produce a distribution map of their nests to assist conservation efforts at the site. These were conducted during the breeding seasons of 2015–2018. As giant ibises generally start to mate in May and June and begin nest building in late June until early August in the wet season (Keo, 2008), our nest searches were undertaken in two phases. During the first phase (May & June), we checked areas where giant ibis nests had been registered during the previous breeding season to document whether these were still used by the species. In our experience, this approach is very effective for finding giant ibis nests when time and personnel are limited. During the second phase (July to mid-August), we searched for new nests in other areas and these searches were guided by the known ecology of the species and information provided by local people

and protected area staff. As the ability and experience of team members improved over time, we retained the most experienced individuals and assigned small groups (two people/group) to search different locations so as to maximize the chance of nest detection. Nest searches were conducted for at least seven consecutive days per field trip to maximise the area covered.

We searched the same area each year to permit comparisons of numbers of nests found between the breeding seasons of 2015–2018 (Fig. 2). Our searches focused on the preferred foraging habitats and nesting sites reported for giant ibis, including rivers, streams and waterholes (Fig. 3) (Keo, 2008; Wright *et al*., 2012a). These included listening posts at waterholes and searches along rivers and streams and within a 2 km radius of each waterhole to detect giant ibises by sight and calls. Upon detection, the bearing and distance of each giant ibis from the observer was first recorded. Team members then navigated to the giant ibis and searched for its nest. Once located, each nest was visited for half an hour once every fortnight until it had fledged or failed. The arrival and departure times of surveyors were recorded, as were the activities of birds and signs of predators in the vicinity of a nest. Nest protection efforts were not undertaken due to resource limitations.

Fig. 3 A pair of giant ibises foraging at a waterhole during the study in Lomphat Wildlife Sanctuary (© Thol S.).

Fig. 4 A pair of giant ibises nesting in a dipterocarp tree (*Shorea obtusa*) during the 2018 breeding season (© Sar S.).

Data analysis

Waterhole surveys: We screened our data to remove potential double counts of the same individual in vocal and sight detections, as follows: 1) when sighted birds were observed flying from the same direction as calling birds previously detected, one of the detections was excluded; 2) vocal detections of individual birds by the same observers within a 45° radius were considered the same individual unless they occurred at the same time. Potential double counts of individual birds moving between waterholes on the same morning (as suggested by their timing) were also excluded (Ty *et al*., 2016). More specifically, we first considered the time a bird was sighted at a given location, the time it departed for another location and the bearing on which it departed. If a bird was then observed flying from the direction in which one had already been recorded, this record was excluded from the count for the new location.

Following data screening, we estimated monthly population counts from sightings and call detections at each waterhole and derived overall monthly population counts by summing these. Our population figure represents a minimum population estimate and differs from the number of detections which represents the number of occasions we recorded giant ibis (from sightings or call detections) on a given day. Thus, if two or more giant ibises were sighted or heard at the same location, these were considered one detection. As such, the number of detections does not represent the number of giant ibis.

Nest monitoring: Each nest was observed for 30 minutes once every two weeks to record its progress, including incubation and feeding activity of chicks, until fledging or failure (Fig. 4). Nests whose chicks hatched and fledged were regarded as successful. Failed nests were those abandoned by the giant ibis due to predation by small carnivores (i.e. common palm civet *Paradoxurus hermaph-*

roditus), human disturbance (i.e. poaching, felling of nest tree) and/or natural causes.

We summed the number of nests found each year, distinguishing the number of successful nests, the number of fledged chicks recorded at each nest, and the total number of giant ibises recorded (including adults and young seen at nests). We estimated the total number of giant ibis by summing the number of fledged chicks and adults seen at nests during the monitoring period. The average number of chicks per nest was estimated by dividing the total number of fledged chicks with the total number of successful nests.

Results

Waterhole surveys

Over the course of the study, 37 detections of giant ibises (eight sightings and 29 call detections) were recorded in January, 40 (seven sightings and 33 call detections) in February, and 18 (eight sightings and ten call detections) in March (Table 1). Total numbers of sight-based detections were similar between the three study months, whereas the highest number of call detections occurred in February. The overall number of giant ibises encountered was 62 in January, 60 in February and 29 in March.

Following data screening to remove possible double counts, 28 detections were removed from our data for January, 24 from February and ten from March. The estimated number of individual giant ibises was 34 in January, 36 in February and 19 in March (Table 1). The greatest number of giant ibises were recorded in waterhole group 3, with 31 individuals.

Nest monitoring

A total of 31 giant ibis nests were discovered and monitored over the course of our study (Table 2). The number of nests we found increased significantly in 2017 and 2018 (nine nests and 16 nests, respectively) despite similar search effort in the same areas in previous years.

Nest success rates were high at 90% (28 of 31 nests). The average number of fledged chicks per nest was 1.53 (range 1.25–2.00) and 10.25 chicks fledged each year on

Table 1 Numbers of sightings and call-based detections of giant ibis across four groups of waterholes in Lomphat Wildlife Sanctuary in January–March 2019. Figures in parenthesis are numbers of birds recorded before removal of double counts.

Water hole group	January 2019				Febuary 2019				March 2019			
	No. of detections			Estim. birds	No. of detections			Estim. birds	No. of detections			Estim. birds
	Sighting	Calls	Total		Sighting	Calls	Total		Sighting	Calls	Total	
1	1	0	1 (3)	**3**	0	3	3 (4)	**2**	3	1	4 (10)	**4**
2	3	7	10 (11)	**8**	2	13	15 (20)	**11**	3	4	7 (8)	**6**
3	2	9	11 (17)	**13**	3	12	15 (22)	**15**	1	2	3 (3)	**3**
4	2	13	15 (31)	**10**	2	5	7 (14)	**8**	1	3	4 (8)	**6**
Total	**8**	**29**	**37 (62)**	**34**	**7**	**33**	**40 (60)**	**36**	**8**	**10**	**18 (29)**	**19**

Table 2 Results of nest monitoring during the 2015–2018 breeding seasons for giant ibis in Lomphat Wildlife Sanctuary.

Breeding season	Nests found	Successful nests	Mature birds per nest	No. of chicks fledged	Total giant ibis count
2015	4	4	2	5	13
2016	2	2	2	4	8
2017	9	9	2	13	31
2018	16	13	2	19	51

average in 2015–2018. At least 13, 8, 31 and 51 giant ibises (including adults and fledged chicks) were recorded at nests in 2015, 2016, 2017 and 2018 respectively, giving an average of 25.75 giant ibises per breeding season. Our figures indicate at least 32 adult giant ibises (two adults/nest x 16 nests) were present in LWS in 2018 (Table 2).

Discussion

Our study is the first attempt to estimate populations of the giant ibis in Lomphat Wildlife Sanctuary. In combining sightings and call detections, our survey method is a simple, inexpensive and useful approach for determining populations of the species at the site.

Our waterhole surveys suggest at least 36 mature giant ibises (the highest monthly count during the study) occur in Lomphat Wildlife Sanctuary. This figure is similar to the previous population estimate of 10–15 pairs derived from opportunistic sightings (BirdLife International, 2018). Due to resource limitations, we selected waterholes based on prior information to maximize our detections of giant ibis. While this could have biased our results, it is unlikely to have led to overestimation because potential double counts were carefully excluded from the survey data. However, as our study only sampled ≈25% of the waterholes known in LWS (49 of ≈200), our population estimate would likely have been much higher (approximately 30–40 pairs across LWS) if all of the known waterholes were included. For example, between 2015 and 2019, over 230 incidental sightings of giant ibis were recorded in various locations in LWS, including surveyed and un-surveyed waterholes, rice fields and grasslands (BirdLife International Cambodia Programme, unpublished data).

Obtaining sight-based detections of the giant ibis is challenging because it naturally occurs in low numbers and is very sensitive to the presence of humans. However, as the species generally produces a loud, long and well-patterned call which can be heard up to 2 km away (Ty, 2013), employing call detections in surveys generates more data per unit effort and improves population estimates. To ensure that data are reliable, training is important to ensure that field staff can accurately record the distance and bearing of calling birds. In our study, estimation of the distances to calling giant ibises was subjective, being based on the personal experience of each surveyor. Notwithstanding this, increasing the number of waterholes sampled and maximizing the number of experienced surveyors would help to minimize potential double counts and thereby improve the population estimates. As such, an expanded study using the same methods should be considered for medium and long-term monitoring of populations of giant ibis in LWS.

