PROJECT REPORT

Ecology and conservation of the Giant Ibis *Thaumatibis gigantea* in Cambodia

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Introduction

Among 36 species of the ibis family Threskiornithidae, one is classified as extinct, four as Critically Endangered, three as Endangered, and one as Vulnerable (BirdLife International 2004). A rate of eight threatened species out of 36, or 22%, is much higher than the average for all species of bird (12%: BirdLife International 2004), and is some evidence of the far greater susceptibility to extinction of large waterbirds. This susceptibility seems to be the result of a combination of factors, mainly habitat destruction, habitat disturbance and direct persecution.

The Giant Ibis *Thaumatibis gigantea*, the largest of the worldwide ibis family, is one of the Critically Endangered species. Historically it was known from Thailand, Cambodia, Laos and Vietnam (see Figure 1), but it was only ever considered common in part of Cambodia, and after the 1960s there was a period without any records during which it was feared possibly extinct, until it was rediscovered in Laos

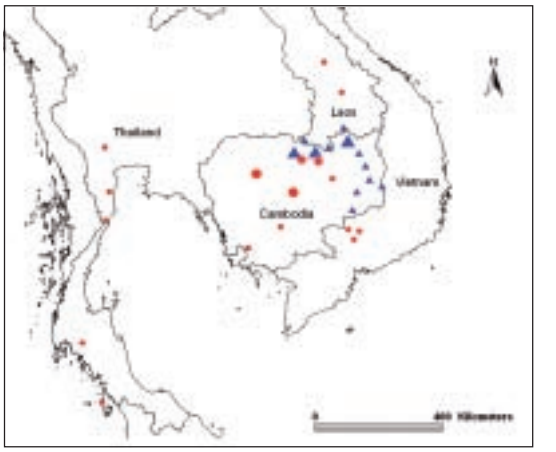

Figure 1. The past and present distribution of the Giant Ibis. Red circles = before 1970, blue triangles = since 1970; small symbols = <10, large = >10. Map remodelled from that in BirdLife International (2001) with the inclusion of more recent personal data for northern Cambodia and one record from the Cambodia/Vietnam border in Eames *et al*. (2004).

Plate 1. Giant Ibis *Thaumatibis gigantea*. May 2005.

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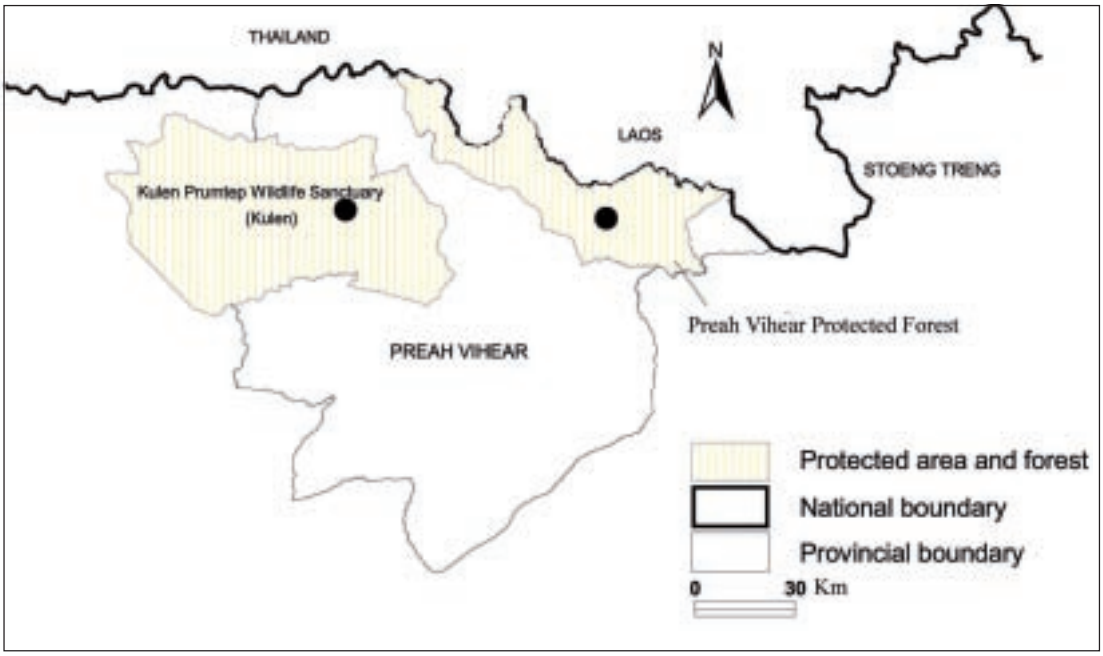

Figure 2. Map of the study areas in Preah Vihear province.

in 1993. Soon afterwards a tiny breeding population was found in the remote open dipterocarp forests of northern Cambodia, on the border with Laos. At that stage nothing at all was known about the species: we did not know why it had declined nor what it needed in order to survive. Research into its constraints and requirements was therefore urgently required.

