The first population census of the Critically Endangered giant ibis in Western Siem Pang, northeastern Cambodia

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មូលន័យសង្ខេប

ត្រយងយក្ស *Thaumatibis gigantea* ជាបក្សីជិតផុតពូជដែលមានមាឌធំជាងគេក្នុងចំណោមត្រយងទាំង៣៦ប្រភេទនៃអំបូរ Threskiornithidae ហើយវាក៏ជានិមិត្តរូបបក្សីជាតិនៃប្រទេសកម្ពុជាផងដែរ។ ពីមុនមក ត្រយងយក្សធ្លាប់មានវត្តមាននៅទូទាំងភូមិភាគអាស៊ីអាគ្នេយ៍ ប៉ុន្តែបច្ចុប្បន្ននេះវត្តមានរបស់វាស្ទើរតែទាំងអស់មានតែនៅភាគខាងជើង និងខាងកើតនៃប្រទេសកម្ពុជាប៉ុណ្ណោះ។ តាមការប៉ាន់ស្មាន មានត្រយងយក្សពេញវ័យប្រហែល១៩៤ក្បាលប៉ុណ្ណោះនៅក្នុងពិភពលោក។ ការប៉ាន់ស្មាននេះគឺពឹងផ្អែកលើទិន្នន័យដែលមានប្រភពមិនច្បាស់លាស់ និងការប៉ាន់ស្មានរបស់អ្នកជំនាញប៉ុណ្ណោះ ដូច្នេះវិធីវាប់មួយចំនួនដែលមានសុពលភាពគឺត្រូវការជាចាំបាច់ចំពោះប្រភេទដែលពិបាកសិក្សានេះ។ នេះជាលទ្ធផលនៃការវាយតម្លៃជាប្រព័ន្ធដំបូងគេលើចំនួនរបស់ត្រយងយក្សក្នុងទីតាំងមួយកន្លែង។ វិធីសាស្ត្រដែលបានប្រើសម្រាប់ការសិក្សាគឺជាការរួមបញ្ចូលគ្នារវាងការកត់ត្រា តាមរយៈការអង្កេតដោយផ្ទាល់ និងតាមរយៈការស្តាប់សំឡេងនៅតាមត្រពាំង។ វិធីសាស្ត្រនេះចំណាយថវិកាតិច ដោយផ្អែកលើអេកូឡូស៊ីរបស់ប្រភេទសត្វនេះ។ ហើយវិធីសាស្ត្រនេះត្រូវបានសិក្សាសាកល្បងនៅដែនជម្រកសត្វព្រៃសៀមប៉ាងលិច ភាគឥសានៃកម្ពុជាដែលពីមុនគេស្គាល់ថា តំបន់សត្វស្លាបសំខាន់ភាគខាងលិចសៀមប៉ាង នេះជាតំបន់មួយក្នុងចំណោមតំបន់ផ្សេងទៀតដែលមានចំនួនត្រយងយក្សច្រើនជាងគេ។ យើងប៉ាន់ស្មានថាមានត្រយងយក្សចំនួន៤៩.៥±១០ក្បាល នៅមានវត្តមាននៅក្នុងតំបន់នេះ។ យើងពិនិត្យយ៉ាងជាក់លាក់ទៅលើវិធីសាស្ត្រនេះ នឹងស្នើសុំឱ្យមានការផ្តល់យោបល់កែលម្អពីអ្នកជំនាញ។ ជាអនុសាសន៍ គឺស្នើឲ្យមានការរាប់ចំនួនឡើងវិញជាទៀងទាត់ ដោយប្រើវិធីសាស្ត្រស្តង់ដាលើគ្រប់តំបន់ការពារអាទិភាពនៃប្រភេទនេះ។ ជាលទ្ធផលគឺអាចឲ្យយើងដឹងពីបម្រែបម្រួលនៃចំនួន ក្នុងគោលបំណងវាយតម្លៃពីប្រសិទ្ធភាពនៃការអនុវត្តគម្រោងអភិរក្ស ព្រមទាំងការព្រមានទាន់ពេលវេលា ទប់ស្កាត់ការធ្លាក់ចុះនៃចំនួនប្រភេទសត្វដែលជិតផុតពូជនេះ។