The aim of our study was to generate reliable information on the number of giant ibises (including fledged chicks and parents) in LWS. Four and two nests were found in 2015 and 2016 respectively, whereas nine and 16 nests were found 2017 and 2018 respectively. This increase was likely because our field team became more experienced. We suggest that nest monitoring can contribute to meaningful estimation of giant ibis populations. Notably, numbers of giant ibises estimated from waterhole surveys and nest monitoring were comparable (approximately 32 and 36 mature individuals, respectively), likely because both surveys mostly covered the same areas (Fig. 2). Our nest monitoring data also suggest that the reproductive success of giant ibis increased markedly during the study (Table 2). As such, LWS may support one of the few viable populations of the species in Cambodia. We also suggest that nest monitoring is appropriate for assessing populations of other large waterbird species, including sympatric white-shouldered ibis, lesser adjutant and Asian woollyneck.

Our study waterholes were distributed across different management zones in LWS: community/sustainable use zones (including economic land concessions), conservation zones and core zones. During our surveys, we recorded several incidences of resource-competition between local people and wildlife at waterholes. For instance, domestic animals such as dogs and cattle were observed with people who were collecting water and catching fish, including eels, which are prey for giant ibis (Keo, 2008; Wright *et al*., 2012a). According to the protected areas law of 2008, local communities are allowed to access and use areas such as community and sustainable use zones in LWS. However, unchecked competition between humans and wildlife for resources could increase levels of disturbance to foraging giant ibis. Overall, LWS supports a wide range of globally threatened species including mammals and birds (Birdlife International Cambodia Programme, unpublished data; Tordoff *et al*., 2005; Goes, 2009; Sum *et al*., 2011; Gray *et al*., 2012; Wright *et al*., 2012b; Clements *et al*., 2013; Wright *et al*., 2013b). Despite its designation as a wildlife sanctuary, the biodiversity of LWS faces ongoing threats from agricultural development, illegal land encroachment (Hor *et al*., 2014; Chanrith *et al*., 2016) and wildlife poaching. Immediate action by the relevant government authorities, supported by partner NGOs, is needed to prevent the destruction of the protected area and its biodiversity.

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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 edited for English and brevity.

Otolith ring counts reveal age composition of drifting larval striped catfish *Pangasianodon hypophthalmus* in the Mekong River, Cambodia

CHHUOY Samol

មូលន័យសង្ខេប

ត្រីប្រាធំមានឈ្មោះវិទ្យាសាស្ត្រ *Pangasianodon hypophthalmus* (Sauvage, 1878) គឺជាប្រភេទត្រីដែលស្ថិតនៅក្នុងអម្បូរត្រីអត់ស្រកា Pangasiidae ដែលមានសារសំខាន់ផ្នែកសេដ្ឋកិច្ច និងមានពាសពេញក្នុងអាងទន្លេមេគង្គ និងទន្លេចៅព្រះយ៉ា។ សព្វថ្ងៃនេះត្រីប្រាធំត្រូវបានគេចុះក្នុងបញ្ជីក្រហម IUCN ថាជាប្រភេទត្រីកំពុងរងគ្រោះ។ ទោះបីវាជាប្រភេទត្រីពេញនិយមសម្រាប់វារីវប្បកម្មក៏ដោយ ក៏វដ្តជីវិតដំបូងរបស់វានៅតែមិនទាន់មានគេសិក្សានៅឡើយនៅប្រទេសកម្ពុជា។ ក្នុងការស្រាវជ្រាវនេះ ខ្ញុំបានសិក្សាពីទម្រង់តូចៗនៃអូតូលីត (otoliths) របស់ត្រីប្រាធំ ដើម្បីយល់ដឹងពីវដ្តជីវិត ពេលវេលា និងទីកន្លែងដែលវាពង និងការចរាចរនៃកូនញាស់របស់វាទាក់ទងជាមួយនឹងលំហូរទឹក។ ទម្រង់តូចៗនៃអូតូលីតគឺជាគន្លឹះក្នុងការកំណត់ពីវដ្តជីវិតដំបូង និងបម្រែបម្រួលប៉ូពុយឡាស្យុងរបស់ត្រី ពីព្រោះការកកើតកាំអូតូលីតនីមួយៗអាចប្រើប្រាស់ដើម្បីកំណត់អាយុ និងការលូតលាស់របស់វាបាន។ ក្នុងការសិក្សានេះ ខ្ញុំបានប្រមូលទិន្នន័យកូនត្រីតាមដងទន្លេមេគង្គក្នុងក្រុងភ្នំពេញជាប្រចាំ។ ការប្រមូលសំណាកកូនត្រី (អាយុ៥-៣៤ថ្ងៃ) មានរយៈពេលសរុប ៣០ថ្ងៃ ដោយគិតចាប់ពីថ្ងៃទី១ ខែឧសភា ដល់ថ្ងៃទី៣០ ខែកញ្ញា ឆ្នាំ២០១៥។ កាំអូតូលីតសាជីតា (sagittae) និងឡាពីលី (lapilli) ត្រូវបានយកចេញពីក្បាលកូនត្រីធម្មជាតិចំនួន ៣៩០ ក្បាល (កូនត្រីសរុបចំនួន ៤០៣៤ ក្បាល) និងកូនត្រីភ្ញាស់ក្នុងស្ថានីយ៍ចំនួន ១៥០ ក្បាល។ លទ្ធផលបានបង្ហាញថា កាំអូតូលីតសាជីតា និងឡាពីលី អាចប្រើបានដោយជឿជាក់ក្នុងការកំណត់ និងប៉ាន់ស្មានពីអាយុកូនត្រីធម្មជាតិ។ ទោះបីជាការកកើតប្រចាំថ្ងៃ នៃឡាពីលីមានលក្ខណៈប្រសើរជាងសាជីតាក្នុងការរាប់ចំនួនកាំអូតូលីតក៏ដោយ ក៏កាំអូតូលីតចំនួន ២ ឬ៣ បានរកឃើញមុនពេលកូនត្រីញាស់។ ប្រវែងស្តង់ដារ និងការកកើតឡាពីលី និងសាជិតាមានទំនាក់ទំនងជាវិជ្ជមានក្នុងកម្រិតជឿជាក់តែសម្រាប់កូនត្រីភ្ញាស់ក្នុងស្ថានីយ៍តែប៉ុណ្ណោះ។ បន្ថែមពីនេះលំហូរទឹកគឺជាកត្តាសំខាន់ដែលជះឥទ្ធិពលដល់ពេលវេលាពង និងការផ្លាស់ទីរបស់កូនត្រីទៅតំបន់ខ្សែទឹកខាងក្រោមនៃដងទន្លេ។ ត្រីប្រាធំប្រហែលជាទម្លាក់ពងភាគច្រើនក្នុងអំឡុងខែមិថុនា និងខែកក្កដា (ដើមខ្នើត និងខែពេញបូណ៌មី) ហើយកូនញាស់របស់វាទំនងជាផ្លាស់ទីចេញពីខេត្តស្ទឹងត្រែង និងក្រចេះ។ លទ្ធផលនៃការសិក្សានេះគឺជាព័ត៌មានដ៏សំខាន់សម្រាប់ការអភិរក្ស និងគ្រប់គ្រងប៉ូពុយឡាស្យុងត្រីប្រាធំក្នុងប្រទេសកម្ពុជា។

Abstract

The striped catfish *Pangasianodon hypophthalmus* (Sauvage, 1878) is a commercially important species which occurs throughout the Mekong and Chao Praya basins. It is currently listed as Endangered and while popular in aquaculture, its early life history is unstudied in Cambodia. I investigated the microstructure of otoliths in striped catfish to elucidate their spawning times, spawning grounds and the larval drifting dynamics in relation to hydrology. Otolith microstructures are useful for evaluating the early life history and population dynamics of fish as their daily ring formations are reliable for estimating age and growth. I collected data on larval fish in the Mekong River in Phnom Penh each day from the 1st May to 30th September 2015. Hatchery-raised larvae and juvenile striped catfish of known ages (5–34 days) were also collected daily for 30 days. Otoliths (lapilli and sagittae) were extracted from 390 wild larvae (from a total sample of 4,034 individuals) and 150 individuals of hatchery-raised larvae and juveniles. I found daily increments in lapilli and sagittae (rings) were reliable for determining age and estimating wild larval ages. Formation of the first ring occurred 2–3 rings prior to hatching, although daily increments in lapilli were more suitable for counting rings than sagittae.