I began my PhD study on the ecology and conservation of the Giant Ibis in 2003, based at the University of East Anglia (UEA), Norwich, U.K. I undertook three seasons of fieldwork on the species (2004–2006 inclusive), looking at breeding habitat selection, constraints on breeding success, feeding habitat selection in the dry (non-breeding) season and the possibly detrimental influences of human disturbance and habitat alteration. The work proved difficult, owing to primitive conditions in the study area and the very low densities of the birds, but the results when drawn together provide us with a profile of the species that can be used for its immediate management as well as for new research initiatives into its conservation.

Through the Bertram Smythies Fund, OBC put a significant amount of money into this research along with other funding bodies, and this report is offered in acknowledgement of the generosity and trust the club showed me.

Study area

My general study area was located in Preah Vihear province in northern Cambodia, bordering both Laos and Thailand (Figure 2). Preah Vihear has a total land area of around 14,000 km² and a human population in 2007 of 160,000, nearly 80% of whom were engaged in farming and forestry for their livelihoods. Two protected areas exist in Preah Vihear: Kulen Prumtep Wildlife Sanctuary (KPWS) (Kulen district) and Preah Vihear Protected Forest for Conservation of Genetic Resources of Forest and Wildlife (PVPF) (Chhep district). I had particular study sites in both these areas, but largely concentrated on PVPF. These two protected areas are managed by the appropriate government ministries, with steady support from the Wildlife Conservation Society (WCS).

Preah Vihear has more forest cover than any other province in Cambodia, based on 2002 forest cover assessments (Forest Administration 2004). About 90% of the province was covered by forest, 70% being deciduous, 16% evergreen and 12% semi-evergreen. Recent data from the Department of Agronomy indicate that a little more than 3% was agricultural land (of which 74% was rice) in 2007. Despite these figures, illegal logging was severe in the years 1995–1998 in Preah Vihear.

The study sites harbour many other threatened birds and mammals. These include White-shouldered Ibis *Pseudibis davisoni*, Red-headed *Sarcogyps calvus*, Slender-billed *Gyps tenuirostris* and White-rumped Vultures *G. bengalensis*, Greater *Leptoptilos dubius* and Lesser Adjutants *L. javanicus*, White-winged Duck *Cairina scutulata*, Sarus Crane *Grus antigone* and Green Peafowl *Pavo*

muticus. Other large waterbirds present are Black-necked *Ephippiorhynchus asiaticus* and Woolly-necked Storks *Ciconia episcopus*. Key mammals are Tiger *Panthera tigris*, Leopard *P. pardus*, Asian Elephant *Elephas maximus*, Gaur *Bos gaurus*, Banteng *B. javanicus* and Eld's Deer *Cervus eldii*. Kouprey *Bos sauveli* was once estimated to number at least 100 individuals in the study sites, but it is now thought extinct.

Nest tree selection by the Giant Ibis

During the 2004, 2005 and 2006 breeding seasons, six conservation teams looked for Giant Ibis nests in Chhep and Kulen and concentrated on areas where Giant Ibises were found feeding or where their distinctive territorial calls were heard prior to the breeding season. In 2004, 27 nests were found, and in 2005 26; 13 nests were used in both years and thus were only included once, giving a total of 40 independent nest-trees (29 in Chhep and 11 in Kulen).

Giant Ibises used five of the 78 tree species available in the nesting areas in Chhep and Kulen: Trach *Dipterocarpus intricatus*, Korki *Hopea odorata*, Chheuteal *Dipterocarpus alatus*, Phadiek *Anisoptera costata* and Tbeng *Dipterocarpus obtusifolius*. Half the trees used (20/40) were Trach and 40% (16/40) were Tbeng. Giant Ibis nests were mainly located at the top of the nest-tree, usually supported by three slightly angled-up branches, mostly open to the sky. The reason Giant Ibises selected specific trees is probably because other trees were shorter and lacked suitable structures for nesting.

