Black-necked Stork
Ephippiorhynchus asiaticus
Husbandry Manual

IUCN Status: Near Threatened

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This manual was produced following the guidelines in Jackson (2003) with the addition of some dietary information suggested by Fidgett (2005).

Disclaimer:

This manual has been prepared as part of the requirements for the Graduate Diploma of Ornithology offered at Charles Sturt University. The subject is listed under BIO437.

This manual is intended to be used as a guide only and not as an authoritative statement of every conceivable issue or aspect relating to the species described.

Captive Animal keepers should use this Manual as a guide to the care, management and development of the *Ephippiorhynchus asiaticus* within the proper facilities and not use it as a complete or authoritative research document on the species.

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Facing page: Black-necked Stork *Ephippiorhynchus asiaticus australis*, 'Jabbie' (F) and 'James' (M) engaging in pre-copulation behaviour at the nest with eggs, at Wildlife Habitat Port Douglas, Queensland, Australia (Rebecca Lynch).

Contents

1. Introduction

1.1. Introduction to the species

In European folklore, legends of the White Stork *Ciconia ciconia* as a bringer of babies are ancient but rose to prominence following the publication of Hans Christian Andersen's story 'The Storks' in the nineteenth century (Chadd & Taylor, 2016). In mainland Europe storks are considered good omens, however the African Marabou Stork *Leptoptilos crumenifer* has sometimes been called the 'undertaker bird' (Chadd & Taylor, 2016). In the Indigenous Binbinga tribe in northern Australia married men and women were forbidden from eating the Black-necked Stork *Ephippiorhynchus asiaticus* due to fears that an unborn child would scratch the walls of the mother's womb causing her death (Chadd & Taylor, 2016). The Black-necked Stork is a large charismatic stork and one of nineteen species of storks worldwide.

The Black-neck Stork *Ephippiorhynchus asiaticus* is the only extant species of stork found in Australia and is a striking, wetland bird, using its large bill to catch fish and other prey items. Adults have bright red legs, a white body, and black and white wings. The head and neck are a glossy black, with a lilac crown. The Australian subspecies, *E. a. australis* has a greener sheen to the head and neck, while the nominate subspecies tends towards a bluish sheen (Davies, Marchant and Higgins, 1985). With its erect posture, iridescent head and neck and large size the Black-necked Stork is easily recognisable in the wild. The Black-necked Stork is one of only two species of stork to show sexual dichromatism, with the female having a yellow iris and the male a black iris. The lack of functional syringeal muscles means the Black-necked Stork is unable to produce song (Gill and Prum, 2019; Norton & Whiteside, 2014; F. van Gessel, pers. comm.). Sound is produced by rapidly clapping the bill together (Norton & Whiteside, 2014; F. van Gessel, pers. comm.). Although not classically considered song, the sound produced can still be depicted in a traditional sonogram (**Figure 1**). Boles (2005) describes two smaller species of stork: *Ciconia nana* (previously named *Xenorhynchus nanus*) found in the Darling Downs, south-eastern Queensland and *Ciconia louisebolesae* found at Riversleigh, north-western Queensland.

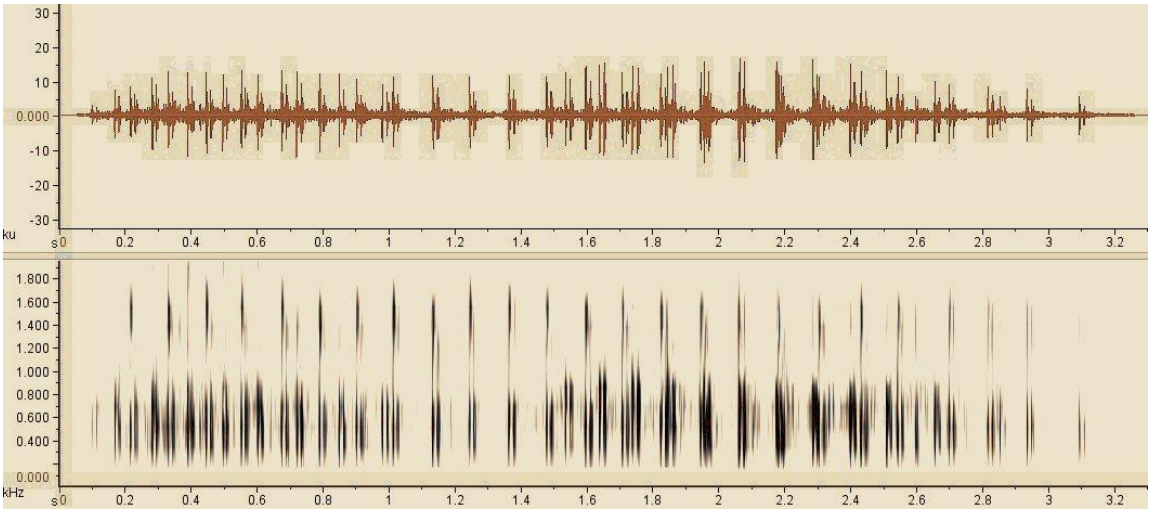

Figure 1: Pictorial representation of Black-necked Stork male bill clapping (snapping) display. Above is the wave form of the sound in dB. Below is the sonogram, also called a spectrogram, showing frequency in kHz and time in seconds (F. van Gessel, pers. comm.).

Images of the Black-necked Stork have featured on stamps in several countries including Australia, Sri Lanka, Guyana and Solomon Islands (**Figure 2**, **Figure 3**, & **Figure 4**). One interesting stamp featuring a Black-necked Stork involved an illegally issued stamp for Nagaland, India (**Figure 5**). Nagaland does not have its own separate postal administration making this is an illegal stamp. The stamp was circulated by a private dealer in the United Kingdom with the intent to deceive stamp collectors and has no postal validity (Colnect, 2022).

Figure 2: Australian stamps featuring images or depictions of the Black-necked Stork issued by Australia Post on various dates. Left: 2 June 1997. Middle: 14 February 1991. Right: 4 March 1993.

Figure 3: Stamps featuring Black-necked Stork issued by Sri Lanka Post. Left: 27 September 2003. Middle: 28 July 2013. Right: 26 January 2016.

Figure 4: Two stamps showing images of the Black-necked Stork incorrectly labelled as a Jabiru, *Jabiru mycteria*, a different species found in South America. The Jabiru has no black in the wings and the legs are not red.

Figure 5: Illegal stamp purportedly issued in Nagaland in 1969 with no postal validity featuring Black-necked Stork.

1.2 History in captivity

There is little information to be found in the literature regarding the history of this species in captivity. Paintings by Shaykh Zayn al-din are thought to be based on birds held by Lady Mary Impey, a natural historian and wife of Lord Impey, the Chief Justice to Bengal in India from 1774 – 1778 (**Figure 6**). The painting of an adult bird (**Figure 7**) was possibly painted at Port Jackson (now Sydney, Australia) between 1776 and 1780.

The Australian subspecies of Black-necked Stork is held in a number of wildlife parks and zoos in Australia in small numbers. These include Wildlife Habitat Port Douglas in Queensland, Featherdale Wildlife Park in New South Wales, Gorge Wildlife Park in South Australia, Currumbin Wildlife Sanctuary in Queensland, Perth Zoo in Western Australia and Adelaide Zoo in South Australia and other smaller wildlife parks (Species 360, 2018; pers. obs.) Internationally the nominate subspecies of Black-necked Stork is held in Jurong Birdpark, Singapore; Kathmandu National Trust for Nature Conservation, Nepal; Angkor Centre for Conservation of Biodiversity, Cambodia and Khao Kheow Open Zoo in Thailand (Species 360, 2018; Zootierliste, n.d.).

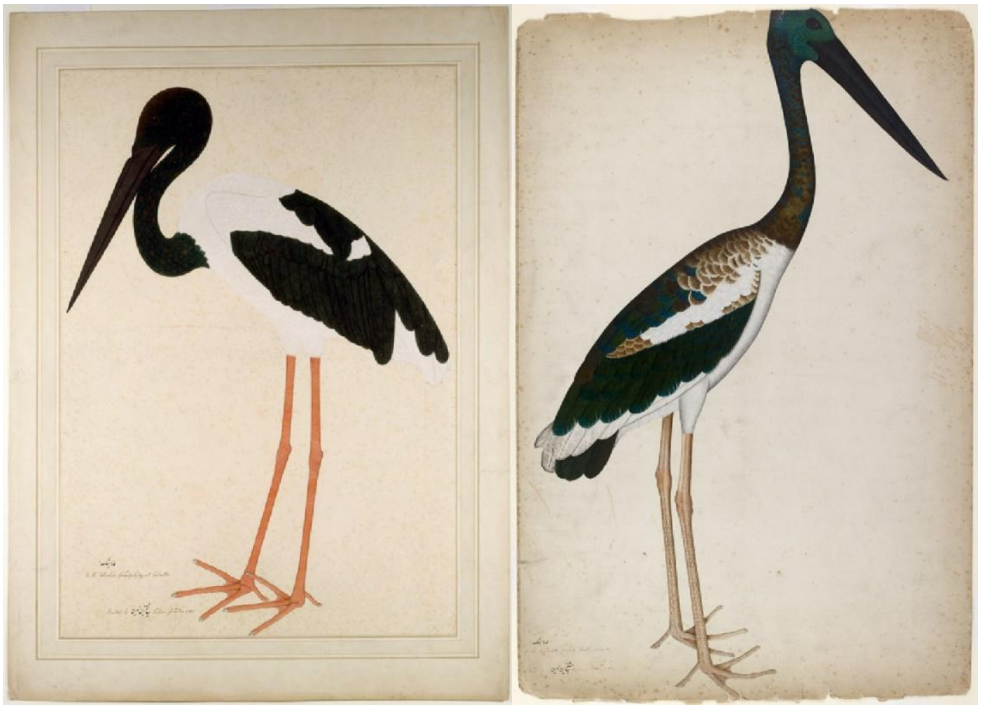

Figure 6: Two paintings of Black-necked Stork commissioned by Lady Mary Impey from birds held in her menagerie in Calcutta. Left: adult bird, right: immature bird (Shaykh Zayn al-din, left 1781, right 1782).

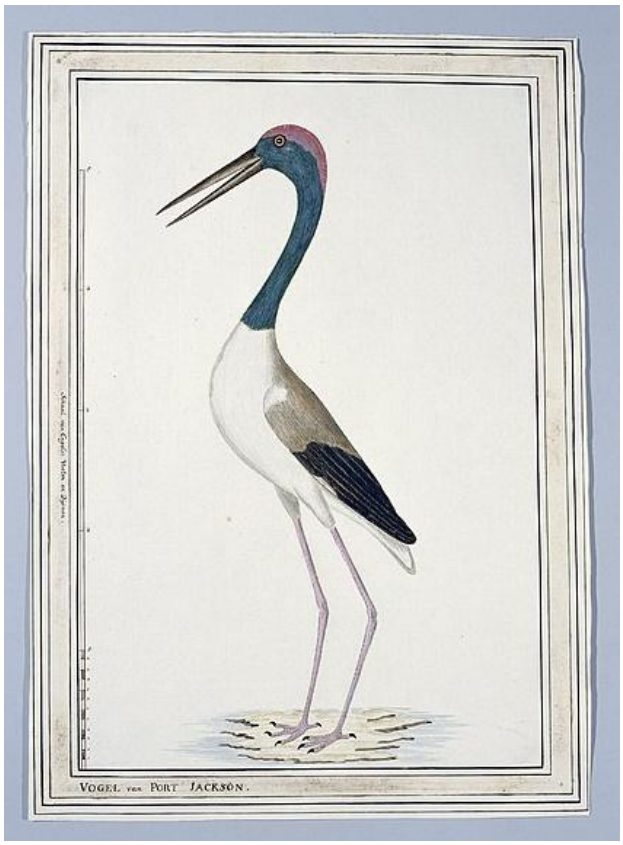

Figure 7: *Ephippiorhynchus asiaticus?* (Black-necked Stork) Bird of Port Jackson (title on object). Bird Study: a Black-necked Stork with scale in English sizes. (artist uncertain, possibly John Hunter or anonymous, 1776 – before 1780).

1.3 Value for education, conservation and research

Due to the vast differences in the populations of each subspecies (see 3.2 below) and the potential in the future for separation into two species (see 2.5 below) as well as limited availability of morphometric data (see 3.3.3 below), this easily recognised species is well-situated for education conservation and research. The Black-necked Stork could be seen as a flagship species for educational purposes when talking about diminishing natural wetlands and the importance of their healthy preservation for not just this species, but other species that use these habitats. Zoos and wildlife parks play an important role in providing this sort of information on a global and local scale. Visitors can view displays, read species information, listen to keeper talks and attend feeding sessions where conservation messages are conveyed.

Until 2019 only one Wildlife Park (Wildlife Habitat Port Douglas, Queensland, Australia) had successfully bred this species in captivity consistently until the death of the adult male (R. Lynch, pers. comm.) These chicks were all raised naturally by the parents in captivity (R. Lynch, pers, comm.). Since 2019 both Gorge Wildlife Park, Adelaide, Australia and Featherdale Wildlife Park, Sydney, Australia have artificially incubated eggs and successfully raised chicks (O. Caulfield, pers. comm., S. McKeachnie, pers. comm.). The information learned from these captive breeding successes could assist in putting strategies in place to protect the nominate subspecies of the Black-necked Stork. As little is known about the biology of the Black-necked Stork and its status as a species or subspecies further research is vital to their future preservation, particularly in areas where the status is Near Threatened or Endangered.