Relationships between standard length and daily increments of lapilli and sagittae were positively and significantly correlated for hatchery-raised larvae and juveniles but not significantly for wild larvae. Hydrology was important in influencing spawning times and downstream drift of larvae. Striped catfish seemed to mostly spawn in June and July (during new and full moon periods) and their drifting larvae likely originated from the Stung Treng and Kratie provinces. The findings of my study can be used to inform conservation and management of striped catfish populations in Cambodia.

Quantity and economic value of fish harvested by gillnets along the Tonle Sap River, Cambodia

HEY Sarun

មូលន័យសង្ខេប

បឹងទន្លេសាបគឺជាបឹងទឹកសាបដែលមានផលិតភាពខ្ពស់បំផុតនៅលើពិភពលោក។ ជារៀងរាល់ឆ្នាំចាប់ពីខែមិថុនាដល់ខែកញ្ញាមានកូនត្រីរាប់លានក្បាល និងប្រភេទត្រីបន្លាស់ទីជាច្រើនប្រភេទ ចូលមករស់នៅក្នុងតំបន់លិចទឹកជុំវិញបឹងទន្លេសាប តាមរយៈទន្លេសាប។ ការគ្រប់គ្រងជលផលទាំងនេះកំពុងប្រឈមនឹងបញ្ហាជាច្រើន ដែលបណ្តាលមកពីសកម្មភាពមនុស្ស កំណើនចំនួនប្រជាជន ការបំផ្លិំបំផ្លាញទីជម្រកធម្មជាតិ ការប្រែប្រួលជលសាស្ត្រ ការបំពុលបរិស្ថាន វត្តមាននៃប្រភេទរាតត្បាតចង្រៃ ការប្រែប្រួលអាកាសធាតុ ព្រមទាំងការប្រើប្រាស់ឧបករណ៍នេសាទមិនត្រឹមត្រូវ។ ដូច្នេះការសិក្សាស្រាវជ្រាវរបស់ខ្ញុំមានគោលបំណងជួយទ្រទ្រង់ដល់ផែនការគ្រប់គ្រងជលផល តាមរយៈការប្រមូលព័ត៌មានពីបរិមាណ និងតម្លៃសេដ្ឋកិច្ចនៃប្រភេទត្រីនេសាទដែលបានដោយប្រើប្រាស់ឧបករណ៍មងនៅតាមដងទន្លេសាប។ ទំនាក់ទំនងរវាងប្រវែង និងទម្ងន់ខ្លួនរបស់ត្រីក៏ត្រូវបានសិក្សាវាយតម្លៃ ដើម្បីទាញការសន្និដ្ឋានអំពីលំនាំនៃការលូតលាស់របស់ត្រីចំនួន១២ប្រភេទ។ ខ្ញុំបានប្រមូលទិន្នន័យជលនេសាទដោយឧបករណ៍មងបណ្តែត ពីទីតាំងចំនួន៣ផ្សេងគ្នានៅតាមដងទន្លេសាប ចាប់ពីខែធ្នូ ឆ្នាំ២០១៨ ដល់ខែកុម្ភៈ ឆ្នាំ២០១៩។ លទ្ធផលសិក្សារបស់ខ្ញុំបានបង្ហាញថា ផលចាប់សរុបគឺប្រហែល ៣៨១តោន (៥៨៦ ៤៤៦ ១៥៣ ក្បាល) ដែលមាន៦២ប្រភេទ ១៩អម្បូរ និង៨លំដាប់។ ត្រីនៅក្នុងអម្បូរ Cyprinidae ត្រូវបានចាប់ច្រើនជាងគេ គឺមានចំនួនរហូតដល់២៨ប្រភេទ បន្ទាប់មកគឺ Pangasiidae (១៧ប្រភេទ) និង Bagridae (១៤ប្រភេទ)។ ផលនេសាទប្រចាំខែជាមធ្យមមានចំនួន ៦២,៩៦% (±០,៤៨) តោន រីឯផលនេសាទប្រចាំថ្ងៃជាមធ្យមក្នុងមួយទូកគឺ ៥០,៧៧ (±០,៤២) គីឡូក្រាម ក្នុងអំឡុងពេលផលចាប់ខ្ពស់ និង១៣,១០ (±០,៧) គីឡូក្រាម ក្នុងអំឡុងពេលផលចាប់ទាប។ តម្លៃមធ្យមត្រីលក់ពីទូកគឺ ៧ ១០៦,១៦ (±៩៣,៣៧) រៀលក្នុងមួយគីឡូក្រាម ប៉ុន្តែតម្លៃត្រីមានការផ្លាស់ប្តូរទៅតាមទីតាំង ពេលវេលា និងបម្រែបម្រួលទិន្នផលនេសាទ។ តម្លៃប៉ាន់ស្មាននៃផលចាប់សរុបបានពីការសិក្សានេះគឺ ៦៣៤ ៣១៣ ដុល្លាអាមេរិក។ ប្រវែងនិងទម្ងន់ត្រីទាំង១២ប្រភេទ ស្ថិតក្នុងចន្លោះពី ៦,៤ ដល់ ៤០,៥ ម.ម និង ៣,២ ដល់ ៧២,៥ ក្រាម។ Regression models បានបង្ហាញថា ត្រីចំនួន១១ប្រភេទមានតម្លៃមេគុណ (coefficient value) b<៣ ដែលបង្ហាញពីភាពអវិជ្ជមាននៃការលូតលាស់របស់ត្រី ប៉ុន្តែមានត្រី១ប្រភេទគឺ *Puntioplites proctozytron* តម្លៃមេគុណ b>៣ ដែលបង្ហាញពីអវិជ្ជមាននៃការលូតលាស់របស់ត្រី។

Abstract

The Tonle Sap Lake is the most productive freshwater lake in the world. From June until September each year, millions of fingerlings and some migratory fish species access flooded areas surrounding the lake via the Tonle Sap River. These fisheries face many management challenges due to human activities and population growth, habitat degradation, hydrological changes, environmental pollution, invasive species, climate change and use of inappropriate fishing gears. My study aimed to support their management by documenting the quantity and economic value of fish species harvested in gillnets along the Tonle Sap River. Relationships between length and weight were also evaluated to infer growth patterns in 12 fish species. I collected data on drift gillnet fisheries at three sites along the Tonle Sap River from December 2018 to February 2019. My results suggest that the total study catch comprised approximately 381 tonnes of fish (586,446,153 individuals) which belonged to 62 species, 19 families and eight orders. Members of the Cyprinidae

were caught the most with 28 species, followed by Pangasiidae (17 species) and Bagridae (14). The average monthly catch was 62.96 (±0.48) tonnes, whereas the average daily catch per boat was 50.77 (±0.42) kg during peak periods and 13.10 (±0.7) kg during low periods. First-sale-landing-prices were 7,106.16 (±93.37) riel/kg on average, but varied according to study site, lunar-phase and trends in catches. The total estimated value of fish caught during the study was 634,313 USD. Fish lengths and weights ranged from 6.4 to 40.5 mm and 3.2 to 72.5 g respectively across the 12 species assessed. Regression models showed that 11 of these had a coefficient value of b<3, indicating negative allometric growth, whereas one species (*Puntioplites proctozytron*) had a coefficient value of b>3, indicating positive allometric growth.

The diversity, community structure and health of corals at Koh Arch Seh in Kep Province, Cambodia

