Lessons from the first successful ex situ conservation breeding of the Critically Endangered white-shouldered ibis [Threskiornithidae: *Pseudibis davisoni* (Hume, 1875)] in Cambodia

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ការបង្កាត់ពូជអភិរក្សក្រៅតំបន់ធម្មជាតិ (ex situ) ត្រូវបានប្រើប្រាស់កាន់តែច្រើនឡើងដើម្បីការពារការផុតពូជនៃប្រភេទបក្សីដែលកំពុងរងការគំរាមកំហែង។ ប្រទេសកម្ពុជា ជាជម្រករបស់សត្វត្រយ៉ងចង្កំកស *Pseudibis davisoni* ដែលកំពុងរងការគំរាមកំហែង។ ដោយមានការគាំទ្រពីអាជ្ញាធររដ្ឋាភិបាល មជ្ឈមណ្ឌលអង្គរសម្រាប់ការអភិរក្សជីវចម្រុះបានបង្កើតប៉ូពុយឡាស្យុង ex situនៃប្រភេទសត្វដោយផ្អែកលើឯកត្តៈដែលបានជួយសង្គ្រោះ និងរឹបអូស ដោយមានគោលដៅបង្កើតឡើងនូវប៉ូពុយឡាស្យុងដែលធានានិរន្តរភាពសេនេទិច។ ក្នុងរដូវបង្កាត់ឆ្នាំ២០២២ - ២០២៣ យើងបង្កាត់បានកូនបក្សីពីរក្បាលដោយជោគជ័យ ដែលតំណាងឲ្យការបង្កាត់ក្រៅតំបន់ធម្មជាតិ (ex situ) ប្រកបដោយភាពជោគជ័យជាលើកដំបូងនៅលើពិភពលោក។ បទពិសោធន៍នេះបានផ្តល់ឲ្យយើងនូវឱកាសដើម្បីពិចារណាពីមេរៀនដែលយើងទទួលបាន និងជាព័ត៌មាននាពេលអនាគត។ សកម្មភាពប្រចាំថ្ងៃរបស់យើងមានដូចជាការផ្គត់ផ្គង់វត្ថុធាតុដើមសម្រាប់ធ្វើសំបុក ការផ្លាស់ប្តូររបបអាហារតាមរដូវកាលដើម្បីធ្វើត្រាប់តាមលក្ខខណ្ឌធម្មជាតិ និងការផ្តល់ឱកាសជ្រើសរើសដៃគូបន្តពូជដោយសេរី ដែលមានសារៈសំខាន់នៅក្នុងការជម្រុញការបង្កាត់ពូជ។ ត្រូវមានការប្រុងប្រយ័ត្នដើម្បីការពារការខូចទ្រង់ទ្រាយរូបសាស្ត្រដែលអាចបង្កឡើងដោយវិធីសាស្ត្រនៃការចិញ្ចឹមសត្វ។ ការកែប្រែកន្លែងបង្កាត់ពូជចាំបាច់ត្រូវធ្វើឱ្យប្រសើរឡើងនូវការដាក់ដោយឡែកនៃគូបង្កាត់ពូជ ដើម្បីកាត់បន្ថយអកប្បកិរិយាខឹងច្រឡោតរវាងឯកត្តៈនីមួយៗ។

Abstract

Ex situ conservation breeding is increasingly used to prevent the extinction of threatened bird species. Cambodia is home to the highly threatened white-shouldered ibis *Pseudibis davisoni*. With support from government authorities, the Angkor Centre for Conservation of Biodiversity has developed an ex situ population of the species based on rescued and confiscated individuals with the goal of establishing a genetically sustainable assurance population. During the 2022–2023 breeding season, we successfully bred two chicks, which represents the first successful ex situ breeding effort worldwide. This experience provided us an opportunity to consider lessons learned and inform future efforts. Our daily provision of nesting material, seasonal change of diet to mimic natural conditions and allowance of free mate choice may have been important in stimulating breeding. Caution must be taken to prevent morphological deformities

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that could be caused by husbandry procedures. Modifications to our breeding complex are needed to improve separation of breeding pairs so as to minimize aggressive behaviour between individuals.

Keywords Captive breeding, hatching success, mate choice, nestling success, reproductive success, seasonal diet.