2. Taxonomy

2.1 Nomenclature

Kingdom: Animalia
Phylum: Cordata
Class: Aves
Order: Ciconiiformes
Family: Ciconiidae
Genus: *Ephippiorhynchus*
Species: *E. asiaticus* (Latham, 1790) *Index orn*. 2:670
Common name: Black-necked Stork

2.2 Subspecies

Ephippiorhynchus asiaticus asiaticus (nominate race)
Ephippiorhynchus asiaticus australis (Shaw, 1800)

2.3 Recent synonyms

Mycteria asiatica Latham, 1790
Xenorhynchus (Bonaparte, 1855)
Xenorhynchus asiaticus
Aphippiorhynchus asiaticus asiaticus
Asiatischer Riesentorch (German)
Asiatischer Groβstorch (German)
Indien- Groβstorch
Jabirú Asiático (Spanish)
Jabiru mycteria
Mycteria australis Shaw,1800
Ciconia leucoptera Wagler, 1827
Mycteria novaehollandiae Donovan, 1813
Xenorhynchus asiaticus rogersi Mathews, 1912
Australischer Riesenstorch (German)
Australischer Groβstorch (German)
żabiru austraijski (Polish) (BioLib, n.d.; Birdlife International, 2016; Species 360, 2018.; Zootierliste, n.d.)

2.4 Other common names

Jabiru
Policeman Bird
Green-necked Stork
Satin Stork (Avibase, n.d.; Birdlife International, 2016; Clancy, 2009; Davies, Marchant and Higgins, 1991).

2.5 Discussion

Bonaparte erected the generic names *Xenohynchus* and *Ephippiorhynchus* simultaneously in 1855 giving them equal priority (Christidis and Boles, 2008). It was not until 1972 when the name of the Black-necked Stork was revised by Kahl and Schüz that *Ephippiorhynchus* was selected as the valid name for the species (Christidis and Boles, 2008). The name *Ephippiorhynchus* is derived from the Greek *ephippios* meaning saddle and *rhunkhos* meaning bill (Elliot et. al., 2020). Currently there are two subspecies of Black-necked Stork: *Ephippiorhynchus asiaticus asiaticus* and *Ephippiorhynchus asiaticus australis*. Notable genetic distance has been found between the two subspecies and there is some question as to whether the Australian subspecies should in fact be a separate species due to the differences in neck iridescence, however this requires further investigation due to the very small sample size (four birds) tested (Elliott et. Al., 2020).

For many years the Black-necked Stork was misnamed in Australia as a Jabiru. The Jabiru, *Jabiru mycteria* is a species of stork found in South America (note differences in **Figure 8**). While researching the phylogenetic relationships between the Early Miocene stork *Grallavis edwardsi* and the interrelationships with living Ciconiidae (Figure 9), De Pietri and Mayr (2014) found the closest relative and sister species to the Black-necked Stork is the Saddle-billed Stork *Ephippiorhynchus senegalensis* (**Figure 10**), while *Jabiru mycteria* is the next most closely related and noted by Christidis and Boles (2008) as a sister species to the Black-necked Stork. The *Ephippiorhynchus* species are the only storks to show sexual dichromatism with the female having a yellow iris.

Figure 8: Left: Pair of Black-neck Stork, the female is on the left and the male on the right at Tomago NSW, Australia (Ann Lindsay, 24 June 2018). Right pair of Jabiru, *Jabiru mycteria*, Brazil (Bernard Dupont, 2016). As can be seen, unlike the Black-necked Stork, the Jabiru has an all-white body with a red collar at the base of the neck.

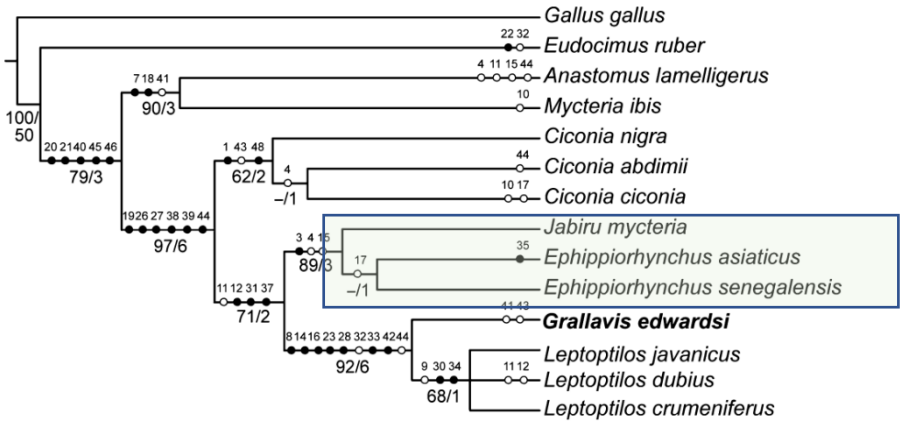

Figure 9: Phylogenetic tree showing the relationship between *E. asiaticus*, *E, senegalensis* and *Jabiru mycteria* (De Pietri and Mayr, 2014).

Figure 10: Saddle-billed Stork *Ephippiorhynchus senegalensis*, South Africa (Bernard Dupont, 2016).

3. Natural History

3.1 Morphometrics

3.1.1. Measurements

Very little data exists on the morphometrics of the Black-necked Stork and further research is needed in this area. Indian data with the combined measurements of both sexes are shown in **Table 1**. The number of specimens used to collect this data are unknown. The limited Australian data is shown in **Table 2** and collected from skins of a single male, a female and a juvenile and may not be representative of the species as a whole. Further data on the morphometrics of juveniles in NSW, Australia is yet to be published (G. Clancy, pers. comm.). Observations at Featherdale Wildlife Park and of wild birds suggest that there is also sexual dimorphism with the female being smaller than the male (pers. obs.).

Table 1: Combined measurements of male and female *Ephippiorhynchus asiaticus asiaticus* from India (Serventy, 1985).

Length:	1290-1370 mm
Wingspan:	c 2 m
Wing:	565-645 mm
Tail:	c300-333 mm
Bill:	298-324 mm
Tarsus:	257-281 mm

Table 2: Australian morphometrics taken from a single sample each of male (1), female (2) and juvenile (3) Black-necked Stork (Davies, Marchant and Higgins, 1991).

	1	2	3
Wing:	606	-	-
9th Primary:	409	-	-
8th Primary:	445	-	-
Bill:	297.5	274	202.1
Tail:	218	-	207
Tarsus:	314.5	277	310
Toe:	120.2	106.4	112.2
Weight:	-	-	4kg

3.2 Distribution

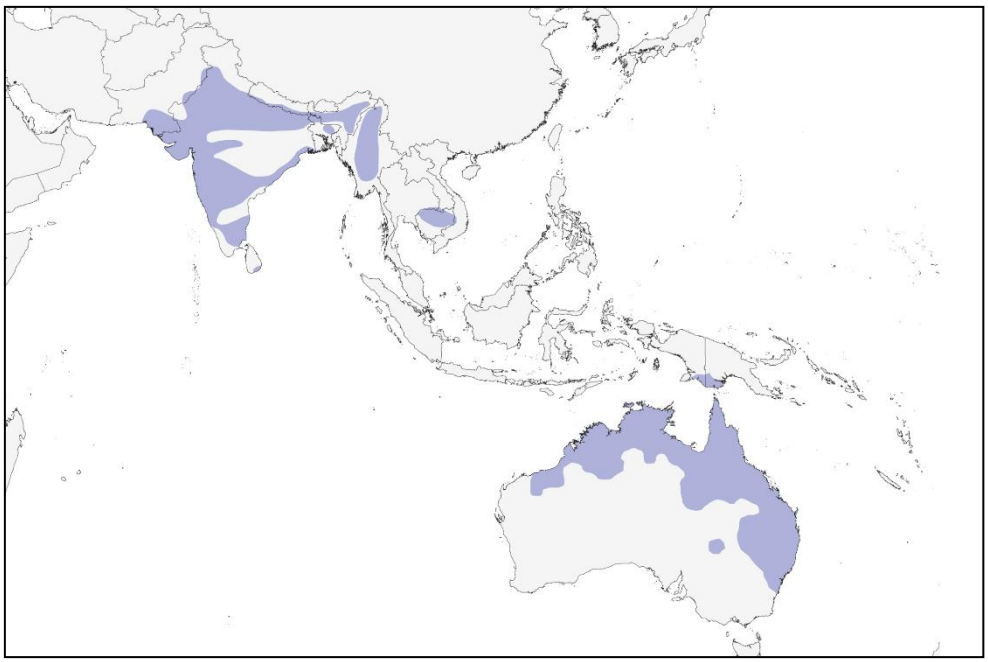

Figure 11: Worldwide distribution of the two subspecies of Black-necked Stork *Ephippiorhynchus asiaticus asiaticus* and *Ephippiorhynchus asiaticus australis* (Elliott et al., 2020).

The Black-necked Stork is distributed over two distinct regions (**Figure *11***). The subspecies *E. a. asiaticus* is native to Bhutan, Cambodia, India, Indonesia, Lao People's Democratic Republic, Myanmar, Nepal and Sri Lanka (Birdlife International, 2016; Ellioitt et. al., 2020). The subspecies *E. a. australis* is found only in Australia and Papua New Guinea (Birdlife International, 2016; Elliott et.al, 2020). The species is extinct from Pakistan and Thailand. The combined populations of *E. a. asiaticus* are thought to be less than 1,000 individuals, while the *E a. australis* population estimates range from 10,000 to 20,000 individuals, the majority of which can be found in northern Australia. New South Wales has a stable population of around 80 pairs. Due to the uncertainty surrounding the number of individuals, the conservative estimate is 15,000 to 35,000 (Birdlife International, 2016; Ellioitt et. al., 2020). Clancy et.al. (2021) estimate the total population of Torresian (Australian) Black-necked Storks to be 30,000 individuals. Of these, breeding pairs are estimated to be: 1,800 in the Northern Territory, Australia; between 1080 and 4741 in Queensland, Australia and 75 to 80 pairs in New South Wales, Australia (Clancy et. al., 2021) There are no similar species found within the range of this species in Australia.

3.3 Habitat

The Black-necked Stork inhabits and requires extensive, largely undisturbed, freshwater wetlands including swamps, lakes, pools in open forest and large rivers and flooded grassland up to 0.5m deep and up to 1,200m in altitude (Birdlife International, 2016). At times the species occurs on dry floodplain and irrigated crops, such as rice paddies and in open, grassy woodland (Birdlife International, 2016). Artificial habitats such as reservoirs, sewage ponds and irrigation stores are also frequented in arid parts of Australia (Birdlife International, 2016). Less common is the use of mangroves and coastal habitats such as brackish lagoons, mudflats, salt marshes and tidal creeks (Birdlife International, 2016).

3.4 Conservation status

3.4.1 International

The IUCN status of the Black-necked Stork is: Near Threatened (Birdlife International, 2016).

3.4.2 National

The conservation status of the Australia breeding population is: Least Concern (Clancy et.el., 2021). The Australian population is considered to be stable (Clancy et. al., 2016).

3.4.3 State

In New South Wales the Black-necked Stork is listed as Endangered under the *Threatened Species Conservation Act* 1995. This listing was gazetted on 30 January 1998 (ALA, n.d.; NSWDPIE, n.d.).

In Queensland and the Northern Territory the listing is: Least Concern (ALA, n.d.).

3.4.4. Discussion

The IUCN have identified many threats faced by the black-necked Stork including:

- Climate change and severe weather
    - causing habitat shift and alteration
    - droughts
- Agriculture and aquaculture
    - Annual and perennial non-timber crops
    - Agro-industry farming
    - Livestock farming and ranching
    - Marine and freshwater aquaculture
- Transportation and service corridors
    - Utility and service lines
- Biological resource use
    - Hunting and trapping terrestrial animals
    - Logging and wood harvesting
    - Fishing and harvesting aquatic resources
- Human intrusions and disturbance
    - Work and other activities
- Natural system modifications
    - Other ecosystem modifications such as weed invasion
- Pollution
    - Agricultural and forestry effluents
    - Soil erosion
    - Sedimentation
- Poisoning
    - Cane Toad *Rhinella marina*.

While climate change and severe weather, non-timber crops plus hunting and trapping show rapid or very rapid declines in population, many of the other threats produce slow, significant population declines. The combination of the threats to this species and the low population of the nominate race in Asia has meant that the Black-necked Stork is now considered Near Threatened globally (IUCN). Most of the Australian breeding population can be found in Queensland and Northern Territory, Australia where it has the status of: Least Concern, while in New South Wales, Australia it is has been classified as Endangered since 1998 (*Threatened Species Conservation Act* 1995). Clancy (2010) has found that 50% of deaths in New South Wales, Australia are caused by impact with powerlines, but that poisoning by the Cane Toad *Rhinella marina* is not a concern. This is in contradiction to the IUCN data (Birdlife International, 2016).