ITH Sreyoun

មូលន័យសង្ខេប

គោលបំណងនៃការសិក្សារបស់ខ្ញុំគឺ ដើម្បីស្ទើបអង្កេតពីនានាភាពនៃផ្កាថ្មប៉ប្រះទឹកនៅជុំវិញកោះអាចម៍សេះក្នុងប្រជុំកោះកែប ព្រមទាំងដើម្បីបង្ហាញពីឥទ្ធិពលនៃកត្តាបរិស្ថានទៅលើសុខភាពរបស់ពួកវា។ ដើម្បីសម្រេចបាននូវគោលបំណងនេះ ខ្ញុំបានកំណត់យកទីតាំងចំនួន១៦កន្លែងនៅជុំវិញកោះ ក្នុងអំឡុងខែមិថុនា ដល់ខែកញ្ញា ឆ្នាំ២០១៩ ដោយប្រើប្រាស់ឧបករណ៍អន្ទាក់ដីល្បាប់ (sediment traps) និងវិធីសាស្ត្រខ្សែបន្ទាត់ (transect) ប្រវែង៥០ម៉ែត្រ ដោយខ្សែបន្ទាត់នីមួយៗមានការ៉ (quadrate) ចំនួន១១ប៉ុនៗគ្នា។ សមាសភាពផ្កាថ្ម របាយ ការប្រែទៅជាពណ៌ាស និងជំងឺត្រូវបានវាស់វែងដោយការវិភាគរូបភាពឌីជីថលនៃការ៉ែនីមួយៗ ហើយការវិភាគបែបចង្កោមហានុក្រម(hierarchical cluster) ត្រូវបានប្រើដើម្បីកំណត់ចំណែកថ្នាក់នៃសហគមន៍ផ្កាថ្មនៅជុំវិញកោះ។ មាត្រដ្ឋានពហុវិមាត្រមិនមែនលេខ(NMDS) ត្រូវបានប្រើដើម្បីបង្ហាញពីទំនាក់ទំនងរវាងផ្កាថ្ម ទៅនឹងកត្តាបរិស្ថាន (សីតុណ្ហភាព កម្រិតរលាយអុកស៊ីសែន កម្រិតអាស៊ីត-បាស កម្រិតអំបិល និងកករ)។ លទ្ធផលរបស់ខ្ញុំបានបង្ហាញថា សហគមន៍ផ្កាថ្មស្ថិតនៅភាគខាងត្បូង ភាគខាងកើត និងភាគខាងលិចនៃកោះអាចម៍សេះ ត្រូវបានចែកចេញជា៣ក្រុម ដែលខុសគ្នាមិនដាច់ ខាតបើធៀបដោយភាគរយនៃគម្របផ្កាថ្មជារួម។ ជំងឺនិងការប្រែជាពណ៌ាសរបស់ផ្កាថ្មមិនត្រូវបានប្រទះឃើញទេ និងNMDS បានបង្ហាញថា គ្មានកត្តាបរិស្ថានណាមួយដែលមានទំនាក់ទំនងជាមួយនឹងសហគមន៍ផ្កាថ្មឡើយ ទោះបីជាមានទិន្នន័យផ្សេងទៀតបានស្នើឡើងថា នៅភាគខាងកើតនៃកោះមានកម្រិតកករខ្ពស់ជាងភាគផ្សេងទៀតក៏ដោយ។ *Favites spp* និង *Goniastrea spp* ត្រូវបានរកឃើញជាប្រភេទសូចនាករសម្រាប់សហគមន៍ផ្កាថ្មប៉ប្រះទឹកនៅភាគខាងត្បូង និងភាគខាងលិចនៃកោះ ចំណែកឯ *Goniastrea spp* គឺជាប្រភេទសូចនាករសម្រាប់សហគមន៍ផ្កាថ្មនៅភាគខាងត្បូង។ សរុបមកការសិក្សារបស់ខ្ញុំបានផ្តល់ជាទិន្នន័យមូលដ្ឋានសម្រាប់ការតាមដានពីស្ថានភាពអភិរក្ស និងសុខភាពរបស់ផ្កាថ្មប៉ប្រះទឹកនៅជុំវិញកោះអាចម៍សេះសម្រាប់ពេលអនាគត។

Abstract

The aim of my study was to investigate the diversity of coral reefs surrounding Koh Arch Seh in the Kep Archipelago and explore the influence of selected environmental factors on their health. To achieve this, I sampled 16 sites around the island from June to September 2019 using sediment traps and 50 m long transects, each comprising 11 equidistant quadrats. Coral composition, cover, bleaching and disease were measured through digital analysis of photographic imagery for each quadrat and hierarchical cluster analysis was used to determine taxonomic variation in coral communities surrounding the island. Non-metric multi-dimensional scaling (NMDS) was employed to relate coral genera to several environmental variables (temperature, dissolved oxygen, pH, salinity and sedimentation). My results indicated that coral communities on the southern, eastern and western sides of Koh Arch Seh belong to three separate taxonomic clusters which do not differ significantly in terms of their overall percentage cover. Coral disease and bleaching were not observed and NMDS suggested that none of the environmental factors sampled were significantly associated with the coral communities, although other data suggested that the eastern side of the island experiences greater sedimenta-

tion stress. *Favites* spp. and *Goniastrea* spp. were found to be indicator taxa for coral communities on the latter side of the island, whereas *Goniastrea* spp. were indicative of coral communities on the southern side. Taken together, my study provides a baseline for future monitoring of the conservation status and health of coral reefs surrounding Koh Arch Seh.

Distribution patterns and community structure of freshwater fish in Cambodia

NUT Savat

មូលន័យសង្ខេប

ប្រទេសកម្ពុជាទ្រទ្រង់ចម្រុះភាពរបស់ត្រីយ៉ាងច្រើនសម្បូរបែប ហើយជលផលត្រីទឹកសាបរបស់ប្រទេសនេះចូលរួមយ៉ាងច្រើនក្នុងការរក្សាសន្តិសុខស្បៀងសម្រាប់ប្រជាជនរាប់លាននាក់។ ទោះជាយ៉ាងនេះក្តីមានការសិក្សាតិចតួចណាស់ដែលបានធ្វើឡើងដើម្បីស្វែងយល់អំពីចម្រុះភាព និងការប្រមូលផ្តុំរបស់សហគមន៍ត្រីទឹកសាបទូទាំងប្រទេស។ គោលបំណងនៃការសិក្សានេះគឺដើម្បីបំពេញភាពខ្វះខាតខាងលើនេះ ដោយធ្វើការវិភាគទិន្នន័យផលចាប់ត្រីប្រចាំថ្ងៃពេញមួយឆ្នាំ២០១៧ ដែលប្រមូលពីទីតាំងសិក្សាចំនួន ៣២ កន្លែង ក្នុងដែនទឹកសាបសំខាន់នៃប្រទេសកម្ពុជា។ យើងក៏បានធ្វើការសិក្សាពីទំនាក់ទំនងរវាងប្រវែងបណ្តោយខ្លួន និងទម្ងន់របស់ប្រភេទត្រីសូចនាករនៅក្នុងសហគមន៍ផ្សេងៗគ្នារបស់វា។ លទ្ធផលនៃការសិក្សាបានបង្ហាញថា ត្រីចំនួន ១២៥ប្រភេទ ដែលស្ថិតក្នុង៨៩ពូក ៣៣អំបូរ និង១៤លំដាប់ ត្រូវបានចាប់ពីទីតាំងសិក្សាទាំង៣២ក្នុងឆ្នាំ២០១៧។ ត្រីដែលចាប់បានប្រមាណ ៥២% គឺស្ថិតក្នុងអំបូរ Cyprinidae។ ចេញពីសំណាកត្រីដែលបានប្រមូលទាំងអស់ យើងអាចបែងចែកវាជាបួនក្រុមដាច់ពីគ្នា ដោយយោងទៅលើភាពប្រហាក់ប្រហែលគ្នានៃទម្រង់នៃការប្រមូលផ្តុំ ហើយក្រុមទាំងបួននេះមានត្រីដែលជាសូចនាករចំនួន៩៥ប្រភេទ។ បណ្តុំប្រភេទត្រីដែលមានតម្លៃសន្ទស្សន៍ចម្រុះភាពខ្ពស់ជាងគេគឺនៅផ្នែកខាងលើទន្លេមេគង្គកម្ពុជា (ប្រព័ន្ធទន្លេ ៣) ខណៈបណ្តុំប្រភេទត្រីដែលមានតម្លៃសន្ទស្សន៍ចម្រុះភាពទាបជាងគេគឺនៅតំបន់ភាគខាងជើង និងភាគខាងត្បូងនៃបឹងទន្លេសាប។ ការវិភាគពីទំនាក់ទំនងរវាងប្រវែងបណ្តោយខ្លួន និងទម្ងន់បានបង្ហាញថា ត្រីដែលជាសូចនាករភាគច្រើនមានសន្ទស្សន៍ការលូតលាស់អវិជ្ជមាន។ លទ្ធផលនៃការសិក្សានេះអាចយកទៅប្រើប្រាស់ដើម្បីបង្កើនប្រសិទ្ធិភាពគ្រប់គ្រង និងអភិរក្សជលផលទឹកសាបក្នុងប្រទេសកម្ពុជា។

Abstract

Cambodia supports exceptionally high fish biodiversity and its freshwater fisheries contribute substantially to the food security of millions of rural people. Despite this, few studies have been undertaken to understand country-wide patterns in the diversity and assemblage structure of inland fish communities. My study aimed to address this knowledge gap by analysing daily fish catch data collected throughout 2017 at 32 study sites including all of the main freshwater bodies in Cambodia. I also investigated relationships between length and weight for selected indicator species in different fish assemblages. My results indicate that 125 fish species arranged in 14 orders, 33 families and 89 genera were caught at the 32 study sites in 2017, 51% of which belonged to the Cyprinidae. Across the fish assemblages sampled, four distinct clusters were apparent due to similarities in assemblage structure and these were collectively characterised by 95 indicator species. The fish assemblages with the highest diversity index values occurred in the upper sections of the Mekong River in Cambodia (the 3S system), whereas those with the lowest diversity values occurred in the northern and southern areas of the Tonle Sap Lake. Analyses of length-weight relationships suggested that most of the indicator species had negative allometric growth patterns. The results of my study can be used to improve conservation and management initiatives for freshwater fisheries in Cambodia.