Trach is regularly used for resin-tapping, Tbeng never, and large trees proved much more likely to be tapped. In general, resin-tapping involves relatively little noise disturbance, since tappers visit trees for fairly short periods, setting a small fire in the trunk to stimulate resin-flow, and returning later to collect the resin. Visits to any one tree thus happen twice in one day but only on one day in every five days to two weeks. Tree death from tapping is relatively low.

On the other hand, the Giant Ibis's preference for large trees for nesting means that logging, which, like resin-tapping, targets larger trees, may be a cause of concern. Logging may also cause great disturbance to nesting birds because of the noise and duration of the operation. In 2005, one nest of Giant Ibis in Chhep was deserted during incubation when there were logging activities around the nest.

Nesting location choice

The habitat of the Giant Ibis has been summarised in BirdLife International (2001). There it was reported that the species appears to have a preference for swampy clearings, pools and rivers, often near forest, and that all records have been from the extreme lowlands, many of them deriving from riparian habitats varying from very small streams to huge rivers.

When BirdLife International (2001) was published, the only breeding record for the species was a report from Dong Khanthung, Laos, in June 1997 of a bird flushed from a tree nest "apparently" with two or three young. Subsequently WCS received information about nests in Cambodia, bordering the Dong Khanthung area. In 2001 WCS rangers found one nest in Chhep, and several more subsequently. None of these findings, although constituting the first certain records of breeding in the species, was published, and until my own project began in 2004 no systematic observations of breeding were made.

Nest-site selection in the Giant Ibis was not influenced by distance to village, road, agricultural land, river or forest, although nests were generally at least 4 km from villages. However, most nests were within a kilometre of pools, and earthworm mounds, which occur in large groups in seasonally flooded grassland, were important predictors of the presence of breeding Giant Ibises; areas with higher proportions of short grass also seemed to be associated with breeding ibises. Seasonal grasslands and pools thus need special consideration for protection in order to maximise optimal habitat for Giant Ibis in the breeding season. Moreover, if Giant Ibises do indeed avoid villages, this is probably because of persecution, so vigilance and a campaign of local education are called for.

Breeding success and nest protection

In September and October 2004, two separate nest-predation events by Common Palm Civets *Paradoxurus hermaphroditus* and/or Yellow-throated Martens *Martes flavigula* suggested that loss of nestlings to mammalian carnivores might be a significant constraint on breeding success, and prompted the idea of testing the effectiveness of predator-exclusion devices.

A total of 52 nests were monitored, in 2004, 2005 and 2006. Whenever a nestling disappeared, the area directly underneath the nest was visited to look for evidence of its fate.

A predator-exclusion experiment was conducted over the course of the 2005 and 2006 breeding seasons. Nests were protected from ground predators by fixing a smooth hard plastic belt to the base of the nest-trees (Plate 2). Around 50% of nests were protected and the rest left as controls.

There was no significant difference in nesting success between 2005 and 2006. However, nests that had been protected with the predator-exclusion devices were more likely to be successful than

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Plate 2. Predator-exclusion device used for protecting Giant Ibis nests from civets and martens.

unprotected nests. Nests with predator-exclusion devices were more likely to survive than nests without protection. For short- and long-term conservation planning, nest protection of the Giant Ibis should be implemented as a cost-effective way of improving breeding success and thereby increasing the chances of a steady recovery in numbers in the wild.

Food and feeding habitat

Although the Giant Ibis has commonly been reported feeding at pools, its feeding habitat preferences and foraging behaviour have not been studied. I investigated these factors for the non-breeding period, through a combination of direct observation, camera trapping method (CTM) and bill probe-mark method (PMM). The cameras were set up at pools at a range of distances to villages. They were positioned near the edge of the mud or water, at an angle intended to cover as much of the pool as possible. Results from 62 camera traps were suitable for analysis (see Plates 3–5).

I quantified a large series of variables to attempt to determine the factors that really influence Giant Ibis preferences. These included detailed measurements of pools and the areas of all surrounding patches of mud, bare earth and vegetation cover (grouped into four types), plus mud penetrability, pool depth, the "visibility" around pools (using a clinometer to measure the angle of the highest vegetation), and the distance of each pool from the nearest village. To survey potential terrestrial prey, I walked a 20 × 2 m transect at each pool and counted the animals I found. Then I assessed the prey present in the mud by digging out 10 quadrats at each pool.