3.5 Diet in the wild

The Black-necked Stork is carnivorous and requires nearly 1kg of food per day in the wild (Maheswaran & Rahmani, 2002). Approximately 70% of the diet of the Black-necked Stork is comprised of fish. The balance is made up of invertebrates, endothermic vertebrates and exothermic vertebrates in equal proportions (ALA, n.d.). in addition to fish, Black-necked Stork have been observed to eat crustaceans, insects, snakes, eels, turtles and their eggs, waterbirds (including Little Grebe *Tachybaptus ruficollis* and Common (Eurasian) Coot *Fulic atra*) and carrion (Birdlife International, 2016; Davies, Marchant and Higgins, 1991; Whiting & Guinea, 2016). The Black-necked Stork usually feeds in shallow water up to 0.5 m deep (Elliott et. al. 2016; Maheswaran & Rahmani, 2001), however in New South Wales, Australia feeds in water 0.05 to 0.3 m (Clancy. 2011). Foraging typically occurs at mid-tarsus water depth (Ishtiaq, 2010). Fish are manipulated until head-down before eating, while snakes are thrashed or jabbed with the bill (Davies, Marchant and Higgins, 1991). In a New South Wales study by Clancy (2011) prey was observed to be 66% invertebrates and 34% vertebrates. A similar study in India identified the majority of prey to be fish and frogs (Sundar, 2011a).

3.6 Longevity

3.6.1 In the wild

Very little is known about the longevity of the Black-necked Stork in the wild. The ABBBS reports only a small number (54) of this species as being banded between October 1962 and November 2021 (ABBBS, 2022). Banding of chicks prior to fledging in New South Wales since 2003 by G. Clancy has provided very few recoveries of banded adults (pers. comm.). This is partially due to these birds dispersing over large distances and their preference for large, isolated wetlands makes banded birds difficult to see by birdwatchers and other members of the public (G. Clancy, pers. comm.). Of the birds recovered and reported to ABBBS the oldest age recorded is 5 years 10.7 months. This bird was first banded in September 2008 and recovered dead in August 2014 (ABBBS, 2022). This is unlikely to be a true reflection of the longevity of the Black-necked Stork in the wild given the known long lifespan of other ciconids such as the White Stork *Ciconia ciconia* and the Black Stork *Ciconia nigra*. Banding studies of both species indicate that the White Stork can live between 34 to 39 years in the wild while the Black Stork records a lifespan in the wild of at least 18 years (Tamas, 2011). These studies are ongoing and further data is likely to be published in the future. Baylis, Lisle & Hauber (2014) suggest caution in the use of mark/recapture data and captive lifespan data in the estimation of longevity in any species.

3.6.2 In captivity

In captivity the Black-necked Stork has been known to live into their late 40-s (R. Lynch, pers. comm.). At the time of writing this manual, Featherdale Wildlife Park in Sydney, Australia were holding a pair of Black-necked Storks aged in their 40s (O. Caulfield, pers. comm.; pers. obs.).

3.6.3 Techniques used to determine age in adults

The Black-necked Stork can be aged by their plumage as a young bird, however once adult plumage is obtained the only way to accurately determine the age of the bird is if it was banded or colour-banded as a chick and later identified or recovered in the field. There are no distinguishing plumage features to differentiate between a five-year-old bird and a twenty-year-old bird. There is a possibility that the colour in the legs of older bird fades a little and the legs become scalier, as in the Brolga *Grus rubicunda*, but this is uncertain (S. McKeachnie, pers. comm.).

4. Housing Requirements

4.1 Exhibit Design

Unlike many other stork species, the Black-necked Stork is a solitary nesting species (Clancy, 2009). Enclosures therefore need to be large enough to accommodate one or two birds, and if breeding, any chicks that are raised naturally by the parents. Exhibit design varies between institutions including large open enclosures with birds physically restricted from flying, traditional mesh cage type enclosures and large mixed species walk-in enclosed aviaries. Enclosures should allow sufficient space both horizontally and vertically to allow the birds to be able to take off, fly and land successfully and without injuries, with provision for shelter from the elements and access to direct sunlight (NSW Department of Primary Industry, 2019). Enclosures should be predator proof and netting or mesh visible to the birds to ensure they do not collide with the enclosure or other animals in the enclosure and cause themselves injuries and should be of sufficient size for the animal to withdraw from other animals or people (NSW Department of Primary Industry, 2019).

A standard enclosure for two birds (and any chicks they may have from time to time) is shown below (**Figure 12**). Where birds are pinioned or otherwise restricted from flying, they may be kept in an open enclosure (**Figure 13**) which may be smaller than that required if it could fly (NSW Department of Primary Industry, 2019). Given the large size of this species such an enclosure should still allow the birds sufficient space to roam without injury. **Figure 13** is an example of a large open enclosure which still contains all the necessary features of an exhibit space for this species. Entry into the enclosure should be by inward opening doors to minimize opportunities for animals to escape (NSW Department of Primary Industry, 2019). Double door systems should provide sufficient space between doors to allow a person or persons to stand and operate the doors with one closed at all times and both opening inwards (NSW Department of Primary Industry, 2019).

Figure 12: Black-necked Stork enclosure at Featherdale Wildlife Park, Sydney. This enclosure is approximately 10m x 14m x 2.8m and fully enclosed and contains two shelters on the southern side, one in each corner, nest platform, small trees for shade or perching and two water ponds (J Little, 16 August 2022).

Figure 13: Open air enclosure for exhibition of pinioned/clipped birds at Featherdale Wildlife Park, Sydney. Enclosure contains a small pond, shelter and natural substrate, with logs and stumps for elevated perching and trees for shade (J. Little 16 August 2022).

4.2 Holding Area Design

Holding areas may vary in size depending on the purpose and the length of time the bird will be held in such an enclosure. Below (**Figure 18**) is an open enclosure off-exhibit, containing a juvenile bird with its wings clipped waiting to be moved to a more permanent enclosure. Once the bird is moved to its permanent enclosure the wings will be allowed to grow as normal (O. Caulfield, pers. comm.). A fully flighted bird will require a fully enclosed pen.

4.3 Spatial Requirements

Due to their large size the Black-necked Stork requires a large enclosure to retain their capacity for flight and limit the possibility of injury. In New South Wales this is governed by the *Exhibited Animals Protection Act* (1986) and the *Exhibited Animals Protection Regulation* (2021). In addition, the 'General Standards for Exhibiting Animals in New South Wales' (February 2019) should be followed. These documents can all be found on the NSW Government Department of Primary Industries website (https://www.dpi.nsw.gov.au/animals-and-livestock/animal-welfare/exhibit). Other States and Territories have similar legislation and policy documents. Carers should check the legislative requirements in their local area. **Figure 16** and **Figure 17** depict different views of the large walk-in aviary at Wildlife Habitat Port Douglas, Queensland. This was the aviary where a pair of Black-necked Storks successfully bred naturally for a number of years (R. Lynch, pers. comm.). At Gorge Wildlife Park, Adelaide birds are housed in two aviaries, one 25m x 20m x 6m (high) covered with nylon netting (**Figure 14**) and a second breeding aviary also covered in nylon netting 25m L x 8m W x 6 – 7m H (**Figure 15**) (S. McKeachnie, pers. comm.).

Figure 14: One of the aviaries at Gorge Wildlife Park, Adelaide (S. McKeachnie, 13 October 2022).

Figure 15: Female in breeding aviary at Gorge Wildlife Park, Adelaide. (S. McKeachnie, 13 October 2022).

Figure 16: Partial view of walk-in aviary at Wildlife Habitat Port Douglas, Queensland showing one of the large ponds, trees for shade and perching, artificial shelter in the background and mulch substrate. The large awning is used by the birds as both a shelter and a sunny roost site (J. Little, 1 September 2022).

Figure 17: Walk-in aviary Wildlife Habitat Port Douglas, Queensland: view of second pond with waterfall, coarse sand substrate and old nest stump (now decayed). The roof mesh is visible (J. Little, 1 September 2022).

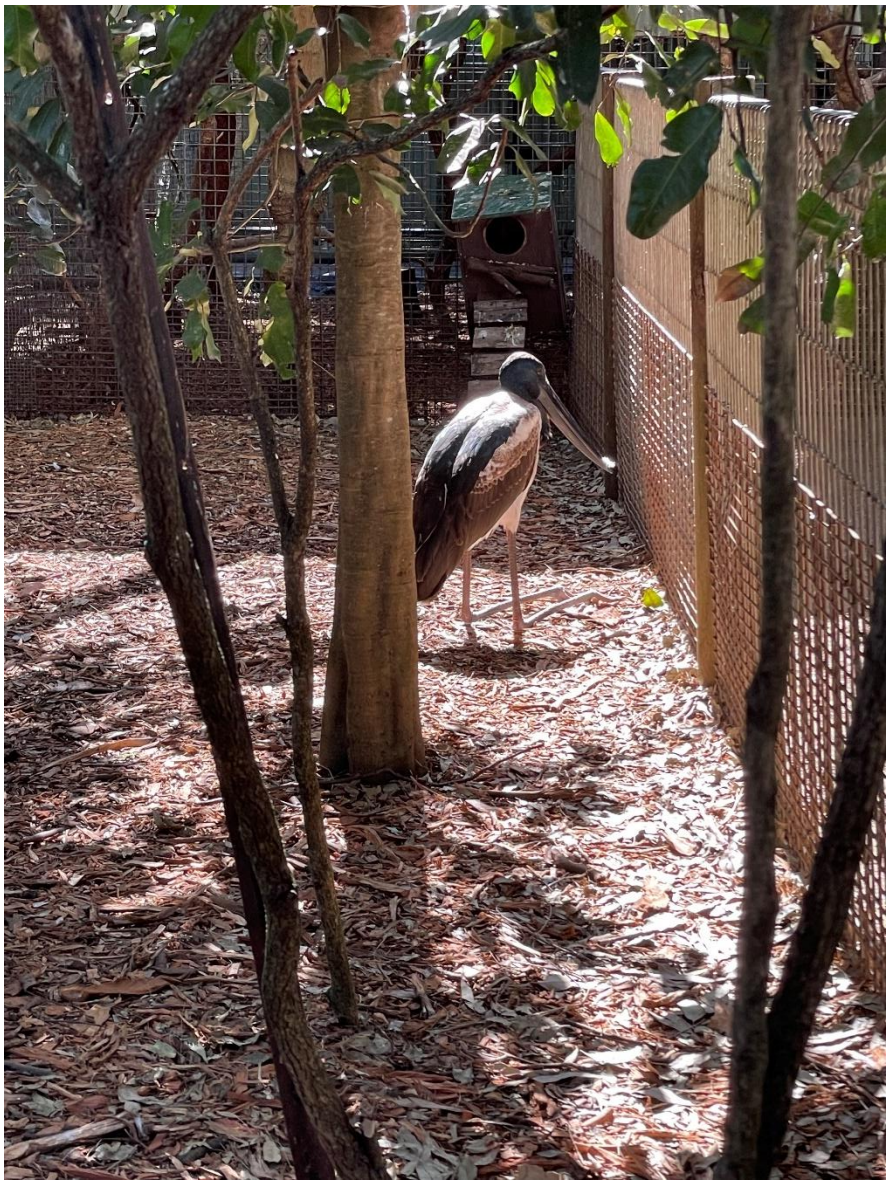

Figure 18: Juvenile (12 months) Black-necked Stork enjoying the sun in a holding pen at Featherdale Wildlife Park, Sydney, prior to moving to a permanent enclosure. This is an open enclosure so the bird is temporarily restricted from flying by having its wings clipped. Sex of this bird is yet to be determined as no testing has been done and if a female, the eye will not change colour until around two years of age. The main substrate in this enclosure is mulch (J Little, 16 August 2022).

4.4 Position of Enclosures

Enclosures should be positioned such that the birds can seek adequate shade or shelter from the elements but with access to large areas of sunlight. Black-necked Stork are known to favour sunny positions for resting during the day (O. Caulfield; R. Lynch; pers. comm.).

4.5 Weather Protection

Shelter should be provided in different parts of the enclosure with different orientation from prevailing weather events to allow the birds refuge options in the case of adverse weather such as rain, storms and excess heat. Examples of different types of shelter can be seen in **Figure 12** and **Figure 19**. These shelters should include access to water and perching options.

Figure 19: View of pond with structures and tree providing shade and perching options in the background and coarse sand and pebbles with scattered perching logs as substrate in the foreground at Wildlife Habitat Port Douglas. Due to the large size of this aviary other shelter options are available (J. Little, 1 September 2022).

4.6 Temperature Requirements

There are no specific temperature requirements.

4.7 Substrate

Ideally substrate should be as natural as possible and include coarse sand, mud, grass and both still and flowing open water. Use of hard concrete surfaces should be limited to avoid birds developing bumblefoot. Examples of different substrate are shown in **Figure 13**, **Figure 16**, **Figure 17**, **Figure 18**, **Figure 19** and **Figure 20**.

Figure 20: Female Black-necked Stork on substrate of coarse river sand surrounding one of the ponds at Wildlife Habitat Port Douglas, Queensland (J. Little, 1 September 2022).