Occupancy modelling and activity patterns of large mammals and small carnivores in Srepok Wildlife Sanctuary, eastern Cambodia

TOEM Yean

មូលន័យសង្ខេប

ការសិក្សានេះធ្វើឡើងក្នុងគោលបំណងពិនិត្យទៅលើការកាន់កាប់ទីជម្រក អត្រានៃការជួបប្រទះ សកម្មភាពប្រចាំថ្ងៃ និងទំនោរនៃការប្រើប្រាស់ទីជម្រករបស់សត្វដំរី សត្វចតុប្បាទទំពារអៀង និងពពួកមំសាសត្វមួយចំនួននៅក្នុងដែនជម្រកសត្វព្រៃស្រែពក ភាគខាងកើតប្រទេសកម្ពុជា។ ដើម្បីសម្រេចគោលបំណង យើងបានប្រមូលទិន្នន័យរូបភាពពីម៉ាស៊ីនថតស្វ័យប្រវត្តិដែលបានដាក់នៅក្នុង៦៩ទីតាំងក្នុងតំបន់ស្នូលនៃដែនជម្រកសត្វព្រៃស្រែពក ពីខែកុម្ភៈ ដល់ខែឧសភា ឆ្នាំ២០១៩។ សត្វដំរី ទន្សោង និងខ្ទីងមានអត្រាថតបានតិតតូច (relative abundance index [RAI]=៧,៧៩) ខណៈសត្វឈ្លូស និងជ្រូកព្រៃមានអត្រាថតបានខ្ពស់ជាងគេ (RAI=១៧,២៣)។ សត្វឈ្លូស ធ្វើសកម្មភាពខ្លាំងនៅពេលព្រឹកព្រលឹម រីឯជ្រូកព្រៃធ្វើសកម្មភាពខ្លាំងទាំងពេលព្រឹកព្រលឹម និងក្បាលព្រលប់។ សត្វដំរី និងទន្សោងធ្វើសកម្មភាពខ្លាំងនៅពេលយប់ ហើយប្រើប្រាស់ទីជម្រកក្នុងព្រៃល្បោះ (DDF) ច្រើនជាងព្រៃពាក់កណ្តាលស្រោង (SEF)។ ផ្ទុយទៅវិញសត្វឈ្លូសមានទំនោរប្រើប្រាស់ទីជម្រកក្នុងព្រៃពាក់កណ្តាលស្រោង ខណៈជ្រូកព្រៃមានទំនោរប្រើប្រាស់ទីជម្រកក្នុងព្រៃទាំងពីរប្រភេទប្រហាក់ប្រហែលគ្នា។ មំសាសត្វតូចៗចំនួន៧ប្រភេទត្រូវបានកត់ត្រា ហើយភាគច្រើនមានទំនោរប្រើប្រាស់ទីជម្រកក្នុងព្រៃពាក់កណ្តាលស្រោងលើកលែងតែសត្វខ្ទីង (*Viverra megaspila*) ដែលចូលចិត្តបង្ហាញខ្លួនក្នុងព្រៃល្បោះ។ ក្នុងចំណោមប្រភេទសត្វតូចៗដែលបានកត់ត្រា សត្វប្រមា (*Hystrix brachyura*) មានអត្រាថតបានច្រើនជាងគេ (RAI=៥,៦៨) ហើយបន្ទាប់មកគឺសត្វសំពោចវល្លិ៍ ឬសំពោចតូច (*V. zibetha*) (RAI=៣,២២)។ លទ្ធផលនេះ មានលក្ខណៈប្រហាក់ប្រហែលនឹងលទ្ធផលនៃការសិក្សាកន្លងមកក្នុងដែនជម្រកសត្វព្រៃស្រែពក ក៏ដូចជាក្នុងទីតាំងផ្សេងៗទៀតនៃតំបន់អាស៊ីអាគ្នេយ៍។ យ៉ាងណាក្តីយើងបានកត់ត្រានូវសកម្មភាពល្មើសជាច្រើនរបស់មនុស្សនៅក្នុងតំបន់ស្នូល ដែលអាចជាមូលហេតុបណ្តាលឱ្យមានការថយចុះនូវប្រភេទសត្វដែលកំពុងរងការគំរាមកំហែងក្នុងដែនជម្រកសត្វព្រៃស្រែពក ជាពិសេសគឺសត្វទន្សោង។ ការអភិរក្សព្រៃល្បោះ ព្រៃពាក់កណ្តាលស្រោង និងត្រពាំងទឹកធម្មជាតិគួរតែជាសកម្មភាពអាទិភាពដើម្បីគ្រប់គ្រងប្រភេទសត្វកំពុងរងការគំរាមកំហែង ដែលកំពុងមានវត្តមានក្នុងដែនជម្រកសត្វព្រៃស្រែពក។ ជាងនេះទៅទៀតការអនុវត្តច្បាប់ក៏គួរតែធ្វើឱ្យប្រសើរឡើងដើម្បីការពារប្រភេទសត្វទាំងអស់នេះសម្រាប់ជាប្រយោជន៍ដល់ប្រជាជនកម្ពុជាជំនាន់ក្រោយទៀត។

Abstract

My study aimed to investigate the occupancy, detection probabilities, activity patterns and habitat preferences of elephants, ungulates and carnivores in Srepok Wildlife Sanctuary, eastern Cambodia. To achieve this, I collected data from 69 camera stations within the core zone of the sanctuary from February to May 2019. Asian elephant *Elephas maximus*, banteng *Bos javanicus* and gaur *B. gaurus* were registered at very low rates (relative abundance index [RAI]=7.79), whereas red muntjac *Muntiacus muntjac* and wild pig *Sus scrofa* were recorded the most (RAI=17.13). The activity of red muntjacs peaked in early morning, whereas wild pigs were most active in the evening and early morning. Elephants and banteng were most active during the evening and their occupancy was greater in dry deciduous forest (DDF) than semi-evergreen forest (SEF). In contrast, red muntjacs preferred SEF, whereas wild pigs preferred DDF and SEF. Seven species of small carnivore were recorded which mostly preferred SEF, apart from the large-spotted civet *Viverra megaspila* which preferred DDF. Among the smaller species recorded, Asian porcupines *Hystrix brachyura* had the highest capture rates (RAI=5.68), followed by large Indian civets *V. zibetha* (RAI=3.22). My results on the activity and habitat preferences of these species are similar to those previously documented in the sanctuary and elsewhere in Southeast Asia. However, very high levels of illegal human activity have been documented in the core zone of the sanctuary and could be causing declines in several globally endangered species there, particularly for banteng. Conservation of DDF and SEF, as well as water holes, should be given priority for threatened species management in the sanctuary. Significantly greater commitments to law enforcement will also be required to preserve these species for the benefit of future generations in Cambodia.

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. Corresponding authors may be willing to provide free reprints or electronic copies on request and their email addresses, where known, are included in the summaries below.

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

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New species & taxonomic reviews

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

The author describes two new species of beetles to science, including one from Cambodia: *Pseudolathra armigera* sp. nov. The first country records of three additional species in the same genus are also documented and a catalogue of *Pseudolathra* species in the East Palaearctic and Oriental regions is provided. Author: vassing.hann@t-online.de

Assing, V. (2019) A revision of Palaearctic and Oriental *Scymbalium* and *Micrillus* IV. The fauna of Cambodia (Coleoptera, Staphylinidae, Paederinae). *Linzer biologische Beiträge*, **51**, 21–31.

This paper describes three new species of beetles to science from Cambodia: *Micrillus rossianus* sp. nov., *M. variceps* sp. nov. and *M. bispinosus* sp. nov. Records of one species of *Scymbalium* and four additional species of *Micrillus* are also documented. Author: vassing.hann@t-online.de

Assing, V. (2019) Three new species of *Platyprosopus* from Thailand, Cambodia, and Sierra Leone, and additional records (Coleoptera, Staphylinidae, Staphylininae). *Linzer biologische Beiträge*, **51**, 707–715.