Introduction

Ex situ conservation breeding is increasingly used to prevent the extinction of threatened bird species and populations (Seddon *et al*., 2007; Redford *et al*., 2011; Biega *et al*., 2019; Bussolini *et al*., 2023). Successful conservation breeding programmes include the California condor *Gymnogyps californianus* in North America (Snyder & Snyder, 2000), the crested ibis *Nipponia nippon* in Asia (Xi *et al*., 2002) and most recently, the Spix's macaw *Cyanopsitta spixii* in Brazil (Vercillo *et al*., 2023). While captive breeding programmes have suceeded for some bird species (Butchart *et al*., 2006), they can be time-consuming, resource-intensive and difficult to implement (D'Elia 2010; Hoffmann *et al*., 2010; Collar & Butchart 2014; Bussolini *et al*., 2023). Success is by no means guaranteed, because many programmes are limited by decreased reproductive success in captive environments.

Decreased reproductive success in captive environments is not the only reason for the failure of ex situ conservation projects. Other challenges such as lack of suitable habitat for reintroduction and difficulties in monitoring and managing populations post-release also contribute to the failure of these programmes (Lees & Wilcken, 2009; Mason, 2010; Leus, 2011; Farquharson *et al*., 2018; Bubac *et al*., 2019). As such, a thorough understanding of potential challenges is crucial to planning and successfully implementing ex situ conservation projects.

Removing individuals from the wild to create founder populations for ex situ breeding programmes can increase species extinction risk (Snyder *et al*., 1996). On the other hand, ex situ conservation efforts can buy time for the causes of population declines in the wild to be addressed through actions such as eliminating introduced predators, restoring habitats or enacting legislative changes that create conditions for species to survive (Andrew *et al*., 2016; Mahood *et al*., 2021). If individuals need to be taken from the wild, ex situ breeding programmes should only be undertaken when sufficient numbers remain in situ. Determining the necessity and feasibility of establishing a founder generation from the wild should be based on a One Plan Approach (Byers *et al*., 2013).

Cambodia supports the white-shouldered ibis *Pseudibis davisoni*, which is regarded as Critically Endangered (BirdLife International, 2018). The species was once widely distributed in Southeast Asia but has declined substantially in the last 50 years (Thewlis & Timmins, 1996; BirdLife International, 2018). Currently, it is almost entirely confined to northern and eastern parts of Cambodia (ca. 87–95 % of the global population) with a fragmented population estimated at 670 mature individuals globally (BirdLife International, 2018). Conversion of dry forests for infrastructure development, settlement and agriculture have been projected to cause further, severe declines in the species (Wright *et al*., 2010b, 2012b).

During the dry season in Cambodia (November–May), white-shouldered ibises nest in dipterocarp trees in dry forests close to seasonally abandoned wet-season rice-fields, large contiguous areas of dry forest and in flooded forest within the Mekong channel (Wright *et al*., 2013b; BirdLife International, 2018). During this season, they forage at waterholes (known as *trapeangs* in Khmer) (Wright *et al*., 2010a; BirdLife International, 2018) and the species appears to benefit from the presence of large wild herbivores, which are believed to have historically played a role in maintaining trapeangs in dry forest landscapes. As such, the decline of large herbivore species in the region may have contributed to the decline of the ibis, with only a few suitable areas now remaining for the species in Cambodia. In the absence of large herbivores, the wallowing and grazing behaviour of domestic water buffaloes may serve a similar function (Wright *et al*., 2010a; Eames *et al*., 2018).

Actions have been undertaken to conserve populations of white-shouldered ibises in Cambodia over the last two decades. For example, its population has been monitored annually through a coordinated national census and its nests are monitored and protected in priority areas for the species through schemes which offer incentives to community members to locate and report nest locations (Clements *et al*., 2010; Wright *et al*., 2010b, 2012b, 2013a; Cambodia Ibis Working Group [CIWG], 2023). A community-managed ecotourism initiative has been initiated at Tmatboey and Siem Pang incorporating nest-finding and monitoring (BirdLife International, 2018). Communities have also been engaged in low-intensity, sustainable and wildlife-friendly agriculture through the promotion of an Ibis Rice scheme, which protects foraging areas for the species and encourages coexistence between the farmers and ibises (Ibis Rice, 2023; Sansom Mlup Prey, 2023). Finally, the CIWG was established by a national government decree in 2023 and facilitates cooperation between different stakeholders striving to protect the species.