4.8 Nest Material

During the breeding season the birds should have access to two or three different nest platforms or sites of various heights, usually one to two metres from the ground to allow them to choose a nest location. The sites should be elevated with sufficient space to allow the birds to fly to and from the nest site with nesting material and later food for chicks. Nesting material should include large sticks up to 10mm in diameter and up to 1m in length with and without leaves for the main nest structure, along with smaller diameter and length sticks, leaves, grasses and reeds for lining the nest (**Figure 21** and **Figure 22**). Sticks from Eucalyptus or Melaleuca trees are suitable. Pandanus should be avoided or stripped of spines if it is offered as these can cause injury to the birds (R. Lynch, pers. comm.). Both Featherdale Wildlife Park, Sydney and Gorge Wildlife Park, Adelaide, provide a 'starter nest' to the breeding pair and offer further materials for the birds to complete the nest building to their satisfaction (O. Caulfield, pers. comm.; S McKeachnie, pers. comm.). Materials are provided throughout the breeding event to allow the birds to make repairs (pers. obs.).

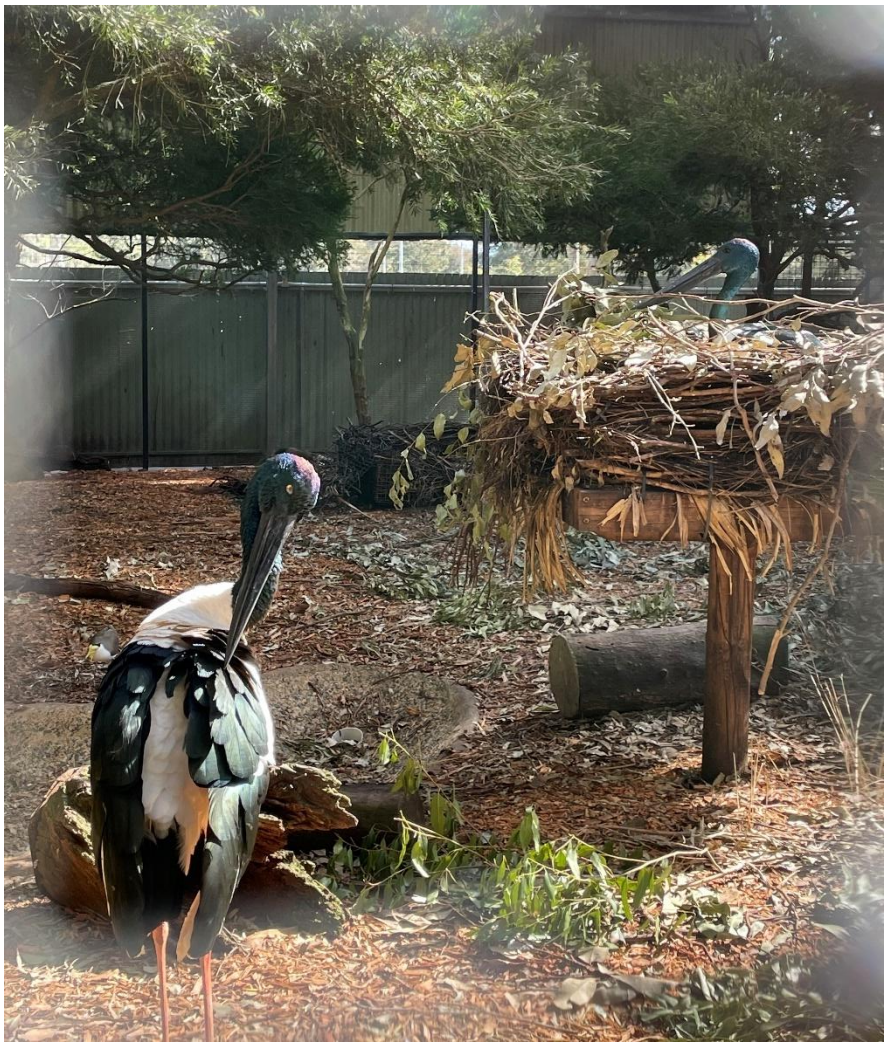

Figure 21: Female Black-necked Stork preening while male incubates eggs on nest. Close-up view of nest showing construction materials of sticks and small branches and lined with grass and leaves (J. Little, 1 September 2022).

Figure 22: Nest platform in centre/top of image at Gorge Wildlife Park, Adelaide (S. McKeachnie, 13 October 2022).

4.9 Enclosure Furnishings

Furnishings should include platforms, dead branches or stumps and live trees for roosting or nesting; pools of water for fishing or cooling and areas of shade and direct sunlight as can be seen in **Figure 13**, **Figure 16**, **Figure 17**, **Figure 18**, **Figure 19** and **Figure 20**. The enclosure at Gorge Wildlife Park, Adelaide also includes a reed bed to allow for wading and fossicking (S. McKeachnie, pers. comm.).

5. General Husbandry

5.1 Hygiene and Cleaning

Enclosures should be raked and swept clean at least daily and any waste removed from the enclosure and taken off-site to reduce the risk of disease and pests. Any excess food should be cleared away once the birds have finished feeding and food bowls (if used) washed and disinfected after each use.

5.2 Record Keeping

Records are to be kept on each species or group of species held and be available for inspection if required (NSW Department of Primary Industry, 2019). Records pertaining to each animal should travel with the animal if it moves to a different facility (NSW Department of Primary Industry, 2019). Animal record books must be kept up to date and produced when required for licensing purposes (NSW Department of Primary Industry, 2019). Until recently many facilities kept paper records of the animals in their holdings (**Appendix 1)**. In more recent times keeping of records has moved to the ZIMMS database (R. Lynch pers. comm.).

5.3 Methods of Identification

Once the Black-necked Stork attains adult plumage, other than eye colour, there is little to tell the birds apart. The best way to identify individuals is by way of metal bands with an individual identifying number (NSW Department of Primary Industry, 2019). Colour bands could also be used to signify the origin of the birds (ie birth location) or year of birth. An example of this would be to band all chicks from one facility with the same colour signifying the origins of the bird at a glance, with an additional colour to indicate the year hatched.

5.4 Routine Data Collection

Other than visual inspection of the birds and monitoring for any changes in faeces daily there is minimal routine data collection from adult Black-necked Storks in captivity (R. Lynch, pers. comm.). The birds are largely left to their own devices and only captured for checking with a vet if a problem arises (R. Lynch, pers. comm.; S McKeachnie, pers. comm.). A more rigorous data collection regime exists for hand-reared chicks, at least until fledged (S. McKeachnie, pers. comm.; see section 11 below).

6. Feeding & Nutrition Requirements

6.1 Captive Diet

Diet for adult birds consists largely of various types of fish. Barramundi fingerlings up to around 10cm long are a favourite food items for the Black-necked Stork at Wildlife Habitat Port Douglas, Queensland, however mullet and a small amount of meal worms are also provided (R. Lynch, pers. comm.). Featherdale Wildlife Park, Sydney offer whiting and pilchards (O. Caulfield, pers. comm.). A small number (seven or eight per bird; O. Caulfield, pers. comm.) of previously frozen fish are offered once or twice per day depending on the facility with a larger supply offered when the birds are feeding chicks. At Featherdale Wildlife Park, Sydney birds are also offered a meat mix containing day old chicks and mince (O. Caulfield, pers. comm.). At Port Douglas live fish are also provided, allowing the bird to experience the process of gathering its own food (R. Lynch, pers. comm.). Gorge Wildlife Park, Adelaide offers a larger variety of food including: chicken necks, chicken hearts, chicken frames, whole and cut fish, day old chicks, mice and rats, with chicken necks being a favourite food (S. McKeachnie, pers. comm.). Details regarding feeding diet and feeding for hand-reared chicks can be found in section 11 below.

6.2 Feeding Schedule

Feeding schedules vary between institutions. The morning feed may be in conjunction with a keeper talk such as at Wildlife Habitat Port Douglas, Queensland (pers. obs.), although food is available throughout the day (R. Lynch, pers. comm.). At Featherdale Wildlife Park, Sydney birds are provided fish in the morning and a meat mix in the afternoon. When a second meal is offered this will be later in the afternoon.

6.3 Presentation of Food

Food is placed in bowls on the ground, except for live food which is in the water allowing the bird to search for and capture food as in the natural environment. During keeper talks a small amount of food may offered by hand (**Figure 23**) (pers. obs.). Live food is available in ponds at Wildlife Habitat Port Douglas, Queensland from time to time for enrichment purposes to allow the birds to experience a more natural feeding and foraging regime (R. Lynch, pers. comm.).

6.4 Nutrient Composition

Unknown at this stage.

6.5 Supplements

The use of supplements varies between institutions. Gorge Wildlife Park, Adelaide do not provide any supplements to the Black-necked Storks held by them (S McKeachnie, pers. comm.) due to the level of natural calcium provided via bone in food. The only exception to this is any vitamins and minerals provided to hand-reared chick which is addressed below in section 11 (S. McKeachnie, pers. comm.). Featherdale Wildlife Park, Sydney provides a calcium supplement in the meat mix once a day, which is increased when they are rearing chicks or required supplementary feeding (O. Caulfield, pers. comm.). At Wildlife Habitat Port Douglas, Queensland, Seabird Tablets (vitamins) are provided in all food, other than live fish (R. Lynch, pers. comm.).

6.5 Hand Rearing Protocols

Dietary information for hand rearing is found in section 11.8 below.

6.6 Dietary Heath Issues

There are no reported dietary health issues.

Figure 23: Black-necked Stork handling prey item (fish fingerling) provided during keeper talk at Wildlife Habitat Port Douglas, Queensland (J. Little, 1 September 2022).

7. Handling and Transport

7.1 Timing of Capture and Handling

Ideally where capture is necessary either for health reasons or for transport to another institution, birds should be captured either early in the morning or late in the afternoon away from view of members of the public and when noise levels are low to avoid causing additional stress to the birds. In instances where this is unavoidable such as where an injury requiring treatment has occurred, where possible limit viewing by member of the public as many may find the process distressing and cause a scene which could further stress an already unwell animal. Many birds in captivity will be accustomed to keepers being nearby and should be approachable.

7.2 Catching Bags

This species is too large for a catching bag, and it may be more appropriate to wrap in a towel or blanket, keeping the head covered being mindful of the neck and legs. If a bag is required for a short period such as to weigh the animal, a large 150L brattice garden bag from Bunnings, measuring 70cm x 1150cm has been used when weighing chicks to be banded in the field (**Figure 24**).

Figure 24: Garden Bag from Bunnings, 150L capacity made from brattice used for weighing Black-necked Stork chicks in the field. The field guide is shown for scale (J. Little, 3 0ctober 2022).

7.3 Capture and Restraint Techniques

Capture can be by way of a long-handled net or by hand if able to get close (Norton & Whiteside, 2014). If possible maneuver the animal into a corner or a smaller space. The bird should be held firmly around the body with the wings tucked in, bill secured and legs free (**Figure 25**). Alternately the head and body can be covered to help keep the bird calm (**Figure 26**) how much of the bird is covered will depend on the procedure the bird is being subjected to The bill should be held firmly but not so tight that the bird is unable to breath and nostrils should be uncovered (**Figure 27**). As with other long-legged birds Ciconiidae capture-myopathy is not uncommon, so care should be taken with the legs and they should be re-positioned regularly, particularly during lengthy examinations (Norton & Whiteside, 2014). Sufficient staff must be available to safely secure the legs and bill to prevent trauma to the bird (Norton & Whiteside, 2014). Handlers need to use caution and safety glasses or a face shield is recommended to avoid eye injuries to humans, particularly if the bird is aggressive (Norton & Whiteside, 2014). For additional safety placing a tube over the bill may prevent eye injury to handlers (Norton & Whiteside, 2014).

Figure 25: G. Little restraining a wild juvenile Black-necked Stork after banding and prior to placing back on the nest at Hexham, NSW. Note the bill is secured and facing away from the face of the handler, wings tucked securely into the body and held firmly and legs hanging freely (R, Kyte, 19 November 2021).

Figure 26: Alternate restraint method, head, bill and body is covered, and bill and legs held by A. Williams while immature rescue bird is banded by G. Clancy at Medowie, NSW (G. Little, 10 September 2018).

Figure 27: Close-up view of bill and leg restraint by handler (G. Little, 10 September 2018).

7.4 Weighing and Examination

Up to three people will usually be required to weigh and examine a bird, one to restrain, one to perform the examination or take measurements and one to record the data using the same techniques described above in 7.3. In **Figure 28** below one person is both restraining and measuring the bird. Generally once captured the Black-necked Stork will be calm and not prone to struggling excessively and can be easily restrained (G. Little, pers. comm.). In **Figure 28** the bird is sitting on the ground with the handler securing the bird between the legs.

Figure 28: R. Kyte taking morphometric data in the field (G. Little, 25 October 2020).

7.5 Release

When releasing after any capture and examination procedure the bird should be in a quiet space with no obstacles and sufficient space to fly or walk off as the animal chooses. Birds should be released during the day (S. McKeachnie, pers. comm.).

7.6 Transport Requirements

In New South Wales transportation of animals must comply with current International Air Transport Association (IATA) guidelines (NSW Department of Primary Industry, 2019). Similar guidelines will apply in other States and Territories.

7.6.1 Box Design

An example of a transport box that has been used for Black-necked Stork is shown in **Figure 29** below. Consult IATA for prior to transportation to determine a suitable size box.