The author describes three new species of beetles to science, including one from Cambodia: *Platyprosopus rossii* sp. nov. Additional records of three species of *Platyprosopus* are also reported, primarily from Cambodia, including two new records for the country. Author: vassing.hann@t-online.de

Bayarsaikhan, U., Ko J., Kwon H.-W. & Bae Y.-S. (2020) A new species of the genus *Tatargina* (Lepidoptera, Erebidae, Arctiinae) from Cambodia. *Zootaxa*, **4731**, 589–594.

This paper describes a new species of moth to science from Cambodia (*Tatargina erythromelaena* sp. nov.) and re-describes another species (*T. picta*) previously recorded in the country. Illustrations of adults and male genitalia of species in Cambodia and Thailand are also provided. Author: baeys@inu.ac.kr

Choi J.B., Han G.Y., Park J. & Park J.K. (2020) A taxonomic study on the genus *Amphimenes* Bates (Coleoptera: Carabidae: Lebiinae) from Cambodia. *Journal of Asia-Pacific Biodiversity*, **13**, 24–28.

The authors present the first record of the ground beetle genus *Amphimenes* (represented by *A. rugulipennis*) in Cambodia and describe a new species of *Amphimenes* to science from the country (*A. wooshini* sp. nov.). Illustrations and an identification key are also provided. Author: entopark@knu.ac.kr

Khorngton, S., Souladeth, P. & Prajaksood, A. (2020) *Eriocaulon longibracteatum* (Eriocaulaceae), a new species from Thailand and Cambodia. *Kew Bulletin*. DOI 10.1007/S12225-020-9879-1

This paper describes a new species of herbaceous plant to science from Cambodia and Thailand. The new species qualifies as Endangered under red list criteria and is presently known only from three populations and three localities. Authors: amopra@kku.ac.th

Kim B.-Y., Won H., Phourin C., Lim C.-K., Shin J.-S., Kim Y.-S. & Cho S.-H. (2019) *Impatiens cardamomensis* (Balsaminaceae), a new species from Cambodia. *Korean Journal of Plant Taxonomists*, **49**, 319–323.

The authors describe a new plant species to science from the Cardamom Mountains in Cambodia. The new species is similar to *Impatiens noei* from Thailand in some respects, but is readily distinguished by its ovate to widely ovate leaves, shorter petioles, widely elliptic dorsal petals and smaller seeds. Author: dricetea1@gmail.com

Likhitrakarn, N., Golovatch, S.I., Thach, P., Chhuoy S., Ngor P.B., Srisonchai, R., Sutcharit, C. & Panha, S. (2020) Two new species of the millipede genus *Plusioglyphiulus* Silvestri, 1923 from Cambodia (Diplopoda, Spirostreptida). *ZooKeys*, **938**, 137–151.

This paper describes two new species of millipedes to science based on specimens collected in southern Cambodia: *Plusioglyphiulus biserratus* sp. nov. and *P. khmer* sp. nov. A key to all four species of *Plusioglyphiulus* currently known to occur in Cambodia is also presented. Author: somsak.pan@chula.ac.th

Nuraliev, M.S., Yudina, S.V., Truong B.V., Do T.X., Luu H.T., Kuznetsov, A.N. & Kuznetsova, S.P. (2020) A revision of the family Thismiaceae (Dioscoreales) in Cambodia, Laos and Vietnam. *Phytotaxa*. DOI 10.11646/phytotaxa.441.3.1

Paper not seen.

Sanoamuang, L. & Watiroyram, S. (2020) *Phyllodiaptomus* (*Phyllodiaptomus*) *roietensis*, a new diaptomid copepod (Copepoda, Calanoida) from temporary waters in Thailand and Cambodia, with a key to the species. *Zookeys*, **911**, 1–20.

The authors describe a new species of copepod to science from specimens collected in Kampong Thom Province in Cambodia and two provinces in northeastern Thailand. An updated key to the species of the genus *Phyllodiaptomus* is also provided. Author: santi.watiroyram@npu.ac.th

Spitsyn, V.M. (2020) *Cyana pseudojavanica* sp. nov. from Thailand and Cambodia (Lepidoptera: Erebidae: Arctiinae). *Ecologica Montenegrina*, **31**, 6–9.

The author describes a new species of moth to science from Cambodia and Thailand. The new species is morphologically similar to *Cyana javanica* and was previously misidentified as this taxon. Author: spitsyn.v.m.91993@yandex.ru

Stuart, B.L., Som H.E., Neang T., Huy D.H., Duong T.T.L., Vinh Q.D., Potter K. & Rowley, J.J.L. (2020) Integrative taxonomic analysis reveals a new species of *Leptobrachium* (Anura: Megophryidae) from north-eastern Cambodia and central Vietnam. *Journal of Natural History*. DOI 10.1080/00222933.2020.1756498

The authors describe a new species of amphibian to science from northeastern Cambodia and the central highlands of Vietnam: *Leptobrachium lunatum* sp. nov. Their integrated analyses also indicate that three species of red-eyed *Leptobrachium* exist in southern Indochina. Author: bryan.stuart@naturalsciences.org

Zettel, H. & Pangantihon, C.V. (2020) A new species of the *Timasius livens* species group (Hemiptera: Heteroptera: Hebridae) from Cambodia and Vietnam. *Far Eastern Entomologist*, **405**, 8–14.

This paper describes a new hemipteran species to science based on specimens collected in Cambodia and Vietnam: *Timasius alveus* sp. nov. An updated diagnosis for the *T. livens* species group and a preliminary key to its species is also provided. Author: herbert.zettel@nhm-wien.ac.at

Field guides

Cambodia Bird Guide Association (2019) *Birds of Cambodia*. Lynx Edicions, Barcelona, Spain.

This 288-page field guide is an comprehensive introduction to the birds of Cambodia and includes almost 1,400 colour illustrations and text accounts for 629 species. The illustrations include all of these species and distinctive subspecies and where appropriate, renderings of birds in flight, males and females, juveniles and non-breeding plumages. Range maps are provided for all species other than vagrants. Text accounts are given for each species which detail their status, habitats and behaviour, age, sex and geographical variation and vocalisations. QR codes linked to audio-visual material are also provided for each species.

Nuñez, G.B., Cunningham, A., Fils, E.M.B., Frick, W., Islam, M.N., Jolliffe, T., Kading, R., Kepel, A., Kingston, T., Leopardi, S., Medellín, R., Mendenhall, I., Parsons, S., Racey, P., Russo, D., Shapiro, J.T., Vicente-Santos, A., Víquez-R, L. & Vu D.T. (2020) *IUCN SSC Bat Specialist Group (BSG) Recommended Strategy for Researchers to Reduce the Risk of Transmission of SARS-CoV-2 from Humans to Bats, MAP: Minimize, Assess, Protect*. Living Document Version 1.0, IUCN Species Survival Commission Bat Specialist Group. Https://www.iucnbsg.org/publications.html [Accessed 20 June 2020].

In April 2020, the bat specialist group of the IUCN SSC recommended the suspension of all field work involving interactions with bats while it convened a global panel of experts to consider the risk of SARS-CoV-2 transmission. The opinion of the panel is that there is a credible risk of human-to-bat transmission of SARS-CoV-2, but this risk can be reduced using appropriate mitigation strategies. This document provides guidance to this end and was developed primarily for researchers. As understanding of SARS-CoV-2 is changing rapidly, updates to the guidance document are anticipated.

Biodiversity inventories

Gray, T.N.E, Grosu, R. & Chum S. (2019) Unexpected discovery in the Cardamom Rainforest Landscape, Cambodia: a white-eared night heron *Gorsachius magnificus* in Botum Sakor National Park. *BirdingASIA*, **32**, 12–14.

The white-eared night heron is a little-known nocturnal heron hitherto documented in southern China, northern Vietnam and eastern India. The authors document a significant range extension for the species based on camera trap images taken in Botum Sakor National Park in March, 2017. Author: gray@wildlifealliance.org

Long K.D. & Try Y. (2018) A survey on parasitoids of rice pest insects in Sisophon, northwest Cambodia. *Academia Journal of Biology*, **40**, 143–146.

The authors document parasitoids of rice insect pests recorded during a short survey in the Sisophon area of Banteay Meanchey Province. These included six larval braconid parasitoids, two pupal ichneumonid species and one egg scelionid parasitoid, all of which are new records for Cambodia. Author: khuatdanglong@gmail.com

Species ecology & status

Brownell Jr., R.L., Reeves, R.R., Read, A.J., Smith, B.D., Thomas, P.O., Ralls, K., Amano, M., Berggren, P., Aung Myo Chit, Collins, T., Currey, R., Dolar, M.L.L., Genov, T., Hobbs, R.C., Kreb, D., Marsh, H., Zhigang M., Perrin, W.F., Phay S., Rojas-Bracho, L., Ryan, G.E., Shelden, K.E.W., Slooten, E., Taylor, B.L., Vidal, O., Ding W., Whitty, T.S. & Wang J.Y. (2019) Bycatch in gillnet fisheries threatens Critically Endangered small cetaceans and other aquatic megafauna. *Endangered Species Research*, **40**, 285–296.