While a One Plan Approach (Byers *et al*., 2013) incorporating in situ and ex situ conservation efforts does not exist for white-shouldered ibises in Cambodia, the need for the latter has been acknowledged (CIWG, 2023). To this end, an ex situ population of white-shouldered ibises has been established at the Angkor Centre for Conservation of Biodiversity (ACCB) using rescued and confiscated individuals with the goal of establishing a genetically viable assurance population (Woesner *et al*., 2021). Situated in Siem Reap Province (13°40'41''N, 104°01'32''E), the ACCB is a species conservation centre of Allwetterzoo Münster (Germany) which focuses on establishing assurance colonies of threatened chelonians and bird species. This paper describes the first successful ex situ breeding of white-shouldered ibises at ACCB and lessons learned during the 2022–2023 breeding season (November 2022 to July 2023).

Methods

Captive breeding site

Cambodia's climate is tropical, with relatively high temperatures and two distinct seasons: a monsoon-driven wet season (May–October) with south-westerly winds ushering in clouds and moisture that accounts for between 80–90% of the country's annual rainfall and a dry season (November–April), with cooler temperatures between November and January (World Bank, 2021). The area around ACCB experiences a mean minimum temperature of 20.5 °C and a mean maximum temperature of 34.6 °C (World Bank, 2021), although temperatures can be more extreme with lowest and highest records of 15.4 °C and 40.0°C (WorldData, 2024). During the 2022–2023 breeding season, minimum and maximum temperatures recorded were 20 °C and 40 °C respectively (AccuWeather, 2023). The mean maximum relative humidity in Cambodia is around 82% (WorldData, 2024).

Our white-shouldered ibises are kept in an off-show complex consisting of four aviaries which are interconnected through sliding doors at ground level. This includes one large aviary (W20) which measures 18x18 m (Fig. 1) and three smaller breeding aviaries (W20.1, W20.2 & W20.3) each measuring 12x6 m. All four aviaries range in height between 4–5 m (Fig. 2), are planted with

Fig. 1 White-shouldered ibis (upper centre) inside the largest aviary (W20) at the ACCB (© ACCB / K. Groot).

Fig. 2 One of three smaller breeding aviaries (W20.2) at the ACCB. The platform pair 1 used to build their nest and raise their chick is located in the far right corner of the enclosure (© ACCB / K. Groot).

trees, bushes and grasses and are equipped with a small pond and perching options at differing heights. Nest sites are also installed in all four. The largest aviary contains multiple woven bamboo baskets, whereas the three smaller aviaries contain a high nest platform (ca. 50x50 cm) placed ca. 4 m above ground level and a smaller round nest basket on a pole.

White-shouldered ibises at ACCB

At the start of the 2022–2023 breeding season, the ex situ population of white-shouldered ibis at ACCB comprised nine individuals (three males, three females and three birds whose sex was undetermined), including some birds of unknown age. Some of these individuals were rescued from the illicit pet trade whereas others were recovered from snares or rescued as nestlings or fledglings that had fallen from nests during bad weather. Through engagement with partner organizations and local communities monitoring nests, injured ibises are promptly identified, enabling swift interventions. Individuals rescued as chicks or juveniles could have been imprinted on humans prior to their arrival at ACCB. The individuals that bred or are suspected to have bred in the 2022–2023 breeding season are shown in Table 1. All of the birds were kept together and had access to all four aviaries at the start of the breeding season.

Diet

The natural diet of white-shouldered ibises comprises small invertebrates such as mole-crickets, insect larvae, amphibians (*Fejervarya limnocharis* and *Microhyla* spp.) and occasionally eels, snakes and leeches. Amphibians appear to form the bulk of the diet, especially during the dry season when these almost excluisvely occur at trapeangs (Wright *et al*., 2012a, 2013b; BirdLife International, 2018).

White-shouldered ibises at ACCB are fed twice a day. The non-breeding diet consists of 75 g of freshwater fish (a mixture of *Barbonymus* spp. and *Cirrhinus* spp.) and 75 g of frogs (East Asian bullfrog *Hoplobatrachus chinensis* bred nearby) per bird feeding, both of which are cut up into small strips or pieces. While none of these species have been recorded in the diet of wild white-shouldered ibises, amphibians form a key part of their diet during the dry season (Wright *et al*., 2010a, 2012a, 2013b). The breeding season diet comprises different quantities of the same components, namely 50 g of freshwater fish and 100 g of frogs per bird twice a day. 'Superworms' (larvae of the tenebrionid beetle *Zophobas morio*) and the supple-

Table 1 Summary information on individuals that potentially bred out of a total of three males, three females and three unsexed birds. The male involved in pair 1 is unknown, hence both males are considered as potential partners in this context. The individual marked * died during the 2022–2023 breeding season, potentially after a mating event.