Figure 29: Crate used by Wildlife Habitat Port Douglas, Queensland for transporting Black-necked Stork (R. Lynch, date unknown).

7.6.2 Furnishings

Interior of the box should be clean and dry and be designed in such a way as to minimize movement and the likelihood of any injury to the bird during transport. If required padding can be inserted on the inside of the top to protect the head of the bird and straw or AstroTurf on the floor (O. Caulfield, pers. comm.). Where a commercial crate is used the door should be covered with cardboard, plywood or shade cloth to avoid the bird getting its bill caught in the mesh (S McKeachnie, pers. comm).

7.6.3 Water and Food

Typically, no food or water is provided during transport (O. Caulfield, pers. comm.).

7.6.4 Animals Per Box

When being transported only one bird is placed in each crate.

7.6.5 Timing of Transportation

Early morning is the most suitable as the temperature is cooler and prior to any feeding as the birds are susceptible to regurgitation when being captured (O. Caulfield, pers. comm.; S McKeachnie, pers. comm.).

7.6.6 Release from Box

When releasing bird from carry cage or box handler should stand to the side or back so that the bird has a clear view outside. The door should be opened/raised slowly to allow the bird to acclimatize to the new environment and be allowed to exit at its own pace. The bird should be released from the box immediately on receipt, the earlier in the day the better, particularly if it is being introduced to another bird (O. Caulfield, pers. comm.; S. McKeachnie, pers. comm.). in the event the bird is received late in the day it should be released into a quiet space such as a quarantine room or off-limits holding pen until early the next morning when it is released into the aviary (S. McKeachnie, pers. comm.). Transported bird should be offered food and water as it may have travelled four or five hours and spent much of this time sitting and will need time to stretch its legs and adjust to the new environment (S. McKeachnie, pers. comm.).

8. Health Requirements

8.1 Daily Health Checks

Daily health checks are typically non-invasive and visual. Birds are constantly checked throughout the day to ensure they appear healthy and are not showing any signs of stress or injury (O. Caulfield, pers. comm.; S, McKeachnie, pers. comm.; R. Lynch, pers. comm.). Birds are only physically checked in the event they present with changes to either appearance or behaviour (O. Caulfield, pers. comm.; S, McKeachnie, pers. comm.; R. Lynch, pers. comm.). Birds at Gorge Wildlife Park have not been re-captured since entering their aviary (S. McKeachnie, pers. comm.). Observations are made of many aspects of the animal including but not limited to:

- Feather condition
- Limb function, legs and wings
- Obvious wounds or injuries
- Eyes being clear and open
- Signs of discharge, nasal or cloacal
- Changes in behaviour, eg increased aggression or sleepiness, lack of movement
- Consistency of faeces eg for signs of diarrhoea or blood (O. Caulfield, pers. comm.; S, McKeachnie, pers. comm.; R. Lynch, pers. comm.).

Changes to any of the above will require further examination and may require capture and review by a veterinarian.

8.2 Detailed Physical Examination

8.2.1 Chemical Restraint

No species-specific information is available however anesthetic techniques are similar to other large birds and induction and maintenance with gaseous anesthetics such as isoflurane or sevoflurane is most common (Norton & Whiteside, 2014). Where gaseous anesthesia is not possible a combination of intramuscular medetomidine, ketamine and midazolam has been successful in large stork species (Norton & Whiteside, 2014). During recovery birds should be held or semi-confined until capable of standing to prevent injury, avoiding keeping legs in one position for the entire procedure or surgery (Norton & Whiteside, 2014). There are no published studies of pharmacokinetics or clinical efficacy studies of analgesics for storks, however there is reported toxicity for fenbendazole at a dosage of 60mg/kg in Marabou Storks *Leptoptilos crumenifer* (Norton & Whiteside, 2014).

8.2.2 Physical Examination

Any physical examination should be systematic, and birds may be safely physically retrained for the examination (Norton & Whiteside, 2014). When collecting specimens and samples it is important to ensure the area is clean as many storks will defecate and urinate on their legs to keep cool (Norton & Whiteside, 2014). As with other species venipuncture may be from the jugular (neck) vein, the medial metatarsal (leg) vein or the ulnar (brachial wing) vein (Norton & Whiteside, 2014).

8.3 Routine Treatments

Routine vaccinations for this species are unknown at this time. Routine worming as a preventative treatment has not been conducted or required at Gorge Wildlife Park, Adelaide (S. McKeachnie, pers. comm.), although the Black-necked Stork at Wildlife Habitat Port Douglas, Queensland is doesed monthly (R. Lynch, pers. comm.). Annual preventative health examinations should include a complete physical examination including weight and an assessment of blood parameters and faecal examination (Norton & Whiteside, 2014; (NSW Department of Primary Industry, 2019). If possible morphometric data should be collected during annual health examinations as there is little published morphometric data on this species.

8.4 Known Health Problems

The Black-necked Stork is a hardy species which do not usually succumb to disease (O. Caulfield, pers. comm.; S, McKeachnie, pers. comm.; R. Lynch, pers. comm.). Two individuals have been reported as deceased in Australia: the first was the male of the breeding pair at Wildlife Habitat Port Douglas which died from an unknown growth in around 2012 after a short illness (R. Lynch, pers. comm.) and the second was the male of the breeding pair at Gorge Wildlife Park which died suddenly in 2022 of an unknown bacterial infection (no other birds held were affected) (S. McKeachnie, pers. comm.). For long-legged birds one of the main risks in captivity is Bumblefoot due to hard substrate surfaces. This can be easily avoided with extensive use of natural substrate and the avoidance of concrete and other unnatural surfaces. Any signs of illness should be investigated by a veterinarian to ensure proper diagnosis and treatment is provided. There is only one report on the impact of infectious disease on Black-necked Stork in captivity during an outbreak of HPAIV – H5N1 (highly pathogenic avian influenza virus subtype H5N1) in Cambodia in December 2003 to January 2004 where one Black-necked Stork was recorded to die, while three specimens survived the outbreak (Desvaux et. al., 2009). Ciconiiformes species are not especially sensitive to infectious disease (Norton & Whiteside, 2014). The only other reported disease is for the parasitic trematode *Chaunocephalus ferox* which has been associated with granulomatous enteritis (Norton & Whiteside, 2014). Table 3 below sets out common diseases recorded for Ciconiiformes in general.

Table 3: List of diseases found in Ciconiiformes, categorised as infectious, parasitic, noninfectious, nutritional and toxcicity. Only two of these are recorded as occurring in specimens of Black-necked Stork and these are marked with an asterix (*). Data has been collected from and amalgamated from a number of sources (Desvaux, 2009; Gulcubuk et. al., 2018; Han et. al., 2009; Melo et. al., 2020; Norton & Whiteside, 2014; Olias et. al., 2010).

Disease type	Zoonosis	Cause
Infectious Diseases		
Ciconiiformes hepnadviruses		
Viral heamorrhagic enteritis		
Avian poxvirus		
Avian paramyxovirus		
West Nile virus		
Eastern equine encephalitis		
Mycobacterios		
Chlamydiosis		
Salmonellosis	Zoonosis	
Aspergillosis (fungal pneumonia)		
Candidiasis		
Bumblefoot		
Vegetative endocarditus		
Campylobacter jejuni	Zoonosis	
HPAIV - H5N1*	Zoonosis	Highly pathogenic avian influenza virus H5N1
Parasitic Diseases		
Eustrongylides ignotus		
Heartworm		
Trematodes*		*Chaunocephalus ferox*
Nematodes		
Oesophageal flukes		
Giardiasis		
Lice		
Mites		

Noninfectious Diseases
Trauma
Musculoskeletal abnormalities
Ingestion of foreign objects
Dermatological issues
Degenerative cardiac disease

Nutritional Diseases
Hypotaminosis E
Hypothiaminosis
Metabolic bone disease
Hyperparathyroidism
Steatitis
Vitamin E defficiency

Toxcicity from Environmental Pollutants
Lead
Mercury
Other heavy metals
Arsenic
Organophosphates
Carbamate pesticides

8.5 Quarantine Requirements

NSW Department of Primary Industry (2019) states that newly acquired animals must be kept in isolation for as long as necessary to provide for examination, acclimatization and, if necessary, restoration to good health before being placed with other animals. For animals quarantined due to ill health, the quarantine period will vary depending on the nature of the illness, however animals should not be released back into exhibits until completely well with no symptoms, particularly for infectious diseases. Featherdale Wildlife Park, Sydney have not found the need to quarantine the Black-necked Stork in the past and believe that due to the size of the bird most institutions place them on display upon receipt (O. Caulfield, pers. comm.). All veterinary records are shared from by the previous holder of the animal (O. Caulfield, pers. comm.).

9. Behaviour

9.1 Activity

A three-year study of Black-necked Storks in India during the non-breeding season by Maheswaran & Rahmani (2007) gives insight into the behaviours of the Black-necked Stork (Table 4). **Figure 0** shows a female Black-necked Stork preening while the male sits out of view incubating eggs (pers. obs.). During the breeding season both parents engage in incubation and rearing of chicks although time spent on each activity varies between the male and female (**Table 1**). In **Figure 301:** Adult male Black-necked Stork foraging at Tomago, NSW (A. Lindsay, 6 July 2017).

Table 4: Time budget for Black-necked Stork: Miscellaneous activities include Walking, Flying, Drinking, Yawning, Wing Stretching, Bill Clattering, Bathing and Feeding Chicks (Maheswaran & Rahmani, 2007).

Preening	Chasing	Foraging	Resting	Flying	Miscellaneous
6.85%	17.30%	17.76%	45.70%	4.17%	8.22%

Figure 30: Female Black-necked Stork preening while the male spends time incubating at the nest (out of view) (J. Little, 16 August 2022).

Table 5: Percent time of male and female Black-necked Stork spent on various activities during the breeding season in Dudhwa National Park, India 1996 - 1997 (Maheswaran & Rahmani, 2005).

Activity	Male	Female
Bill clatter	0.14	0.02
Chick maintenance	6.60	0
Defecation	1.20	0.21
Feeding the chicks	4.39	4.60
Away from nest	26.6	25.3
Nest arrangement	3.61	7.15
Bringing nest material	12.0	8.71
Preening	9.39	13.7
Re-ingestion	1.02	0.34
Standing/brooding	17.24	16.7
Incubating/resting	13.6	17.1
Wing stretching	2.53	3.02
Watering	0.81	2.98
Yawning	0.68	0.04

Figure 301: Adult male Black-necked Stork foraging at Tomago, NSW (A. Lindsay, 6 July 2017).

Until 1998 it was thought that all members of the Ciconiidae family except the Wood Stork *Mycteria americana* were diurnal, until they were observed predating sea turtle hatchlings on an Island near Darwin, Northern Territory, Australia (Whiting & Guinea, 1999). At that time it was unknown if this was common behaviour, however, since that time they have been recorded as depredating the eggs of the Three-striped Roofed Turtle *Kachuga dhongoka* at 03h45 in India in February 2006 (Chauhan & Andrews, 2006). Given these observations it is likely that the Black-necked Stork will forage at night, particularly at hotter times of the years as it is common for them to forage at cooler times of the day (Whiting & Guinea, 1999).

9.2 Social Behaviour

Unlike other stork species, the Black-necked Stork is usually found alone, with a mate, of in a family group (Sundar 2004). During a 30-month study Sundar (2004) found that most sightings were of a single bird. The Black-necked Stork is rarely found in large flocks and it is thought that adverse conditions in dry years may cause birds to cluster in remaining wetlands (Sundar, Clancy & Shah, 2006). In large wetlands residential pairs may defend territories (Sundar, Clancy & Shah, 2006). The Black-necked Stork is thought to have a territory size of a few square kilometres (Sundar, Clancy & Shah, 2006). Black-necked Storks are highly territorial and spend around 17% of their time chasing off other birds, including other Black-necked Storks (Maheswaran & Rahmani, 2007). Males, in particular will also exhibit territorial behaviour when breeding and caring for chicks (R. Lynch, pers. comm.).

9.3 Reproductive Behaviour

Clancy & Ford (2011) observed two displays by Black-necked Storks, the classic 'up-down display' and the 'tree-top display. The up-down display usually occurred at the nest but has been observed away from the nest and may be initiated by either the male or female (Clancy & Ford, 2011; Warnock, 2014). Images of the up-down display (**Figure 312** and **Figure 32**) were captured by R. Warnock (2014) in the presence of an immature female which was later chased away by the older female (Warnock, 2014). This display was recorded by Clancy & Ford (2011) pre and post egg laying and also while chicks were present in the nest. The tree-top display involved the following sequence: one adult landing precariously on top of a tall tree after a short period of low circling by the pair; the second bird attempted to land and either failed or caused the first to lose balance and fly off; the first bird then circled around and landed in another tree and the process was repeated (Clancy & Ford, 2011). This tree-top display was not previously recorded (Clancy & Ford (2011). Mating occurred on the nest and only during nest construction an possibly early egg laying and not associated with any display (Clancy & Ford, 2011; cover photo). These behaviours were observed in New South Wales between May and August (Clancy & Ford, 2011; Warnock, 2014).

Figure 312: Female Black-necked Stork commencing the up-down display with wings raised as the male bows towards her, while an immature bird looks on 9R. Warnock, 21 May 2014).