The conservation status of small cetaceans has worsened since the 1980s and 13 species, subspecies or populations of these are currently listed as Critically Endangered on the IUCN Red List. The authors review information on their status and current threats and consider conservation actions needed to save them. Their major finding is that bycatch in gillnets remains the greatest threat and that very little progress has been made to reduce this over the last 30 years. They conclude that solving this challenge will require development of efficient and inexpensive fishing gears to replace gillnets without jeopardizing fishing livelihoods. Good fishery governance and direct involvement of fishing communities will be also essential to conserve the most threatened small cetaceans. Author: robert.brownell@noaa.gov

Chhin S., Souter, N.J., Ngoprasert, D., Browne, S.J. & Savini, T. (2020) Spatial interactions between sympatric partridges in the Cardamom Mountains, Southwest Cambodia. *Raffles Bulletin of Zoology*, **68**, 308–318.

Identifying the causes of variation in the habitat use and home range of species is important for planning their conservation. The authors evaluated spatial interactions within and between the chestnut-headed partridge *Arborophila cambodiana* and scaly-breasted partridge *Tropicoperdix chloropus* in evergreen forests in the Cardamom Mountains. Their results indicate that while the two species seem to prefer similar habitats, *A. cambodiana* has a slightly larger home range and is restricted to steeper slopes, whereas *T. chloropus* tends to use areas closer to water sources and has a comparatively smaller home range. Their analyses also suggest that small interspecific and minimal intraspecific overlaps occur in their home ranges, with *A. cambodiana* having a slightly greater overlap in intraspecific home range than *T. chloropus*. Author: sopheachhin@gmail.com

Davis, E.O., Gibson, M., Lim T. & Glikman, J.A. (2020) Bear bile use at the intersection of maternal health in Cambodia. *Journal of Ethnobiology and Ethnomedicine*. DOI 10.1186/s13002-020-00380-6

Consumption of bear gallbladders and bear bile is a persistent threat to bear populations in Southeast Asia. The authors interviewed 122 women seeking treatment for post-partum and uterine ailments in seven provinces of Cambodia as part of a larger effort to understand the consumption of bear parts in the country. Their results suggest that the continued use of bear bile and bear gallbladder for these purposes seems to be facilitated by a desire for support from kin networks. They recommend that efforts to reduce consumption should focus on encouraging older kin to change their means of support to western/biomedical and by extension non-wildlife alternatives. Author: edavis@sandiegozoo.org

Gray, T.N.E, Grainger, M.J. & Grosu, R. (2019) Conservation decision-making under uncertainty: identifying when to reintroduce tiger *Panthera tigris* to Cambodia. *Conservation Science and Practice*. DOI 10.1111/csp2.187

Presenting the results of biological monitoring in terms of the probability of a hypothesis being true may have greater utility for decision-making than traditional statistical approaches. The authors adopt this approach in assessing the suitability of the Cardamom Rainforest Landscape for reintroduction of tigers *Panthera tigris*. Their results suggest there is currently a low probability that the core area of the landscape supports sufficient prey to sustain a population of 25 adult tigers and that this in turn means significant prey recovery will be required before the species can be reintroduced there. Author: romicagrosu@gmail.com

Ryan, G.E., Nicholson, E., Eames, J.C., Gray, T.N.E., Loveridge, R., Mahood, S.P., Sum P. & McCarthy, M.A. (2019) Simultaneous-count models to estimate abundance from counts of unmarked individuals with imperfect detection. *Conservation Biology*, **33**, 697–708.

The authors describe a new method to estimate population abundance from simultaneous counts of unmarked individuals at multiple sites. They apply the method to data for three Critically Endangered vulture species in Cambodia to demonstrate its applicability and provide the first abundance estimates for these species. Their method complements existing approaches for estimating the abundance of unmarked individuals and is the first method designed specifically for simultaneous counts. Author: gezryan@gmail.com

Thomas, P.O., Gulland, F.M.D., Reeves, R.R., Kreb, D., Ding W., Smith, B., Malik, M.I., Ryan, G.E. & Phay S. (2019) Electro-

fishing as a potential threat to freshwater cetaceans. *Endangered Species Research*, **39**, 207–220.

Illegal use of electrofishing affects freshwater fish populations in many parts of the world, and has been cited as a cause of mortality for endangered freshwater cetaceans in China and Southeast Asia, although the extent of this threat is unclear. The authors review the evidence that electrofishing is a serious threat to freshwater cetaceans. They conclude that while mortality from electrofishing seems to be uncommon for freshwater cetaceans, given the present uncertainties and many other threats faced by the small populations of these species, high priority should be given to enforcing electrofishing bans in the freshwater habitat of dolphins and finless porpoises. Author: pthomas@mmc.gov

Tubbs, S.E., Keen, E., Jones, A.L. & Thap R. (2020) On the distribution, behaviour and seasonal variation of Irrawaddy dolphins (*Orcaella brevirostris*) in the Kep Archipelago, Cambodia. *Raffles Bulletin of Zoology*, **68**, 137–149.

While much research has been undertaken on freshwater populations of the Endangered Irrawaddy dolphin, marine populations of the species have received much less attention. The authors combined year-long land and boat surveys to identify seasonal habitats for these in the Kep Archipelago and generate information on their behavioural ecology. Their results indicate that Irrawaddy dolphins and juveniles of the species are present in all seasons, which suggests the region is an important nursing ground. Foraging was the most commonly observed behaviour and significant associations were found between certain behavioural states and events, group sizes and seasons, group sizes and juvenile presence, and swimming styles and juvenile presence. Author: sarahtubbs123@gmail.com

Coasts, wetlands & aquatic resources

Bahadur, K.K.C., Elliott, V., Seng R., Pomeroy, R.S., Schenkels, J. & Fraser, E.D.G. (2020) Evaluating community fishery management using fishers' perceptions in the Tonle Sap lake of Cambodia. *Environmental Development*, **33**, 100503.

There is emerging consensus that resource management systems must be developed locally and account for a diverse range of factors if they are to succeed. The authors conducted interviews to evaluate the perspectives of fishers in the Tonle Sap Lake on the impacts of reforms in 2012 which replaced a commercial leasehold system with a community-based fishery management system. Their results indicate that the 2012 reforms are perceived as having helped to improve economic, environmental, and legal conditions at a macro-level, but improvements in economic productivity at an individual level remain inconclusive. Author: krishnak@uoguelph.ca

Campbell, T., Pin K., Ngor P.B. & Hogan, Z. (2020) Conserving Mekong megafishes: current status and critical threats in Cambodia. *Water*. DOI 10.3390/w12061820

The northern Cambodian Mekong River and its major tributaries are one of the last refugia for Mekong megafishes (fishes which attain a maximum body weight of ≥30 kg). The authors interviewed 96 fishers in 12 villages to investigate trends in populations and body size for eight megafish species in this region. Their results suggest that all eight species have declined greatly in body size and that most have changed from common to uncommon, rare, or locally extirpated over the last 20 years. Fishers identified ten threats to megafishes, including seven types of illegal fishing. The authors conclude that Mekong megafishes are severely endangered and require species conservation strategies to recover their populations. Author: zhogan@unr.edu

Kim M., Mam K., Sean V., Try V., Brooks, A., Thay S., Hav V. & Gregory, R. (2019) *A Manual for Community Fish Refuge-Rice Field Fisheries System Management in Cambodia*. Fisheries Administration and WorldFish, Phnom Penh, Cambodia.

This manual provides detailed guidance on the selection of community fish refuges (CFRs), how to design functional CFRs and how to improve their physical and biological characteristics and connectivity with surrounding environments. This in turn enables them to function as sustainable systems which can be harvested for fish by communities in adjacent floodplains and rice field environments.

Krittasudthacheewa, C., Hap N., Bui D.T. & Saykham, V. (2019) *Development and Climate Change in the Mekong Region: Case Studies*. Strategic Information and Research Development Centre, Selangor, Malaysia and Stockholm Environment Institute Asia Centre, Bangkok, Thailand.