A direct study of foraging activity and feeding success, involving at least 15 different Giant Ibises, was conducted in the dry season from January to April 2006. On average, the birds caught 26 prey items per hour spent searching, with frogs accounting for almost 50% of all prey types,

Plate 3. An adult (right) and juvenile (left: blackish down on neck with black eyes) Giant Ibis foraging away from water and captured by camera trap.

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Plate 4. Giant Ibis foraging just back from water and mud and captured by camera trap.

Plate 5. Four Lesser Adjutants and three Woolly-necked Storks foraging in water and captured by camera trap.

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followed by insects, mole-crickets and larvae. Eels accounted for only 3.5%, but are clearly important in terms of energy gain. Frogs and mole-crickets seem to be the main driver in feeding habitat selection outside the breeding season. The main habitats used were short grass and mud. Giant Ibises mainly searched for eels within areas of mud, while frogs, mole-crickets, insects and larvae were mainly taken from short grass. CTM results showed that pools used by Giant Ibis were significantly larger (on average more than 1,000 m²) and with greater mud area than unused pools. Similarly, the mud area was twice as large at used than at unused pools. Mud area was strongly correlated with water area, since water plays a key role in maintaining mud. Buffalo, one of the key predictors of presence of Giant Ibis, may play a major role in increasing the area of mud.

However, although pools are larger close to villages, Giant Ibises select large pools further away from villages. This effect may be related to frog abundance, since there is a greater prevalence of frog and eel hunting near villages; fewer frogs were found close to villages, and pools near villages were found drained for fishing, causing them to dry out quicker. Possibly, however, there is more disturbance at pools closer to villages, or a greater risk of direct persecution. Settlement of local people near pools certainly increases disturbance levels and should not be allowed.

In the dry season, the lack of pools with standing water throughout the study site may be a major issue for the Giant Ibis. During the late dry season, only a few pools from over a hundred retain water. In April 2005, the majority of pools were completely dry. Securing water to maintain mud areas during the late dry season is therefore very important.

Camera traps and the prediction of presence/abundance

To test the effectiveness of the camera-trap method (CTM), I made a comparison with field observations at 24 camera-trapped pools from February to April 2006. All-day observations were made from a hide on days when the camera was operating. The identity and number of each species of bird visiting the pool was recorded along with arrival and departure time.

Direct observation recorded five times as many species (63) as camera-trapping (12). Larger birds were, however, generally better detected by camera traps. Giant Ibis was in fact the bird species with the highest capture rate, probably owing to the

combination of its size and feeding behaviour (walking around the margins of pools rather than wading into them). Most small bird species were missed by the cameras, while many larger ones, e.g. Crested Serpent Eagle *Spilornis cheela* and Changeable Hawk Eagle *Spizaetus cirrhatus*, just paid short visits to drink, so that they, too, commonly went undetected by the traps.

Despite these shortcomings, the experiment proved that camera traps are effective for capturing the presence of Giant Ibises at pools, but less so at indicating their abundance. Camera traps captured fewer than the actual number recorded visually. However, if days devoted to camera-trap surveys were increased, the detection rate might reach almost 100%, and if the number of cameras were doubled the accuracy of inventories of all species would greatly improve.

Effects of fire, drainage and man-made pools

Fire, with both positive and negative effects, is a natural ecological factor in many parts of Cambodia, especially in deciduous forests. The partial draining of pools, in order to facilitate fishing, is a common practice in the north during the dry season, when water levels are already naturally low. In my study site there were also a number of ancient man-made pools. The possible influences of these factors on the Giant Ibis were investigated in April and May 2005, when 62 pools fitted with camera traps were randomly selected and surveyed for evidence of recent past fires (detected by inspecting long grasses on which the burnt stem could still be seen), drainage activity (detected by earth dykes that channel water into the surrounding land, or by wooden structures for supporting draining equipment) and human origin (detected by earth dykes and an unnatural, normally rectangular shape).

Local villagers confirmed that fires occur every year from January till May, generally after the December rice harvest, when they are lit so as to improve hunting success, promote young grass shoots for cattle, and make the entire area generally more accessible. Fire tends to occur further away from villages, probably because more distant pools hold larger areas with long grass and are thus more favoured for burning (in turn, long grass is probably the result of reduced grazing pressure). Areas of water and mud are lower at pools affected by fire than they are at unaffected pools, probably because fire reduces fringing plant cover and thus increases evaporation rates. Nevertheless, fire history did not greatly affect the choice of feeding pool by Giant Ibises, although they used unburnt pools more than burnt ones. Mole-crickets were three times as abundant at unburnt pools as at burnt ones, but frogs and eels showed no variation between such pools. Given that short grass appears to be a key foraging substrate for the Giant Ibis, and that fire had no effect on the extent of short grass at pools, this may explain why Giant Ibises used both types of pool.