Abstract

The Critically Endangered giant ibis *Thaumatibis gigantea* is the largest of 36 species in the Threskiornithidae and the national bird of Cambodia. The species historically occurred throughout Southeast Asia, but is now almost entirely restricted to northern and eastern Cambodia. The global population is estimated at 194 mature individuals. This estimate is based on incidental data and expert opinion, however, and a rigorous population census method has yet to be

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validated for this elusive species. We report the results of the first systematic population assessment of giant ibis at a single site. Our method combines visual and auditory detections at forest pools (trapeang) and provides a cost-effective survey approach based on species ecology. This was tested in Prey Siem Pang Khang Lech Wildlife Sanctuary in Northeast Cambodia, previously known as Western Siem Pang Important Bird Area, one of the last strongholds of the giant ibis. We estimate that 49.5 ±10 birds still occur in the site and critically review our method, suggesting refinements. We conclude by recommending repeated surveys using a standard method at all priority protected sites for the species. This will enable the interpretation of population trends to determine the efficacy of conservation interventions and provide an early warning, should further declines occur in this Critically Endangered species.

Keywords

Auditory detections, census, giant ibis, survey methods, visual detections, Western Siem Pang.

Introduction

Southeast Asia is experiencing the fastest rate of habitat conversion in the world (Sodhi *et al.,* 2010) and recent studies suggest that Cambodia is experiencing faster rates of tree loss than any other country in the region (Hansen *et al.,* 2013; Peterson *et al.,* 2015). Many animals in Cambodia consequently face a high risk of extinction (Keo *et al.,* 2009). For instance, the giant ibis *Thaumatibis gigantea* (Threskiornithidae; Fig. 1) was formerly widespread across mainland Southeast Asia, particularly Thailand, Laos, Vietnam and Cambodia. However, its range has contracted dramatically and the largest remaining populations occur in Cambodia (Fig. 2), with a few individuals believed to persist in Vietnam and Laos (BirdLife International, 2015a). The species is now extirpated from Thailand.

The giant ibis occurs in isolated populations across Cambodia but in relatively higher densities in northern and eastern areas of the country, including Chhep Wildlife Sanctuary (formerly Preah Vihear Protected Forest) and Kulen Promtep Wildlife Sanctuary (where 24 pairs were monitored in 2014; Loveridge & Ty, 2015), and Prey Siem Pang Khang Lech Wildlife Sanctuary (with approximately 40 pairs; H. Wright, in litt., 2012). Other areas with significant populations include Srepok Wildife Sanctuary (formerly Mondulkiri Protected Forest) and Lomphat Wildlife Sanctuary. Sum *et al.* (2011, 2013) estimated at least 10–15 pairs of giant ibises inhabit Lomphat Wildlife Sanctuary, and incidental camera-trap data (Gray *et al.,* 2014) suggest a population of 50 birds in Srepok Wildlife Sanctuary (T. Gray, pers. comm.). Other confirmed, although older sightings suggest that approximately five pairs may exist in Seima Wildlife Sanctuary (formerly Seima Protection Forest), Phnom Prich Wildlife Sanctuary, Veun Sai–Siem Pang National Park (formerly Veun Sai–Siem Pang Conservation Area), Yok Don National Park in Vietnam and scattered across the extreme south of Laos (BirdLife International, 2015b). In addition, the species has also recently been confirmed at five other sites: a stretch of deciduous dipterocarp forest north of Sre Ambel in Koh Kong Province (Evans & Goes, 2011), Sang Sahakum Rukhavoan Community Forest in Oddar Meanchey Province, one site on the Sesan River near Stung Treng, a proposed bird nest protection area along the Mekong River in Kratie Province and Prey Lang Wildlife Sanctuary (Hayes *et al.,* 2015). It is estimated that each of these sites contain at least one pair of giant ibis. However, further survey effort is required to improve understanding of these populations and their distribution ranges to prioritise conservation efforts.