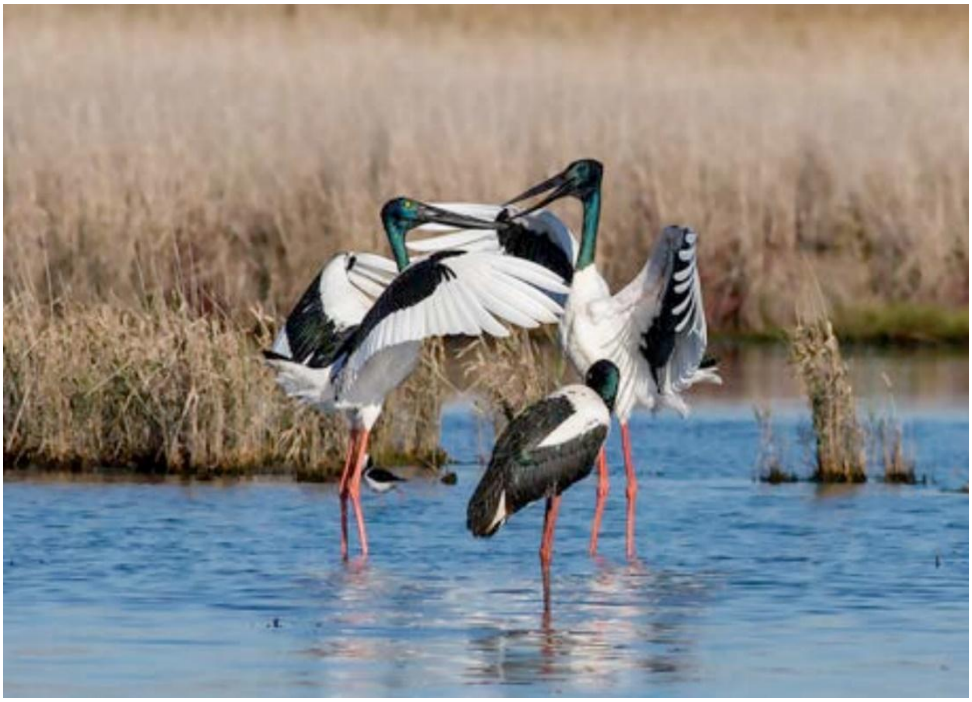

Figure 323: Mid-way through the up-down display sequence (R. Warnock, 21 May 2014).

9.4 Bathing

Fresh clean water should be available at all times for bathing and should be as large as the enclosure will allow while still providing space for

9.5 Behavioural Problems

The main behaviour to be aware of is male aggression during breeding. Steps should be taken to ensure visitors, in particular small children are not at risk from the bill during such times. Temporary physical barriers such as strands of wire may need to be put in place to limit the capacity for flight (R. Lynch, pers. comm.). Otherwise, the Back-necked Stork is generally placid in behaviour.

9.6 Signs of Stress

Signs of stress may include, poor feather condition, lethargy, lack of interest in food or general changes in behaviour.

9.7 Behavioural Enrichment

Live trees to allow for possible nest sites if breeding is proposed. Live food to enable and encourage natural foraging behaviour.

9.8 Introductions and Removals

Where birds need to be either removed from an enclosure or introduced to another bird this should be done as early in the morning as possible (O. Caulfield, pers. comm.). Introductions involve a full day of observing the interactions between the birds (O. Caulfield, pers. comm.). To date there have been no problems with introductions at Featherdale Wildlife Park, Sydney (O. Caulfield, pers. comm.), whereas at Gorge Wildlife Park, Adelaide there was an instance when the current breeding female was first introduced to the male he became aggressive towards her so was removed for a period of 6 months before being re-introduced (S. McKeachie, pers. comm.).

9.9 Intraspecific Compatibility

As a solitary species the Black-necked Stork should only be housed singly or in breeding pairs. Juvenile birds can remain for a period after fledging.

9.10 Interspecific Compatibility

Generally, well suited to being housed with other species, although can show some territoriality during breeding and feeding. While observing foraging habits, Clancy (2011) interspecific aggression was observed towards a number of other species.

9.11 Suitability to Captivity

Well suited to captivity as this large striking bird generally has a gentle nature. Males can become aggressive during breeding and when it is time for chicks to disperse (R. Lynch pers. comm.) Intraspecific aggression was observed in the wild by Clancy (2011).

10. Breeding

10.1 Mating System

The Black-necked Stork is a monogamous territorial breeder and pairs will remain together in successive seasons, often even after breeding is completed (Clancy & Ford, 2011). Further studies are required to determine if the birds engage in extra pair mating in the wild, however in areas where numbers are low this does not appear to be the case (pers. obs.). DNA studies of *Jabiru mycteria* show that almost 87% of pairs are monogamous while less than 14% showed any indication of extra-pair mating (Lopes et. al., 2013). Birds kept in captivity as pairs do not have the opportunity for extra-pair mating.

10.2 Ease of Breeding

The Black-necked Stork were first bred in captivity by Wildlife Habitat Port Douglas and as a result have produced a Breeding Information Sheet (**Appendix 2)**. This breeding success was the result of a lengthy process of around 10 years for the pair to form a breeding bond, despite many attempts from 1998 to 2002 (when the pair first bred successfully) by the male (R. Lynch, pers. comm.). Once the bond had formed and breeding commenced between the pair, they had successive clutches from 2002 until 2018 until the male died (R. Lynch, pers. comm.). During this period between 18 and 23 chicks were raised by the adult birds (R. Lynch, pers. comm.). The breeding pair at Port Douglas were not restricted from flying in any way being neither pinioned nor having their primaries clipped. Breeding success since 2020 at Gorge Wildlife Park, Adelaide and Featherdale Wildlife Park, Sydney also involved birds which were not pinioned or clipped (O. Caulfield; S McKeachnie, pers. comm.) and it is believed that the freedom of flight is, to a large extent, the reason for breeding success (S McKeachnie, pers. comm.) as when copulating the male stands on top of the wings of the female and flight is required to provide the necessary elevation (see cover page photo). A study into the hormone levels of breeding and non-breeding Black-necked Stork make and females at Khao Kheow Open Zoo in Thailand by Kongprom et. al. (n.d.) appears to suggest that they may have had some limited breeding success of the nominate subspecies, however no further information is available at this time. Attempts to breed *E. senegalensis* in captivity have met with limited success, particularly when the male is pinioned (Weibel, et. al., 2021). Until 2013 the only successful breeding attempts were by pairs with fully flighted males (Weibel, et. al., 2021). This confirms the observations made by S McKeachnie in relation to the Black-necked Stork.

10.3 Reproductive Condition

10.3.1 Females

Unknown.

10.3.2 Males

Unknown.

10.4 Techniques Used to Control Breeding

In the event that breeding needs to be controlled for any reason, a simple separation of the male and female during the breeding season would be sufficient. If a longer-term solution was required the male could be pinioned or have the wings clipped. This would however reduce his quality of life and his ability to fly in general.

10.5 Occurrence of Hybrids

There are no known instances of hybrids and the two subspecies of Black-necked Stork are geographically separated.

10.6 Timing of Breeding

The Black-necked Stork is a seasonal breeder and timing of nesting and egg laying varies with location and is often dependant on the end of monsoon season. In India this may be from August to January, while in northern Australia mainly April to June and in New South Wales from May to August (Clancy & Ford, 2011). Once fledged young birds will remain with the adults until the

following breeding season before dispersing. In captivity in southern Australia breeding is usually initiated following the first winter rains between May and August (O. Caulfield, pers. comm.; S McKeachnie, pers. comm.)

10.7 Age at First Breeding and Last Breeding

Age at first and last breeding in the wild is unknown. In captivity to date only three pairs have been known to breed. Ages of these birds have varied. The pair in Port Douglas were both more than 15 years of age before breeding successfully (R. Lynch, pers. comm.). Breeding ceased between the pair when the male fell ill and died of unknown causes (R. Lynch, pers. comm.). There are no plans to re pair the female due to her age (mid-30-s) (R. Lynch, pers. comm.). At Gorge Wildlife Park, the male paired at 11 years but did not successfully breed until 12 years (in 2020) while the age of the female is unknown as this bird was an adult when received by the park(S. McKeachnie, pers. comm.) This bird was received as a wild 'hand-reared' bird in 2018 as a rescue bird from Darwin (S. McKeachnie, pers. comm.). Birds at Featherdale Wildlife Park first bred successfully in 2021 and both the male and female were approximately 9 years of age. Attempts were made in 2019 and 2020 (O. Caulfield, pers. comm.). Unusually when the young pair attempted to breed in 2019 at the end of a long drought the old pair (aged in their 40-s) laid a single infertile egg (O. Caulfield, pers. comm.). They had never previously attempted to lay and have not done so since (O. Caulfield, pers. comm.). the two pairs of birds at Featherdale Wildlife Park, Sydney are housed some distance apart (pers. obs.).

10.8 Ability to Breed Every Year

The Black-necked Stork has the capacity to breed every year and has been observed to do so in the wild (Clancy & Ford, 2011; pers. obs.) and in captivity once a breeding pair is established (O. Caulfield; R. Lynch; S. McKeachnie; pers. comm). The Black-necked Stork will however forgo breeding in dry years (Clancy & Ford, 2011).

10.9 Ability to Breed More than Once Per Year

Typically, the Black-necked Stork will only breed once a year however, as for other Ciconiiformes will double clutch if the first eggs are removed for incubation (O. Caulfield, pers. comm.; Norton & Whiteside, 2014) or in the event of nest failure a pair of Black-necked Stork may make a further attempt at nesting. In the wild where a nest is destroyed due to a storm the birds will re-nest and lay again (pers. obs.). Where eggs are left with the adult birds to hatch and raise chicks the birds will only raise one clutch in a year. Multiple clutches are only laid if eggs are removed after a clutch is laid or a nest is destroy in the wild.

10.10 Nesting Requirements

In the wild a large stick nest between 1 – 2m wide and up to 1m deep and lined with reeds or grass is built at the top of old, often isolated, trees and shrubs in paddocks near wetland or in wetlands (Clancy & Ford, 2011). In captivity birds should provided with at least two nesting options, in suitable locations, with good access to direct sunlight. These options may include a large platform, a large stump or a tree. At Featherdale Wildlife Park two nests were provided to the pair pre-built by staff, one low to the ground and another on a platform of about one metre high with further nesting materials to finish the nest provided to the adult birds (O. Caulfield, pers. comm.). The high platform was chosen by the birds as the best site available (pers. obs.). Wildlife Habitat Port Douglas provided all nesting materials for the birds to build their entire nest (R. Lynch, pers. comm.). Nesting materials consist of branches pruned from trees up to 10cm thick and up to a metre in length, plus reeds and grasses for nest lining (R. Lynch, pers. comm.). These will typically be branches from eucalyptus trees (O. Caulfield; R. Lynch; pers. comm.). Pandanus should be avoided and if provided should first be stripped of all spines as these can cause injury and death to chicks (R. Lynch, pers. comm.). On one occasion at Wildlife Habitat Port Douglas, Queensland the pair had to be discouraged from nesting in a tree close to where keeper talks were held for the safety of the general public as the male can become aggressive when rearing chicks (R. Lynch, pers. comm.).

10.11 Breeding Diet

Diet content during breeding is similar to non-breeding however supply is increased. At Featherdale Wildlife Park when the adults are rearing chicks, they are given an increased food supply plus supplementary feed (O. Caulfield, pers. comm). At Wildlife Habitat Port Douglas, the birds are provisioned with live food and fresh fish instead of frozen fish to ensure chicks received adequate vitamins (R. Lynch, pers. comm.). Up to 20 – 30 barramundi fingerlings a day (total), plus live insects are provided, which is sufficient for the adults and chicks(R. Lynch. pers. comm.).

10.12 Incubation Period

Nest duties are shared between both birds (**Figure 33**) and when not incubating parents spend time repairing the nest, collecting nest lining, transporting water to the nest or standing around (Clancy & Ford, 2011). The transportation of water is thought to increase the moisture in the nest and eggs rather than regulate the temperature (Clancy & Ford, 2011). Incubation period is 32 – 38 days in the wild and when artificially incubated is 35 – 37 days (O. Caulfield, pers. comm.; Clancy & Ford, 2011; S. McKeachnie, pers. comm.). Live incubation by the adults in captivity is 35 days with a hatching interval of 1.5 – 2.5 days (R. Lynch, pers. comm.). Adult birds dump water on eggs and chick, presumably to keep them cool (S. McKeachnie, pers. comm.). McKeachnie (pers. comm.) believe this may be a reason for natural reared nest failure in the southern states as the nest is constantly dirty and wet and it can get quite cold in Adelaide (below 10ºC) when eggs are laid, yet there have been minimal difficulties in artificially raising chicks (S. McKeachnie, pers. comm.). The adult birds regularly turn the eggs using their feet as they walk around the nest and have been seen to 'kick each other off the nest' (R. Lynch, pers. comm.).

Figure 33: Black-necked Stork, male and female standing guard over eggs in the nest. This enclosure has two water ponds, one in the foreground which is full and a second behind the nest which is emptied during nesting to limit the water dumped on the nest and chicks (J. Little, 16 August 2022).