Drained and undrained pools were respectively an average 6.5 and 10.2 km from the nearest village. Eels were 14 times more abundant in undrained pools, presumably because they depend on permanent wetland habitats, and frogs were rather commoner. Even so, drainage did not appear to affect the choice of feeding pool by the Giant Ibis, but since, as noted, the majority of pools in Chhep and Kulen dry out naturally during the late summer, it may be valuable to maintain water levels in some by (a) digging them deeper so as to reduce the effects of evaporation and groundwater flow, (b) preventing people from draining any pools, (c) creating fishpools in villages, and/or (d) increasing alternative food resources.

Man-made pools were usually deeper (by some 50%) than natural pools, and held four times as many shrubs and trees. A deeper pool with a higher density of shrub or tree is likely to have a higher angle of "visibility", yet Giant Ibises were equally likely to use man-made and natural pools, probably because their main prey (frogs, eels and mole-crickets) were roughly similar in abundance at man-made and natural pools. In fact, man-made pools were created hundreds of years ago and their original levels of maintenance have been abandoned, so that the habitat structures are generally rather similar to those in natural pools.

The future

Maintaining feeding and breeding habitats is crucial to the conservation of the Giant Ibis. Many seasonal wetlands and pools where the species occurs have not been included in Cambodia's protected area system, and it is a priority to rectify these omissions. Apart from this, my work has established the value of several management actions:

- install anti-predator belts on all Giant Ibis nest-trees;
- protect all nesting trees, and all potential (i.e. tall) nest-trees, especially Trach;
- Ensure some pools remain wet during the dry season;
- Monitor the abundance of frogs, eels and mole-crickets in the dry season.

Human population growth represents an important long-term challenge for conservation in Cambodia. The country only has 14 million people but the growth rate is 1.7%, and 80% of the population are farmers. The demand for land for

settlement and farming is bound to rise. Increases in the area lost to rice are a special concern. Rice production levels are now rising sharply, and more land for rice will doubtless be sought, given the high price of rice in recent years (and months). Moreover, private concessions will commit more land to rubber, cashew and cassava, all of which are likely to have an impact on the nesting and feeding habitats of the Giant Ibis.

My work concentrated on feeding habitat selection during the dry season, but wet (breeding) season habitat use is little known, except that Giant Ibises select areas with earthworm mounds, probably mainly for provisioning nestlings. Moreover, there is evidence, from historical records, that some birds wander outside the breeding season, at least locally. What proportions of the population or what age-class or sex undertake such movements? The successful long-term management of the Giant Ibis will require a study of this issue, perhaps using satellite telemetry (if a way can be found to catch birds safely), to ensure the identification and control of any threats outside the breeding areas. A detailed study of juvenile survival may also help managers in the long term to increase the overall population. Is there a relationship between reproductive output and distance to and size of foraging areas during the breeding cycle? What is the optimal diet of nestlings? Any evidence on how nest productivity can be improved (apart from fitting anti-predator belts to nest trees) could be very helpful in the short- and long-term management of the species.

Finally, an attempt is needed to determine the real population of the Giant Ibis in Cambodia, involving sustained efforts to penetrate the extensive areas of open dipterocarp forest across the north, north-east and east. This should be matched by an efficient, non-intensive monitoring programme, so that trends in numbers can be detected, charted and, if necessary, countered by management over time.

It is clear that the successful conservation of the Giant Ibis will require a major long-term commitment by the government and people of Cambodia working together with local and national NGOs. One key element will be a campaign of education and publicity across northern Cambodia to indicate the unique global responsibility the region bears for the Giant Ibis, the country's national symbol. Limited ecotourism, both by Cambodians and by international wildlife tourists, might also be developed further—it has already started in a small way—to bring revenue to the region in recognition of (and compensation for) the part it must play in preserving the Giant Ibis and its habitat.

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Publication of these results in full will follow in the peer-reviewed literature, and their appearance here constitutes neither an appropriate source for citation nor a violation of the principle of originality attaching to scientific contributions to journals.

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