The primary habitat of the giant ibis is deciduous dipterocarp forest, where it is generally widespread at very low densities. Within this forest, the species relies on a matrix of habitats including forest pools 'trapeang' (Fig. 3), grasslands, and undisturbed roosting and nesting sites (Keo *et al.,* 2009). It breeds during the wet season (June–September) (Keo, 2008a) and nests in trees, with a preference for large *Dipterocarpus* species, generally more than 4 km from human habitation (Keo, 2008b). The species generally calls twice a day, in the morning from 04:30 to 07:00 hrs and in the evening from 18:00 to 18:30 hrs, and calls more frequently during the mating season before eggs are laid in June and July (Ty, 2013). It generally occurs in singles, pairs or small parties (BirdLife International, 2015b) and feeds in open water and on soft and hard muddy substrates surrounding the edges of trapeang (Wright *et al.,* 2012; J. Eames, pers. obs.). Its diet comprises a variety of invertebrates, crustaceans, eels, frogs and reptiles. The giant ibis is threatened by loss of suitable forest habitat throughout its range due to: 1) wholesale forest clearance by agricultural developments known as Economic Land Concessions (ELCs), 2) habitat conversion by small-scale agricultural encroachment by local communities, and 3) infrastructure and development initiatives, such as road construction through key

Fig. 1 (left) Giant ibis *Thaumatibis gigantea* (© Jonathan C. Eames).

Fig. 2 (below) Distribution of, and priority conservation zone for the giant ibis, including Yok Don National Park (Vietnam), Xe Pian National Biodiversity Conservation Area (Laos) and all priority protected areas for the species in Cambodia: A) Kulen Promtep Wildlife Sanctuary; B) Chhep Wildlife Sanctuary (formerly Preah Vihear Protected Forest); C) Siem Pang Wildlife Sanctuary and Prey Siem Pang Khang Lech Wildlife Sanctuary (formerly Siem Pang Protected Forest and Siem Pang Proposed Protected Forest II); D): Veun Sai–Siem Pang National Park (formerly Veun Sai–Siem Pang Conservation Area); E) Lomphat Wildlife Sanctuary; F) O'Yadao Protected Forest; G) Srepok Wildife Sanctuary (formerly Mondulkiri Protected Forest); H) Phnom Prich Wildlife Sanctuary.