10.13 Clutch Size

Eggs are round to stout oval and small for the size of the bird measuring 72.8 – 74.4mm long by 52.5 – 53.5mm wide (Davies, Marchant and Higgins, 1991 **Figure 34**). **Figure 35** shows the size of an egg of a Black-necked Stork which failed to hatch compared to the lid of a butter container (S. McKeachnie, 2022). The shell of the eggs is quite thick and difficult to candle for fertility purposes in

captivity (O. Caulfield pers. comm.) however new research may overcome this problem in the future (Hall, Potvin & Conroy, 2022). Clutch size is normally two to four eggs and rarely five eggs (Davies, Marchant and Higgins, 1991). Typically, two or three eggs are laid 2.5 – 3 days apart and hatched 2.5 – 3 days apart. In captivity egss are laid 1.5 – 2.5 days apart (R. Lynch, pers. comm.). Clutch size in captivity is from one to three eggs (O. Caulfield; R. Lynch; S. McKeachnie; pers. comm.). In India the Black-necked Stork has been known to raise four (Bhatt, 2006; Sundar, 2011b) and in 2008 five chicks were observed following above average rainfall (Sundar, 2011b). This was the first record for five chicks fledged in single-nesting storks anywhere (Sundar, 2011b). Following above average rainfall in 2021 and 2022 a wild pair at Hexham, New South Wales have also laid five eggs (**Figure 36**7; pers, obs.). The most recorded in captivity is three eggs per clutch (O Caulfield; R. Lynch; pers. comm.).

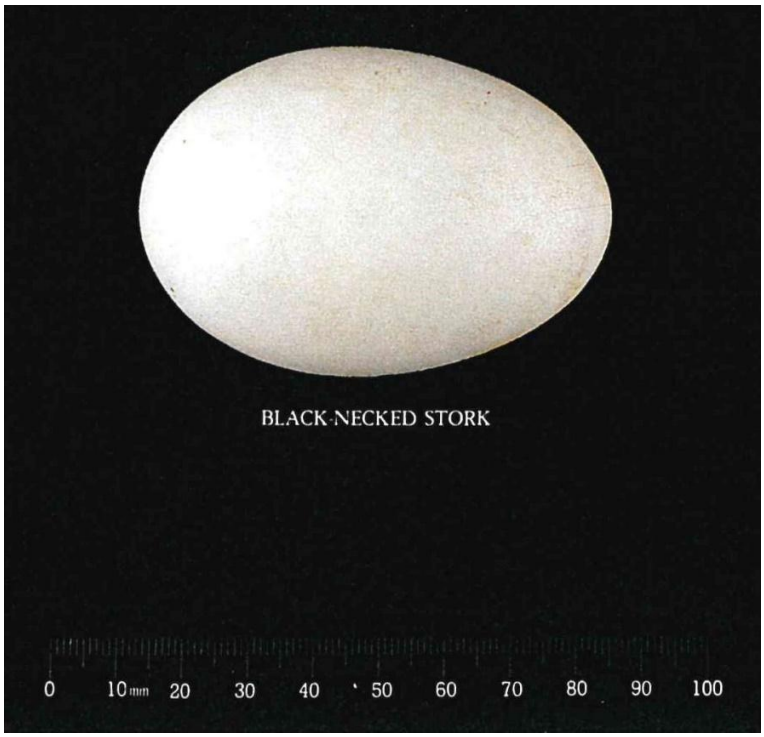

Figure 34: Black-necked Stork egg with scale in mm (J. Fields, n.d.).

Figure 35: Black-necked Stork egg showing size compared to the lid of a 120mm diameter butter container. This egg failed to hatch. (S. McKeachnie, 13 October 2022).

Figure 367: Male Black-necked Stork guarding five eggs, Hexham NSW (L. Williams, 18 August 2022).

10.14 Age at Fledging

There are varying fledging periods in the published data: Davies, Marchant & Higgins (1991) report chicks fledging at 100 – 115; Nawab & Srivastava (2008) state fledglings leave the nest at 60 days; while Clancy & Ford (2013) observed fledging up to 87 days in the wild. Adult raised birds in captivity fledge at between 80 – 100 (R. Lynch, pers. comm.), by which time chicks have lost most of their down and obtained their juvenile plumage. Most nests successfully fledge 1 – 3 chicks but broods of four have been recorded in both India and Australia (Sundar, 2011). There is one record of a brood five chicks in India (Sundar, 2011), however it is unknown if they all fledged. Fledging for the sister species, *Ephippiorhynchus senegalensis* and *Jabiru mycteria* are estimated at 100 -115 days (Barnhill et. al., 2005; Kahl, 1973) however young remain dependent on parents after fledging (Barnhill et. al., 2005). This aspect requires further study.

10.15 Age of Removal from Parents

In the wild young birds are typically chased off by parents and disperse around nine months post hatching, prior to the next breeding season. In captivity the male will become aggressive toward the young, going so far as killing them if they are not removed and adults will begin to push the young birds away at around the same age (R. Lynch, pers. comm.). Birds are removed from the parents and placed in separate enclosures at this stage.

10.16 Growth and Development

Growth charts are not currently available for this species, however McKeachnie (pers. comm.) reports that chick grow at roughly 10% per day. When first hatched chicks feather development is in four stages: downy fluff on hatching; shoulder and wing feathers develop, followed by body feathers, and finally neck feathers, eventually moulting into full adult plumage between two to three years of age

(**Appendix 3** and **Appendix 4).** S. McKeachnie, pers. comm.) Defensive bill-clattering is developed by around 30 days and parents are then able to leave young unattended for short periods to forage and collect food for the chicks (Davies, Marchant & Higgins, 1991). Downy chicks (**Figure 37**) grow rapidly as shoulder and wing feathers develop (**Figure 39**) and by around 60-70 days have lost most of their down (**Figure 380** and **Figure 39**). **Figure 42** depicts an 82-day old chick, while **Figure 41** and **Figure 42** show fully feathered immature Black-necked Storks aged around 12 months and 14 months respectively. Note the differences in the amount of juvenile plumage (brown feathers) between the birds aged 12 and 14 months compared to a bird aged two years (**Figure 43**). From fluffy chick to fully feathered and coloured adults where sex is able to be distinguished in the field takes between two to three years (**Figure 44**).

Figure 378: Black-necked Stork nestlings, Hexham Swamp Nature Reserve, NSW Australia, estimated age 5 – 10 days (G. Little, 15 September 2020).

Figure 39: Black-necked Stork chicks aged 35 - 40 days, just prior to being banded, Hexham Swamp Nature Reserve, NSW Australia (G. Little, 15 October 2020).

Figure 38: Black-necked Stork chick under heat lamp at Gorge Wildlife Park Adelaide hatched 16 August 2022 aged 58 days (S. McKeachnie, 13 October 2022).

Figure 391: Black-necked Stork chicks aged 60-70 days, just after banding, Hexham Swamp Nature Reserve, NSW Australia. Note down is limited mostly to the neck (G. Little, 19 November 2021).

Figure 40: Black-necked Stork, Gorge Wildlife Park, Adelaide hatched 23 July 2022 aged 82 days (S. McKeachnie, 13 October 2022).

Figure 41: Female Black-necked Stork aged around 12 months Gorge Wildlife Park, Adelaide (S. McKeachnie, 13 October 2022).

Figure 42: Immature Black-necked Stork aged around 14 months, fledged from Tomago, NSW Australia. This bird came into care at Medowie NSW, as it was found underweight and emaciated, rehabilitated, banded and released successfully. Sex unknown at this time. Photo taken just prior to release (G. Little, 10 September 2018).

Figure 43: Pair of Black-necked Stork, Gorge Wildlife Park, Adelaide. The female in the foreground is around two years of age. Note that the eye colour is developing, however the bird retains some juvenile plumage and the colour of the legs is duller than the bird in the background (S. McKeachnie, 13 October 2022).

Figure 44: Pair of adult Black-necked Stork of unknown age, female on the left and male on the right, Tomago, NSW Australia, parents of the rehabilitated bird in Figure 37 (A Lindsay, 24 June 2018).

11. Artificial Incubation and Rearing of Birds

11.1 Incubator Type

Since 2019 both Gorge Wildlife Park, Adelaide and Featherdale Wildlife Park, Sydney have both attempted artificial incubation of Black-necked Storks with some success ((O. Caulfield, pers. comm; S. McKeachnie, pers. comm.). Use of an incubator to rear Black-necked Stork chicks encourages the birds to double-clutch if all eggs from the first clutch are removed once laid (O. Caulfield, pers. comm; S. McKeachnie, pers. comm). Gorge Wildlife Park in Adelaide use a Brinsea Parrot Incubator for incubation of all Black-necked Stork eggs (**Figure 45**; S. McKeachnie, pers. comm.). Eggs are not removed from the parents until all eggs have been laid and this is typically 3 – 4 eggs (O. Caulfield, pers. comm; S. McKeachnie, pers. comm.).

Figure 45: Brinsea Parrot Incubator used at Gorge Wildlife Park, Adelaide (S. McKeachnie, 13 October 2022).

11.2 Incubation Temperatures and Humidity

Eggs are incubated at 37.2ºC with a humidity range of 53 – 55% (S McKeachnie, pers. comm.).

11.3 Desired % Egg Mass Loss

Egg mass loss is 15% (S. McKeachnie, pers. comm.)

11.4 Hatching Temperature and Humidity

Once chicks pop a hole in the egg the humidity is increased to 60 – 65% so that the egg does not dry up (S McKeachnie, pers. comm.).

11.5 Normal Pip to Hatch Interval

Normal pip to hatch interval is less than 24 hours (S McKeachnie, pers. comm.).

11.6 Brooder Types/Design

Featherdale Wildlife Park, Sydney use a Brinsea TLC40 Parrot Brooder **Figure 46**; (O. Caulfield, pers. comm.).Gorge Wildlife Park, Adelaide use a Kamani brooder sourced from Western Australia (S. Mc Keachbie, pers. comm.; **Figure 49**).

Figure 46: Brinsea TLC-40 Seriess II Parrot Brooder/Intensive Care Unit/Recovery Incubator (Brinsea, 2022).

Figure 49: Two views of a Kamani brooder used by Gorge Wildlife Park, Adelaide (S. McKeachnie, 13 October 2022)

11.7 Brooder Temperatures

At Featherdale Wildlife Park, Sydney the brooder is set at 36.6ºC and reduced by between 0.2 and 0.5 of a degree every two or three days for around two months at which time the chicks are transitioned into a tub with a heat lamp at one end (O. Caulfield, pers. comm.). Gorge Wildlife Park, Adelaide initially set the temperature at 37ºC for around the first two weeks and then gradually reduce the temperature over the next month to 32ºC (S. McKeachnie, pers. comm.). After this the chicks are placed in a cardboard box with a heat lamp in the 'bird room' with a temperature of 25 – 25ºC (S. McKeachnie, pers. comm.).

11.8 Diet and Feeding Routine

There is no information published on hand-rearing Black-necked Stork chicks. Gorge Wildlife Park, Adelaide have based their feeding regime on data for Cranes and have successfully raised chicks (S. McKeachnie, pers. comm.). Chicks are fed three times a day: early in the morning, around 2.00pm and around 9.00pm (S. McKeachnie, pers. comm.). They are fed sufficient food to keep their growth rate at around 10% per day so that they do not grow too fast as they will overeat (S. McKeachnie, pers. comm.). Chicks are weighed each morning prior to feeding to monitor growth rate (S. McKeachnie, pers. comm.). Young chicks are fed a slurry of bashed chicken necks ensuring the bone is crushed, chicken hearts, fish, pinkies (mice), and day-old chicks, combined with Wamberoo Insectivore Mix (S. McKeachnie, pers. comm.). At Gorge Wildlife Park, Adelaide, no other supplements are used as they believe calcium in the form of bone is better than a supplement (S. McKeachnie, pers. comm.). The slurry is placed in a bowl at the feet of the chicks, and they feed themselves (S. McKeachnie, pers. comm.). This imitates what adult birds do in the nest, putting food on the floor of the nest. Featherdale Wildlife Park, Sydney do add high doses of calcium to the food for chicks to facilitate and promote health development (O.Caulfield, pers. comm.).

11.9 Specific Requirements

Unknown at this time.

11.10 Pinioning Requirements

Where possible birds should not be pinioned, particularly if they are to be part of a breeding pair. If a bird is to be kept in an open enclosure long term wings can be clipped to prevent the bird flying as an alternative to pinioning. This however involves recapture of the bird on a regular basis with the potential to cause stress to the animal. Pinioning as a method of restraint is a last resort method but could be used on older birds who are beyond breeding age.

11.11 Data Recording

As there is little published data on hand-rearing the Black-necked Stork data collection is vital to ensuring that chicks receive the best care possible and any problems are discovered early and able to be rectified. With any data collection the first thing to record is the date. When artificially incubated this will start with the date the eggs were laid and the date they were removed for incubation, followed by pip and hatch dated. Once the chicks have hatch daily records should be kept of the following:

- Date
- Time the information is collected
- Body mass to the nearest gram
- General activity and demeanor
- Characteristics of defecation
- Amount, in grams, of food offered at each feed
- Amount, in grams, of food consumed at each feed
- Any Veterinarian examination and the results

General morphometric data such as: wing chord length, bill length, head/bill length, tarsus and middle toe length should be collected weekly. Photographs of the chicks at each stage of development or weekly should also be included. The collection of this data will assist in reaching a diagnosis if the animal is sick or failing to thrive and will aid in the production of growth curve charts for future clutches.