Pair	ACCB ID	Sex	Arrival date	Estimated birth date	Acquired from
Pair 1	0180006	Male*	18 March 2017	15 February 2017	Ratanakiri
Pair 1	0180007	Male	18 March 2017	15 February 2017	Ratanakiri
Pair 1	0180009	Female	16 January 2018	30 December 2017	Kratie
Pair 2	0180012	Male	7 November 2018	1 January 2015	Stung Treng
Pair 2	0180010	Female	15 March 2018	8 February 2018	Kratie

ment Korvimin ZVT + Reptil (Tierarzt24, Germany) are provided daily during the breeding season.

Nesting materials

Prior to the present study, nesting material was only provided every second day if the birds interacted with it. From early November 2022 onwards, nesting material was provided every two days in the largest aviary (W20) and daily from mid-December onwards. Following incubation, nest material was provided less frequently. The material consisted of a mixture of small branches with green leaves and small bare branches, with a circumference of 14–27 mm, diameter of 4–6 mm and length of 20–50 mm. The ibises also foraged for grass in the enclosure and employed this for nest building.

Data collection

Data were opportunistically collected by ACCB keepers and curators via behavioural observations made with binoculars during the study period. These data included intraspecies interactions (positive and negative), nest building, breeding events and other noteworthy observations and events. All data collected were maintained using the Zoological Management Information System (https://zims.species360.org/).

Results

Nest building

Pair 1 started building a nest on the high breeding platform in the middle aviary (W20.2). However, staff were unable to identify the sire in pair 1 during the 2022–2023 breeding season (Table 1). Nest material was first observed on the platform on 8 February 2023. On 8 March, pair 2 were found to have a nest of their own in one of the trees in the large aviary (W20). It was unknown when this pair began building the nest because the nest area was not accessible.

Incubation

Due to the height and angle of the nest locations, it was not feasible to access and monitor these without disturbing the breeding pairs. The dates that eggs were laid are consequently unknown. There was no indication that a second egg was laid by either pair, although this cannot be confirmed. However, pair 1 began incubating on 13 February, ceased on 16 March, and the chick (ACCB ID 0180022, hereafter chick 1) was first heard (but not seen) on 18 March. We therefore assume that the incubation period of this pair was 31–33 days. However, the pair could have been brooding a very young (and undetected) chick for a few days before incubation ceased. This introduces some uncertainty in estimating the duration of the incubation period. In terms of pair 2, a bird was observed sitting on the nest for the first time on 16 March. However, it is not known for certain whether the pair started incubating earlier. Chick 2 (ACCB ID 0180023) was first heard on 15 April, which would indicate an incubation period of at least 30 days.

Chick development

Chick 1 was not seen until 27 March, nine days after it was first heard. Following this, chick 1 could be monitored daily from outside the aviary (Fig. 3). On 25 April, a deformity in its wings was observed, whereby its primary feathers were rotated outwards on both wings. This could indicate a bilateral valgus deformity known as 'angel wings' (Fig. 4). As the chick was 40 days old and approaching fledging by this time, it was decided to bring it to the on-site veterinary clinic for examination and treatment. Because the superworms were suspected as the cause of the deformity due to their high levels of proteins, these were removed from all diets for the remainder of the breeding season.

The chick was treated by placing a figure of eight bandage on each wing to keep these in the correct position and holding these together in place with a body wrap. Selenium-Vitamin E was also administered (dosage 0.1 mg Se/kg IM) to prevent neuromuscular diseases such as capture myopathy. Because voluntary feeding was not observed, the chick had to be force-fed for the first three days of treatment. Bandages were changed every two days during the first week of treatment. Light-coloured bandages with a camouflage pattern were used, but the bird managed to remove these every two to three days, likely due to the high colour contrast of the bandage against the feathers. Bandages were then changed to a dark-green colour, which proved more effective as these lasted for a week. During each bandage replacement, passive movements of the wings were undertaken to avoid contractures and reduced joint motion due to prolonged bandaging. Despite this, we noticed on 8 May that the wings were starting to become slightly stiff, impairing their complete or normal extension. Because the deformities on both wings were corrected at this point, it was decided to cease bandaging and limit the treatment to physiotherapy, so as to increase wing mobilisation and correct motion. By 15 May, chick 1 had a fully recovered wing motion and was able to fly normally.