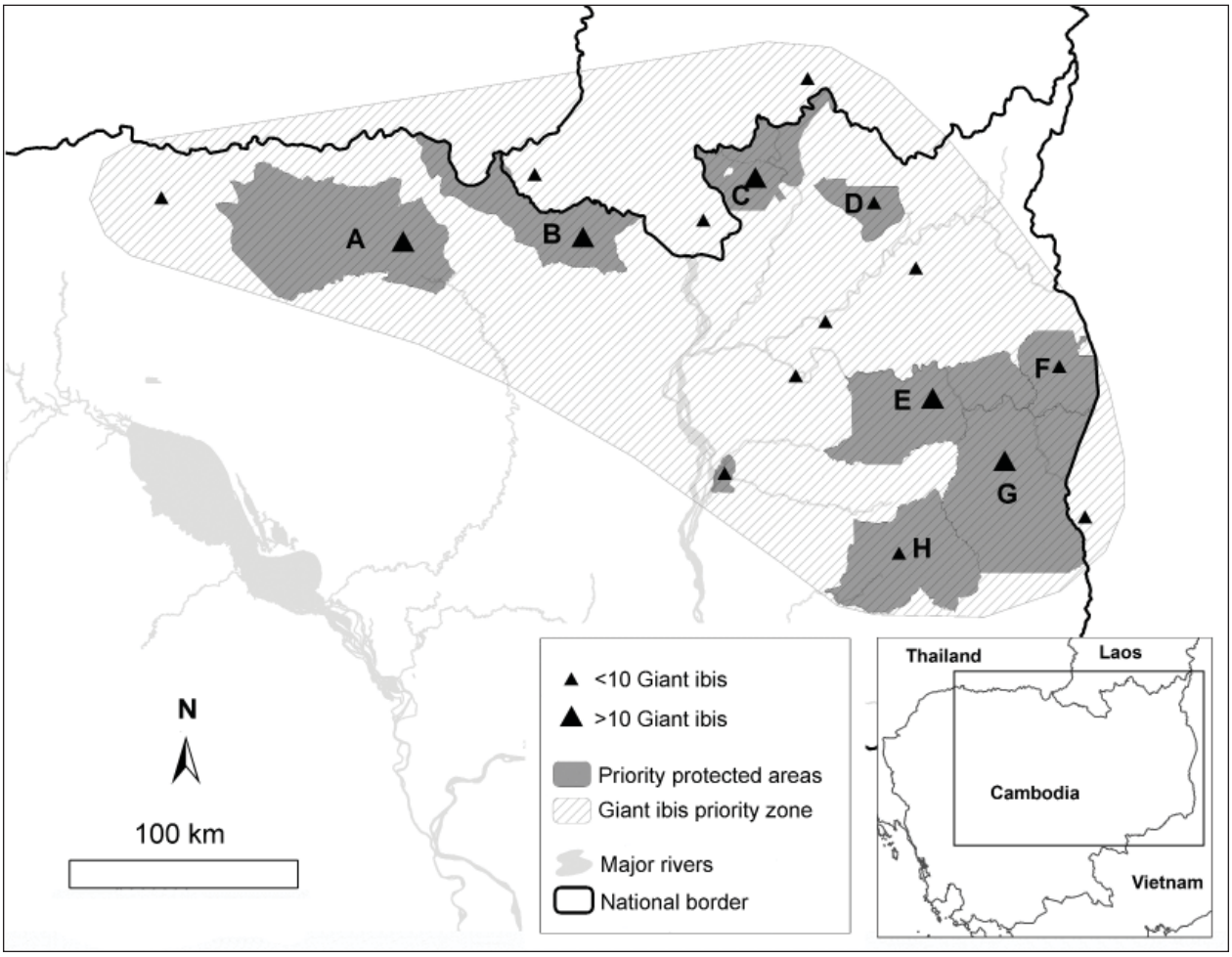

Fig. 3 Aerial photograph of a trapeang (forest pool) in deciduous dipterocarp forest, Cambodia (© Jonathan C. Eames).

habitats (BirdLife International, 2015a; Loveridge & Ty, 2015). These widespread threats are in addition to targeted threats facing the species, which include hunting and poisoning at sites where it occurs (BirdLife International, 2015a).

Recent efforts have been made to improve knowledge of giant ibis populations across Cambodia and the national population is currently estimated at 194 mature individuals (Loveridge & Ty, 2015). However, this estimate is based on incidental data and expert opinion and the development of a cost-effective survey method is urgently needed to identify remaining populations and prioritise future conservation efforts. This study reports the first systematic population assessment for this elusive species in Prey Siem Pang Khang Lech Wildlife Sanctuary, previously known as Western Siem Pang Important Bird Area (Seng *et al.*, 2003), one of the last strongholds for the giant ibis. The method combines visual and auditory detections at trapeang and provides a cost-effective survey approach based on the specific characteristics of the species. As the first census method proposed for the species, we encourage others to critically review this method and suggest refinements to improve its accuracy at minimal cost. We present the method here as the first step towards developing a standard approach that can be applied at all priority protected sites within the species' range. This paper contributes to priority research actions in the 10-year national action plan for the giant ibis (Loveridge & Ty, 2015), specifically action 3.1 (improving baseline data for the species at priority sites) and action 3.2 (developing a unified census method that can be implemented at priority sites).

Methods

Study area

The study was conducted in 2014 in Prey Siem Pang Khang Lech Wildlife Sanctuary (PSPKLWS) which comprises 65,389 ha in Stung Treng Province, Northeast Cambodia (14°07′ N, 106°14′ E; Fig. 3). The site is contiguous with Siem Pang Wildlife Sanctuary (formerly Siem Pang Protected Forest) to the north and, before its designation as a wildlife sanctuary in May 2016, included an ELC largely comprised of deciduous dipterocarp forest

which was cancelled in early 2015. Both sites are contiguous with Virachey National Park to the east and Xe Pian National Biodiversity Conservation Area (Laos) to the west. The two wildlife sanctuaries collectively cover 132,321 ha, 50% of which comprises deciduous dipterocarp forest. Denser semi-evergreen forest represents 40% of the area and the remainder comprises degraded semi-evergreen forest (5%), deforested land including cultivation areas (3%) and water (2%) (BirdLife International, 2012). Forest cover is relatively open in many places, denser in others, and has a grassy understory. Climate is strongly monsoonal with average monthly rainfall as little as 0.9 mm during the dry season (November–April) and up to 333 mm in the wet season (May–October) (Thuon & Chambers, 2006; Wright, 2012). The Sekong River, a major tributary of the Mekong, flows through the area and supports extensive stretches of riverine forest (BirdLife International, 2012). The area supports five Critically Endangered bird species (white-shouldered ibis *Pseudibis davisoni*, giant ibis *Thaumatibis gigantea*, red-shouldered vulture *Sarcogyps calvus*, slender-billed vulture *Gyps tenuirostris* and white-rumped vulture *Gyps bengalensis*), as well as several Endangered mammals (Eld's deer *Rucervus eldii*, gaur *Bos gaurus*, banteng *Bos javanicus* and Indochinese silver langur *Trachypithecus germaini*) (BirdLife International, 2012). PSPKLWS is surrounded by 14 villages in three communes. The total population comprises 10,124 people or 2,229 households, with 38% of households living under poverty line (Bou & Yam, 2014). Rice cultivation, cutting of wood for timber, non-timber forest product collection and fishing contributed most to local livelihoods in 2012 (Wright, 2012).