Environmental sustainability is a major concern in the countries of the Mekong Region (Cambodia, Lao PDR, Myanmar, Thailand and Vietnam). This publication presents case studies on a range of environmental issues within the region, including Cambodia.

Kwok, E.Y.K., Bahadur, K.K.C., Silver, J.J. & Fraser, E. (2019) Perceptions of gender dynamics in small-scale fisheries and conservation areas in the Pursat Province of Tonle Sap Lake, Cambodia. *Asia Pacific Viewpoint*. DOI 10.1111/apv.12225

Women's contributions in fisheries are often overlooked due to socio-cultural expectations of roles and responsibilities. The authors interviewed fishers and key informants in Pursat Province to investigate whether there were differences between men's and women's perceptions of i) fishing and non-fishing practices; ii) power, access and control over fishing resources; and iii) percep-

tions towards conservation and conservation areas in the study area. Their findings suggest that community perspectives and unequal power relations have established specific roles for women which limit their participation in fisheries management. Author: eugeniakwok@outlook.com

Sharma, S., MacKenzie, R.A., Tieng T., Kim S., Tulyasuwan, N., Resanond, A., Blate, G. & Litton, C.M. (2020) The impacts of degradation, deforestation and restoration on mangrove ecosystem carbon stocks across Cambodia. *Science of the Total Environment*. DOI 10.1016/j.scitotenv.2019.135416

Despite their contribution to climate change mitigation and adaptation, mangrove forests have been lost or degraded at an alarming rate. The authors used a gridded sampling approach to examine how land use cover in mangroves (pristine, deforested, degraded and restored forests) affects their total carbon stocks and how total carbon stocks vary in mangroves across Cambodia. They found that carbon stocks were always lower in deforested mangroves compared to pristine mangroves, but did not differ between pristine and degraded mangroves and mangroves restored 25 years previously. They also document spatial variability in the carbon stocks of mangrove forests across Cambodia. Author: richard.mackenzie@usda.gov

Sorn P. & Veth S. (2019) *Climate Change Vulnerability Assessment Koh Kapik Ramsar Site, Cambodia*. IUCN, Bangkok, Thailand.

Koh Kapik Ramsar Site is located along the coastline in southwest Cambodia and overlaps with Peam Krasop Wildlife Sanctuary and Botum Sakor National Park. In addition to evergreen and semi-evergreen forests and seagrass beds, this area hosts some of the last remaining pristine mangrove forests around the Gulf of Thailand. The authors evaluate the vulnerability of ecosystems and livelihoods in and around the site to climate change impacts and identify actions to improve local resilience to these impacts.

Sophanna L., Pok H. & Avent, T. (2019) *Climate Change Vulnerability Assessment for Boueng Prek Lapouv Protected Landscape, Cambodia*. IUCN, Bangkok, Thailand.

Infrastructure developments, deforestation, expansion of irrigated agriculture and increasing urbanisation have led to a decline in wetlands within the Lower Mekong Region. The Boeung Prek Lapouv Protected Landscape in Takeo Province is one of the largest remaining seasonally-inundated grasslands in this region and is also one of three conservation areas for sarus crane *Grus antigone* in Cambodia. The authors evaluate the vulnerability of ecosystems and livelihoods in and around the site to climate change impacts and identify methods to strengthen local resilience to these impacts.

Forests & forest resources

Chan V., Khun S., Sun L., Sokheng T., Kim S., Dary C. & Chheang S. (2020) Ethnobotanical study of medicinal plants used for the treatment of headache, low back, and joint pains in three provinces in Cambodia. *Asian Journal of Pharmacognosy*, **4**, 5–14.

The authors investigated medicinal plants used by traditional Khmer healers to alleviate lower back pains, headaches and joint pains in Kampot, Siem Reap and Phnom Penh. They found 108 species were used to treat these ailments, including 65 species for lower back pain, 35 species for headaches and 46 species for joint pains. They conclude that chemical and pharmacological studies should be undertaken to justify the use of five species reported to have the highest fidelity in traditional healthcare. Author: sokuntheakhn@gmail.com

Johansson, E., Olin, S. & Seaquist, J. (2020) Foreign demand for agricultural commodities drives virtual carbon exports from Cambodia. *Environmental Research Letters*, **15**, 064034.

Rapid deforestation is a major sustainability challenge, partly as the loss of carbon sinks exacerbates global climate change. The authors employed remote sensing to identify hotspots for carbon loss in Cambodia between 1987 and 2017 and linked global consumption and production patterns to their environmental effects in Cambodia by mapping the countries to which land-use embedded carbon are exported. Their results indicate natural forests in the country decreased by 21–57% over the study period and that the highest loss rates occurred in economic land concessions. China was found to be the largest importer of embedded carbon and Cambodian investors also negatively affected carbon pools through export-orientated products like rubber. Author: emmajohansson@gmail.com

Ken S., Entani T., Tsusaka T.W. & Sasaki N. (2020) Effect of REDD+ projects on local livelihood assets in Keo Seima and Oddar Meanchey, Cambodia. *Heliyon*, **6**, e03802.

Climate-change mitigation projects are expected to improve local livelihoods in their target areas, but few studies have examined their effects before and during project implementation. The authors applied a sustainable livelihood framework to assess the livelihood assets of local communities in REDD+ project sites in Oddar Meanchey and Keo Seima to this end. Their results suggest that while livelihood assets increased slightly during the study period, natural capital assets declined sharply. The decline was mainly attributed to illegal logging by study respondents, but the scarcity of carbon-credit buyers and projects' inability to generate carbon-based revenues apparently also led to dissatisfaction among local communities, inducing avoidable illegal activities in pursuit of short-term benefits. The authors

conclude that financial mechanisms are urgently needed to ensure sufficient and sustained financial support regardless of carbon-market volatility. Author: ab18l201@ai.u-hyogo.ac.jp

Ota T., Lonn P. & Mizoue N. (2020) A country scale analysis revealed effective forest policy affecting forest cover changes in Cambodia. *Land Use Policy*, **95**, 104597.

Effective conservation approaches are needed to reduce deforestation and degradation in tropical countries. The authors compared levels of deforestation between 2006 and 2016 in community forests, protected areas, otherwise protected forests and non-conserved forest areas in Cambodia. Their results indicate that the first three management approaches significantly decreased forest loss compared to non-conserved areas and suggest that protected forests and community forests were the most and least effective in doing so, respectively. They also suggest that the authority managing a given approach plays an important part in its effectiveness. Author: ota.tetsuji.887@m.kyushu-u.ac.jp

Riggs, R.A., Langston, J.D., Beauchamp, E., Travers, H., Ken S. & Margules, C. (2020) Examining trajectories of change for prosperous forest landscapes in Cambodia. *Environmental Management*. DOI 10.1007/s00267-020-01290-9

Conservation initiatives for tropical forests must deal with complex social, political and ecological decisions involving trade-offs between the extent of protected areas and quality of conservation. The authors examined the drivers and effects of rural forest landscape transitions in Cambodia to identify trade-offs between conservation and development. They explore three scenarios for the future of conservation in-country and contend that conservation efforts should focus on strengthening governance to meet social and environmental requirements for sustainable forest landscapes. They also conclude that realistic priority setting is needed in contested forest landscapes and that prosperous rural economies are a necessary but not sufficient condition for conservation. Author: Rebecca.riggs@my.jcu.edu.au

Tsujino R., Kajisa T., & Yumoto T. (2019) Causes and history of forest loss in Cambodia. *International Forestry Review*, **21**, 372–384.

The authors investigated literature and statistics on land use and socio-economics to reconstruct patterns of forest loss in Cambodia since the 1960s. Their results indicate that national forest cover stood at 73.3% (13.3 million ha) in the 1960s and declined to 47.3% (8.6 million ha) by 2016. They explore the circumstances associated with the different rates of forest loss observed over this period. Author: tsujino@nara-edu.ac.jp

The Recent Literature section was compiled by Neil Furey, with contributions from Gerard Ryan and Chhin Sophea.

Instructions for Authors

Purpose and Scope

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

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The following types of manucripts are accepted:

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

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- Research on the status or ecology of habitats.
- Checklists of species, whether nationally or for a specific area.
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The Journal does not normally accept formal descriptions of new species, new subspecies or other new taxa. If you wish to submit original taxonomic descriptions, please contact the editors in advance.

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

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- Summaries of important news from an authoritative published source; for example, a new research technique, or a recent development in conservation.

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Recent Literature

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

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

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

Preparation of Manuscripts

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

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

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

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

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

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

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

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

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

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

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

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

The following are examples of house style:

Papers:

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

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

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

Books and chapters:

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

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

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