Chick 2 was first observed perching next to the nest on 8 June and seen walking on the ground on 9 June, 55 days after hatching. At this point, the decision was made to remove the chick from its parents to prevent predation by Javan mongooses *Urva javanica*, which are capable of occasionally entering the aviary. Following a medical check-up, chick 2 was found to be healthy and did not develop any valgus deformity.

Mate choice and aggressive behaviour

During the preceding breeding season (2021–2022), video camera-traps were employed to assess pair bonding among adult birds. Although bonded pairs were subsequently identified and separated into the smaller breeding aviaries (W20.1–W20.3) just before the breeding season, this did not lead to successful breeding as only initial nest building was observed. As a consequence, it was decided to keep all of the birds together during the 2022–2023 breeding season, allowing these to access all four aviaries of the complex and free mate choice. While this yielded positive results, there were also losses in the population and aggressive behaviour was observed between the birds. On 13 March, a male (thought to be a potential mate in pair 1) was found dead in one of the breeding aviaries and necropsy concluded

Fig. 3 Chick 1 on the nest at approximately 18 days old (© ACCB / K. Groot).

Fig. 4 Valgus deformity before treatment on chick 1, noticeable on both right and left wing where the primary feathers protrude outwards from the body (© ACCB / M. Blümm).

this was due to a fight with a conspecific. Subsequently, another male (ACCB ID 0180007, Table 1) raised chick 1 together with the pair 1 female. Six days later, a second male (not thought to be a breeding bird) was found dead under similar circumstances. Further, an unsexed bird was attacked by a pair 2 individual through the netting separating the aviaries when it approached this too closely. Following these incidents, it was decided to separate all individuals except the breeding pairs for the remainder of the breeding season, although they still had visual contact. Following separation, two adults were observed pecking each other through the netting and another unsexed bird was attacked by pair 2 while in the vicinity of the barrier. A visual barrier was therefore erected between the adjacent aviaries to reduce the risk of aggressive behaviour and associated stress.

Discussion

The fledging of two white-shouldered ibis chicks during the 2022–2023 breeding season at ACCB was the first breeding documented for the species in captivity. Although firm conclusions cannot be drawn on our techniques based on two breeding pairs in just one season, the experience gained and lessons learned nonetheless represent valuable information which warrant consideration in future ex situ conservation efforts.

While the age that white-shouldered ibises reach sexual maturity is unknown, northern bald ibis *Geronticus eremita* generally attain this within three years (Sorato & Kotrschal, 2006). Clutch sizes for crested ibises laid by 2–3 years-old and ≥10 years-old birds are significantly smaller than those of 4–10 years-old birds (Yu *et al*., 2014). As 83 % (seven of nine birds) of our suspected breeding individuals of white-shouldered ibis are 3–4 years old, it is possible that these reached reproductive maturity several years before the 2022–2023 breeding season (assuming homogeneous reproductive physiology among members of the Threskiornithidae).

Both of our pairs raised one chick during in the 2022–2023 breeding season, which is less than the average number of fledged chicks per nest in the wild (mean ± SD: 1.8 ± 0.6) (Wright, 2012). However, due to the elevated nest platforms at ACCB, it is unknown whether a second egg or chick existed in an early stage of incubation. Our data indicate the incubation period for chick 1 lasted 31–33 days and at least 30 days for chick 2. The mean incubation period observed in the wild is 30.4 ± 2.7 days (*n*=17), although challenges in determining laying and hatching dates from ground-based observations create some uncertainty in this figure (Wright, 2012). Nonetheless, the incubation duration for both of the chicks at ACCB appears to fall within the range documented in the wild. This contrasts with the overall nesting period (including incubation). Whereas chick 2 left the nest naturally after 55 days, the average nesting period in the wild has been documented at 67.6 ± 5.9 days (*n*=20) (Wright, 2012), indicating that chick 2 left the nest late compared to wild fledglings.