Sampling site selection

Our census method was based on observations at forest pools (trapeang) (Fig. 3), one of the most important foraging habitats for giant ibis and other waterbirds, especially during the dry season from November to May (Keo, 2008a). Due to resource limitations, we did not attempt to survey all trapeang known at PSPKLWS (over 200), but instead maximised the likelihood of detections by focussing on selected trapeang. Existing bird observations from 2009–2013 (BirdLife International, unpublished data) were reviewed to classify each trapeang at the site into four categories: 1) used by giant ibises from the late rainy season to the early dry season (October–December = 18 trapeang), 2) used during the mid dry season (January–March = 49), 3) used from the late dry season to the early rainy season (April–June = 29), and 4) used during the rainy season (July–September = 19). The 49 trapeang where the species was sighted during the dry season months of January–March were selected for the census.

Survey effort and data collection

Monthly census counts were conducted in January–March 2014, from the 23rd to 28th day of each month. The 49 study trapeang were grouped into six zones, each zone comprising trapeang located <3 km apart (Fig. 4). One zone was surveyed per day by a team of 11 observers and overall, each trapeang was visited once a month by observers in pairs or singles.

Ty (2013) found that giant ibises frequently call at roosting sites in PSPKLWS from 05:00 to 06:00 hrs, then cease calling and travel to foraging sites around 06:00 hrs. He also found disturbance from human activity generally begins around 07:00 hrs. As a consequence, census counts were confined to 05:30–07:30 hrs to coincide with the start of call activity and least disturbed period of the day. To further avoid disturbance, surveyors approached trapeang slowly and chose vantage points that provided some concealment and a clear view of the entire trapeang before 05:30 hrs.

Two types of data were recorded during the census: visual detections and auditory detections of calling birds. Giant ibises produce a loud call which can be heard up to two kilometres away and used to locate them (Ty, 2013). For visual detections the following was recorded: number of birds observed; time seen; duration of stay at trapeang; entrance and exit direction, time, and flight height; and the identity of any birds flushed on approach to trapeang. Data recorded on auditory detections comprised call time, direction, bearing and estimated distance.

Data screening and analysis

Prior to analysis, data were screened to exclude three possible sources of double counts of individual birds, as follows:

1) Double counts from auditory and visual detections of the same bird— The direction of calling birds was recorded by observers and if birds were visually detected arriving from the same direction as an earlier auditory detection, the latter was excluded from analysis;

2) Double counts from auditory detections— Repeat auditory detections recorded by the same observer within a 45° degree radius were considered the same individual, unless these occurred simultaneously; and,

3) Double counts from individual birds travelling between trapeang on the same day— Each two-hour trapeang session