We regularly offered nest material from the start of November (the start of the breeding season in Cambodia: Wright *et al*. 2013b; BirdLife International, 2018; CIWG, 2023) until incubation began in mid-February. This differed from previous breeding seasons, where nest material was offered sporadically and only resulted in initial nest building. As such, our daily provision of material could have encouraged nest building in our successful pairs, as suggested by Böhm (2006) and Huyghe *et al*. (2023) for other species. Additionally, the aviary complex required maintenance during the breeding season in previous years. This meant the birds had to be separated into temporary housing which could have fostered a sense of insecurity and instability, contributing to the lack of breeding success. This was not the case during the 2022–2023 season, as there was no need to relocate or disturb the birds for maintenance purposes.

The 2022–2023 breeding season was the first time a seasonal diet (based on breeding) was provided to the white-shouldered ibis colony. This resembled expected changes to the diet of wild white-shouldered ibises during the breeding season, when they forage most extensively on amphibians in the desiccating mud of trapeangs (Wright *et al*., 2010a, 2012a, 2013b). As seasonal changes in diet may encourage breeding in captivity (Greggor *et al*., 2018; Rose, 2021; SNZ & CBI, 2023), this action could have conceivably encouraged the pairs at ACCB to breed.

While the diet of our birds resembled the diets of other captive ibises (Böhm, 2006; Bracko & King, 2019), one of our chicks developed ''angel wings'', a well-known deformity in captive waterfowl which can occur due to a high protein diet (Kear, 1973; Smith, 1997). The diets of captive ibises often include superworms and mealworms (larvae of a tenebrionid beetle, *Tenebrio molitor*) (Böhm, 2006; Bracko & King, 2019) which are provided during the rearing period (Xi *et al*., 2001; Böhm, 2006). These normally possess high levels of protein (39.5 % crude protein) (Dragojlović *et al*., 2022). Following identification of the angel wing deformity in chick 1, superworms were eliminated from all diets. This naturally resulted in a decrease in protein intake of the chick 2, which was ten days old at the time and developed normally thereafter. Nonetheless, other factors associated with angel wings, such as genetics (Sun *et al*., 2023) or excessive heat in the early stages of growth (Wade, 2022), among others, could also have caused the valgus deformity in chick 1.

We allowed free mate choice for the first time during the 2022–2023 breeding season. This may enhance breeding success in conservation breeding programmes (Asa *et al*., 2010; Greggor *et al*., 2018; Martin-Wintle *et al*., 2018; Rose, 2021) and studies on zebra finches *Taeniopygia guttata* (Ihle *et al*., 2015) and mallards *Anas platyrhynchos* (Bluhm & Gowaty, 2004) found that birds given free mate choice had a greater chance of producing a clutch than those with assigned partners. However, caution must be exercised due to the potential for aggressive behaviour, especially in solitary breeders. Unlike many other ibis species commonly kept ex situ (Olmos & Silva, 2001; Tomlinson, 2007; Boucheker *et al*., 2009; Martinez *et al*., 2020), white-shouldered ibises are territorial, display solitary nesting behaviour (Wright *et al*., 2013b) and may be more aggressive when confined together in the breeding season. Nevertheless, the loss of two birds due to aggressive interactions in a short period was unforeseen and is not often seen in other captive ibis species (McCreesh *et al*., 2023). Although most studies to date have focused on more solitary breeding species, aggressive behaviour such as pecking between individuals was only sporadically observed in a study conducted at ACCB (Woesner *et al*., 2021). However, Rutkowski & Gerdsen (2011) found that a hadada ibis *Bostrychia hagedash* (a solitary breeder) showed aggression towards a sacred ibis *Threskiornis aethiopicus* housed in the same enclosure. The timing of the aggressive behaviour in our study was also unexpected, because it occurred later in the breeding season after pairs had already begun incubation approximately one month before, rather than during the initial stages of pair bonding, nest construction and incubation. As a consequence, allowing free mate choice in captive white-shouldered ibises presents challenges. Monitoring of individuals that have formed pair bonds prior to the breeding season and separating pairs once bonded is necessary. Development of additional aviaries to separate bonded pairs within the complex at ACCB will also be essential.

While the 2022–2023 breeding season resulted in successful fledging of two white-shouldered ibises, our experience highlights the need for caution in embarking on ex situ conservation actions for this and other Critically Endangered species, as any fatalities could be detrimental to their overall recovery. We therefore recommend risk assessment of the white-shouldered ibis breeding programme according to IUCN guidelines (IUCN SSC, 2014). This could adopt an approach similar to Mahood *et al*. (2021), which evaluated the benefits and risks of establishing an ex situ captive management program for the Critically Endangered Bengal florican *Houbaropsis bengalensis blandini* in Cambodia.

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