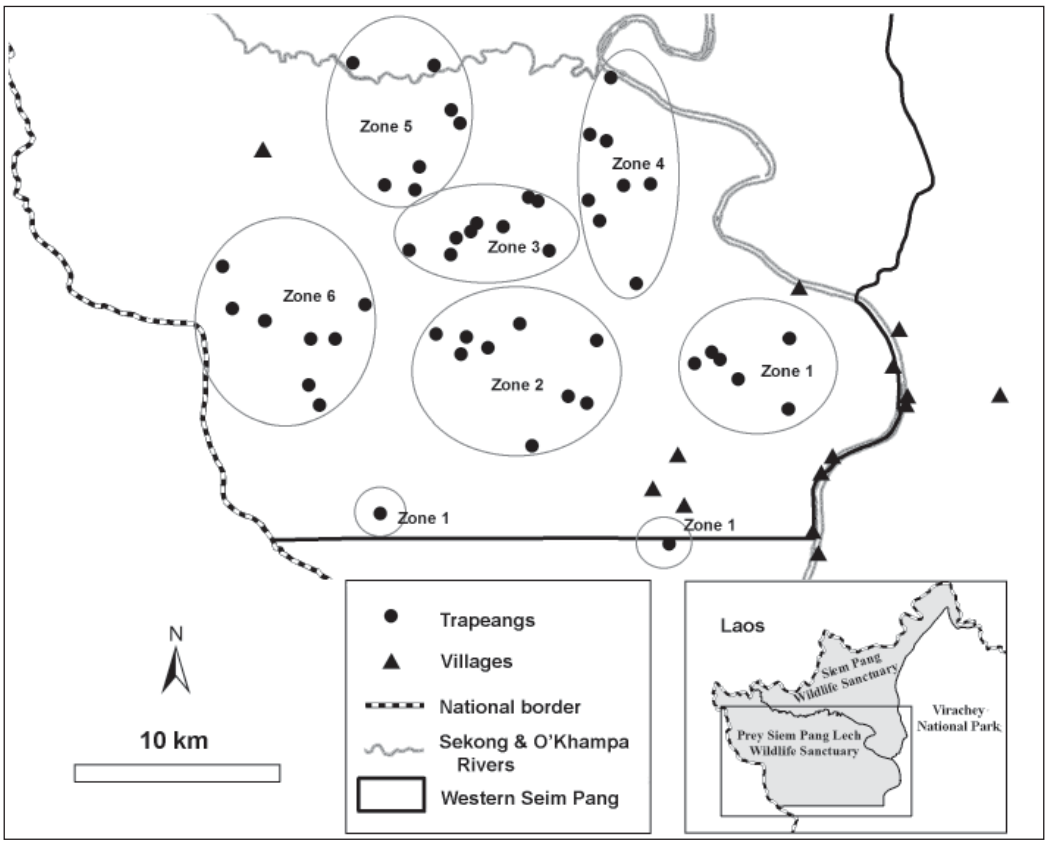

Fig. 4 Distribution of trapeang and survey zones in Prey Siem Pang Khang Lech Wildlife Sanctuary, Cambodia.

was split into four 30-minute intervals and numbers of birds recorded were calculated for each interval. The population count for the trapeang session was taken as the greatest count from a single interval, thereby reducing the likelihood of individual birds being recorded at different trapeang on the same day.

The possibility of double counts arising from the occurrence of individual birds in multiple survey zones was also considered in the census design. The giant ibis resides in deciduous dipterocarp forest and is thought to have a stable home range that incorporates key foraging resources such as trapeang (Keo, 2008a; Wright *et al.,* 2012). As trapeang have a clustered distribution in PSPLWS and survey effort was arranged into geographically discrete zones as far as practicable, individual birds were therefore considered unlikely to have foraged widely over the entire survey area.

On completion of screening, data were analysed to produce monthly population estimates for each of the six zones. A maximum monthly count for each zone was calculated by summing the number of unique individuals recorded by both visual and auditory detections. A minimum monthly population count was then calculated for each zone based on visual detections alone. The actual monthly population estimate for each zone was taken as the mid-point between these two figures in providing a conservative estimate incorporating both types of detections.

Results

Numbers of giant ibises recorded at PSPKLWS each month varied significantly over the course of the 2014 census: 22 birds were recorded in January (=21 visual detections + 1 auditory detection), 59 in February (=40 visual detections + 19 auditory detections), and 33 in March (=16 visual detections + 17 auditory detections) (Table 1). These yielded monthly population estimates of 21.5 (min = 21, max = 22) birds in January, 49.5 (min = 40, max = 59) birds in February, and 24.5 (min = 16, max = 33) birds in March.

Discussion

Our census suggests 49.5 ±10 giant ibis (= 20–25 adult pairs) occur in PSPKLWS. As 40 pairs were previously estimated for the area (BirdLife International, 2012), this could mean a decline has occurred at the site, possibly due to ongoing forest degradation and loss. Repeated surveys using the same methods are required to verify this, however, and assessment of population trends is not attempted here. We consider our figure a conservative or minimum population estimate because: a) only 49 trapeang out of >200 were surveyed at the site, b) potential double counts were rigorously excluded, and c) our estimate does not include all auditory detections.

This study is the first attempt to develop a rigorous method for monitoring giant ibis populations at any site. Wright (2012) recorded 66 birds from 11,402 km of repeat survey journeys in the PSPKLWS area. As no evidence of migration has been observed for the species, this suggests that giant ibises are resident at the site (Wright *et al.*, 2012). Our population estimate is consequently based on the highest monthly population estimate, as we assume all birds recorded during the survey period are resident all year round.

Our findings suggest that February may be the best time to census giant ibises at trapeang sites. This is due to the strong seasonality of the region which reduces the availability of standing water and suitable foraging habitat during the dry season (November–April). During the wet season (May–October), heavy rainfall creates large amounts of standing water in countless depressions scattered throughout the landscape and as a result the giant ibis forages widely during this period, rarely visiting trapeang. By February, however, these have largely evaporated and trapeang tend to contain the only remaining standing water at the site, leading to clustering in activity as the availability of other foraging habitats decreases. In March 2014, almost half of trapeang studied at PSPKLWS had dried out and the birds no longer visited, having moved to feed at pools alongside the margins of rivers that still contained water. Human disturbance also influences the likelihood of giant ibis detections (Keo, 2008b; BirdLife International, 2012; Wright, 2012). During our study, disturbance increased markedly in March when a logging company began operating in the area. This could have forced birds away from preferred foraging habitats into more remote forest areas, resulting in a lower population estimate for that month.

We suggest census approaches that combine visual and auditory detections are acceptable for generating rigorous population estimates, provided appropriate methods are employed to exclude potential double counts of individual birds. As the giant ibis exists at very low population densities and is challenging to detect (Keo, 2008a), censuses based on visual detections are likely to underestimate population size. Because giant ibis calls travel up to 2 km (Ty, 2013), they provide opportunities for additional detections and subsequent improvement of population estimates. Another way to avoid double counts would to be survey all sampling sites simultaneously, but this would require a large number of observers and much greater financial investment. For instance, at least 50–60 people would be needed to census all of the sites in our study simultaneously, whereas only 11 were needed using our approach. At sites where resources are limited therefore, we suggest that a single census employing our approach in February might be sufficient.

Table 1 Monthly numbers of giant ibises recorded from survey zones in Prey Siem Pang Khang Lech Wildlife Sanctuary.

Zone	No. of trapeang	January		February		March	
		Visual Detections	Auditory Detections	Visual Detections	Auditory Detections	Visual Detections	Auditory Detections
1	8	3	0	5	2	0	3
2	9	4	0	6	1	7	4
3	9	3	0	0	7	4	0
4	8	4	0	12	3	0	6
5	7	3	1	7	2	3	4
6	8	4	0	10	4	2	0
	Subtotal	**21**	**1**	**40**	**19**	**16**	**17**
	Total	**22**		**59**		**33**	

Alternative techniques for population estimation include random selection of sampling sites (Gregory *et al.*, 2004) and distance sampling (Bibby *et al.*, 1998). These can be used to generalise across large survey areas and allow lower sampling effort to generate site-based population estimates. As the giant ibis exists at very low population densities and is challenging to detect however, they would be unlikely to generate sufficient observations for meaningful analysis. To overcome low detection frequencies, a targeted approach that samples key habitats based on prior knowledge and pilot surveys may be needed (Loveridge *et al.*, in press). Recent advances in acoustic spatial-capture-recapture methods may also provide opportunities for estimating populations of species with distinctive calls, by sampling reduced, but representative survey areas (Kidney *et al.*, 2016).

We propose our method as a compromise between resource-intensive, single-occasion, large-scale surveys and randomized approaches that might yield insufficient data without numerous iterations. As our method requires prior knowledge of areas used by giant ibises, we encourage field teams to record all opportunistic sightings of the species as a first step towards its implementation. Resources permitting, future censuses in the Siem Pang region should include deciduous dipterocarp forests north of the O'kampa River and east of the Sekong River inside Siem Pang Wildlife Sanctuary to generate a comprehensive estimate for the area encompassed by this site and PSPKLWS. Further research to establish the habitat preferences and home range of giant ibises would also aid future census design in helping to avoid delineation of survey zones that favour the occurrence of a single bird in multiple zones. Ideally, survey zones should be separated by a distance not less than the home range diameter of the species to minimise the chance of individual birds being detected in more than one zone.

In conclusion, we advocate repeated surveys using standard methods at all priority protected sites within the limited range of the giant ibis (Fig. 2). This will enable interpretation of population trends to assess the efficacy of conservation interventions and provide an early warning, should further declines occur in this Critically Endangered species.

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