11.12 Identification Methods

Birds should be marked with individually numbered leg bands and/or coloured leg bands for ease of identification. Prior to adult plumage being attained feather samples can be used for

DNA sexing of individuals (R. Lynch, pers. comm.). Thus, institutions can request birds of a specific sex, minimizing movement of birds between institutions.

11.13 Hygiene

Feeding bowls should be thoroughly cleaned after each feed and waste removed from the brooder or nest daily.

11.14 Behavioural Considerations

Unknown at this time.

11.15 Use of Foster Species

Unknown at this time.

11.16 Weaning

Once a bird is fledged it is able to feed independently. Type and size of food offered will change as the chick matures (S, McKeachnie, pers. comm.).

11.17 Rehabilitation Procedures

Where an animal is hand-reared for eventual release into the wild care must be taken to ensure they are not imprinted on human carers and that they are adequately rehabilitated prior to release (NSW Department of Primary Industry, 2019). All chicks reared in captivity to date have been sent to other zoos and wildlife parks in Australia and overseas (R. Lynch, pers. comm.). When a bird comes into care from the wild all morphometric data, including approximate age if possible, should be recorded once the initial Veterinary examination is concluded and any obvious injuries attended to. The bird should be kept quiet and isolated from other Black-necked Storks and fed a diet of prawns, octopus, fish and live insects (A. Williams, pers. comm.) until it has recovered and is able to be released back into the wild successfully such as the bird in **Figure 42**.

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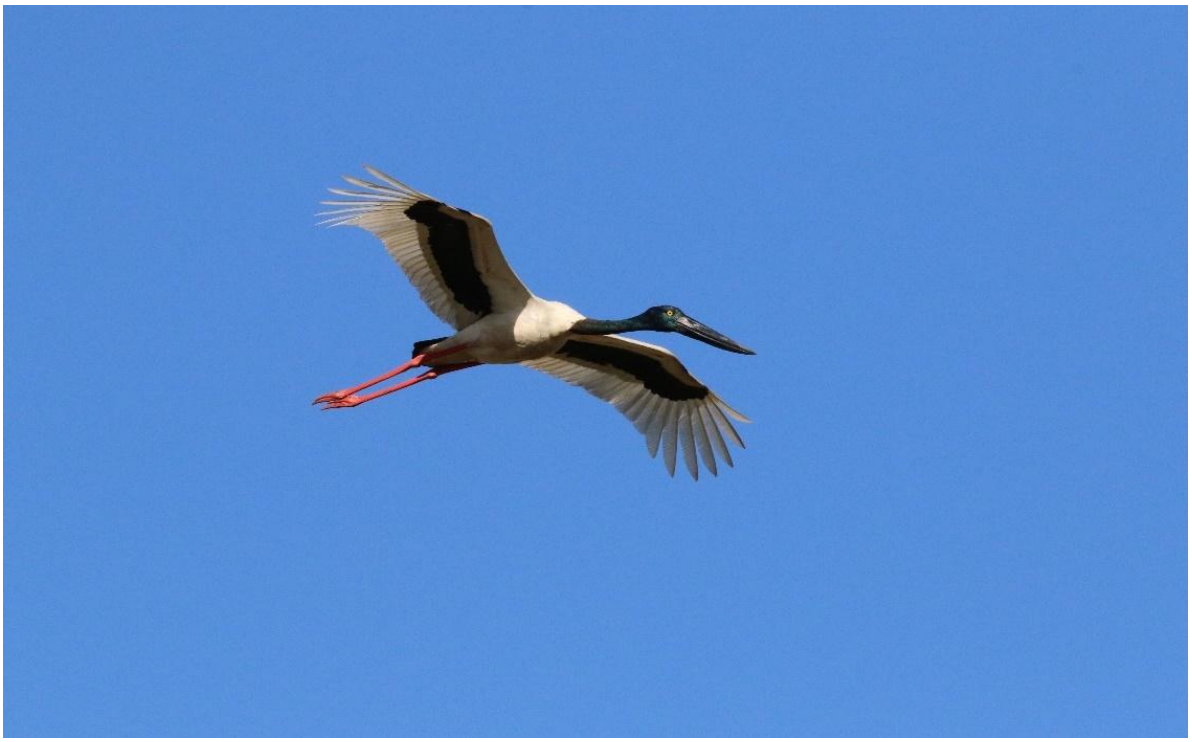


Figure 47: Female Black-necked Stork in flight, Tomago, NSW Australia. Parent to the immature bird in Figure 37 (A Lindsay, 5 June 2017).

13. References

ABBBS (Australian Bird and Bat Banding Scheme) Database search: *Ephippiorhynchus asiaticus*. https://www.environment.gov.aucgi-bin/biodiversity/abbbs/abbbs-search.pl Accessed 8 August 2022.

ALA (Atlas of Living Australia), n.d. Species page: Black-necked Stork. https://bie.ala.org.au/species/urn:lsid:biodiversity.org.au:afd.taxon:e7552037-18c6-494b-8ad3-10bc996e68bd#overview Accessed 11 July 2022.

Avibase, n.d. The World Bird Database. Species page: Black-necked Stork https://avibase.bsc-eoc.org/search.jsp?pg=search&isadv=yes&startstr=&startlang=&fam=&start=&qstr=black-necked+stork&qtype=2&qstr2=&qtype=2&qlang=&qyears=&qauthors=&qinclsp=1 Accessed 27 July 2022.

Barnhill, R.A., Wirisr, D., Young, W.F., Smith, K.G. and James, D.A., 2005. Breeding biology of Jabirus (*Jabiru mycteria*) in Belize. *The Wilson Bulletin*, 117(2):142-153.

Baylis, S. M., de Lisle, M., and Hauber, M. E., 2014. Inferring maximum lifespan from maximum recorded longevity in the wild carries substantial risk of estimation bias. *Ecography*, 37:770-780.

Bhatt, K., 2006. Black-necked Stork *Ephippiorhynchus asiaticus* nest with four chicks in Marine National Park, Gujarat, India. *Indian Birds* 2(2):35.

Biolib, n.d. Taxon profile Black-necked Stork *Ephippiorhynchus asiaticus*. https://www.biolib.cz Accessed 25 July 2022.

Birdlife International, 2016. *Ephippiorhynchus asiaticus. The IUCN Red List of Threatened Species 2016:* e.T22697702A93631316.

British Museum, n.d. https://www.britishmuseum.org/collection/term/BIOG16032 Accessed 7 August 2022.

Boles, W.E., 2005. A review of the Australian fossil storks of the genus *Ciconia* (Aves: Ciconiidae), with the description of a new species. *Records-Australian Museum*, 57(2):165.

Chadd, R.W. and Taylor, M., 2016. *Birds: Myths, Lore and Legend*. Bloomsbury Publishing, Sydney.

Chauhan, R. and Andrews, H. 2006. Black-necked Stork *Ephippiorhynchus asiaticus* and Sarus Crane *Grus antigone* depredating eggs of the three-striped roofed turtle *Kachuga dhongoka*. *Forktail* 22:174-175.

Christidis, L., and Boles, W., 2008. *Systematics and Taxonomy of Australian Birds*. CSIRO Publishing, Collingswood, Victoria, Australia.

Clancy, G.P., 2009. Species Review: The Black-necked Stork '*Ephippiorhynchus asiaticus*'- an Overview. *Australian Field Ornithology*, *26*(4):110-115.

Clancy, G. P., 2010. Causes of mortality in the Black-necked Stork *Ephippiorhynchus asiaticus australis* in New South Wales. *Australian Field Ornithology* 27:65-75.

Clancy, G.P., 2011. The feeding behaviour and diet of the Black-necked Stork *Ephippiorhynchus asiaticus australis* in northern New South Wales. *Corella*, *36*(1), p.17-23.

Clancy, G.P. and Ford, H.A., 2011. Nest site selection and nesting behaviour of the Black-necked Stork *Ephippiorhynchus asiaticus australis* in northern New South Wales. *Corella*, *35*(4):95-100.

Clancy, G.P. and Ford, H.A., 2013. The season, frequency, parental care and success of breeding Black-necked Storks *Ephippiorhynchus asiaticus australis* in northern New South Wales. *Corella*, 37:63-68.

Clancy, G.P., Sundar, K. S. G., Kittur,S., Grant, J. D. A. and Garnett, S. T., 2021. Torresian Black-necked Stork *Ephippiorhynchus asiaticus australis*. In *The Action Plan for Australian Birds 2020*. (Eds. S. T. Garnett and G. B. Baker): 220-221. CSIRO Publishing, Melbourne.

Colnect. Black-necked Stork (*Ephippiorhynchus asiaticus*) https://colnect.com/en/stamps/stamp/624120-Black-necked_Stork_Ephippiorhynchus_asiaticus-India_Nagaland_Illegal_Stamps Accessed 11 August 2022.

Davies, J, N., Marchant, S. and Higgins, P. J. (Eds.), 1991. *Handbook of Australian, New Zealand and Antarctic Birds. In Ratites to Duck, vol. 1, part B.* Oxford University Press, Melbourne.

De Pietri, V.L. and Mayr, G., 2014. The phylogenetic relationships of the Early Miocene stork *Grallavis edwardsi*, with comments on the interrelationships of living Ciconiidae (Aves). *Zoologica Scripta*, *43*(6):576-585.

Desvaux, S., Marx, N., Ong, S., Gaidet, N., Hunt, M., Manuguerra, J.C., Sorn, S., Peiris, M., Van der Werf, S. and Reynes, J.M., 2009. Highly pathogenic avian influenza virus (H5N1) outbreak in captive wild birds and cats, Cambodia. *Emerging infectious diseases*, *15*(3), p.475.

Elliot, A., Garcia, E. F. J. Boesman, P. F. D. and Kirwan, G. M., 2020. 'Black-necked Stork (*Ephippiorhynchus asiaticus*)', version 1.0 in *Birds of the World* (del Hoya, J., Elliott, A., Sargatal, J., Christie, D. A. and de Juana, E., Editors). Cornell Lab of Ornithology, Ithaca, NY, USA.

Fidgett, A.L., 2005. Standardizing nutrition information within husbandry guidelines: the essential ingredients. *International Zoo Yearbook*, 39:132-138.

Gill, F. B. and Prum, R. O., 2019. *Ornithology* (4th Ed). W. H. Freeman and Company, New York.

Gill F, D Donsker & P Rasmussen (Eds), 2022. IOC World Bird List (v12.1). http://www/worldbirdnames.org Accessed 14 July 2022.

Gulcubuk, G.Ü.L.A.Y., Erdogan-Bamac, Ö.Z.G.E., Metiner, K.E.M.A.L., Öztürk, G., Ozgur, N.A.C.İ.Y.E. and Haktanir, D.A.M.L.A., 2018. A case of pulmonary aspergillosis in white storks. *Journal of the Hellenic Veterinary Medical Society*, *69*(2).

Hall, C. A., Potvin, D. A. & Conroy, G. C., 2022. A new candling procedure for thick and opaque eggs and its application to avian conservation management. *Zoo Biology* 2022: 1 – 12.

Han, J.I., Son, H.W., Mo, I.P., Chang, D.W., Kim, S.K., Park, S.R. and Na, K.J., 2009. Gizzard impaction with bile stasis in captive oriental white storks (Ciconia boyciana). *Journal of Veterinary Clinics*, *26*(6), pp.659-662.

Ishtiaq, F., Javed, S., Coulter, M. C. and Rahmani, A. R., 2010. Resource partitioning in three sympatric species of storks in Keoladeo National Park, India. *Waterbirds* 33(1):41-49.

Jackson, S.M., 2003. Standardizing captive-management manuals: guidelines for terrestrial vertebrates. *International Zoo Yearbook*, 38:229-243.

Kahl, M.P., 1973. Comparative ethology of the Ciconiidae. Part 6. The Black-necked, Saddlebill, and Jabiru Storks (genera *Xenorhynchus*, *Ephippiorhynchus*, and *Jabiru*). *The Condor*, *75*(1):17-27.

Kongprom, U., Punkong, C., Thongnoppakun, P., Petsukorn, N., Poothong, S. and Pattanarangsan, R., n.d. Assessment of breeding difficulties in captive Black-necked Stork (*Ephippiorhynchus asiaticus*) by Hormonal Study at Khao Kheow Open Zoo, Thailand. https://khaokheow.zoothailand.org/download/article/article_20161108140421.pdf Accessed 10 July 2022.

Lopes, I.F., Mino, C.I., Rocha, C.D., Oliveira, D.M. and Del Lama, S.N., 2013. Inferred kinship patterns reveal low levels of extra-pair paternity in the endangered Neotropical Jabiru Stork (*Jabiru mycteria*, Aves: Ciconiiformes). *Genetica*, *141*(4):195-203.

Maheswaran, G. and Rahmani, A. R., 2001. Effects of water level changes and wading bird abundance on the foraging behaviour of Black-necked Storks *Ephippiorhynchus asiaticus* in Dudwa National Park, India. *Journal of Bioscience* 26:373-382.

Maheswaran, G. and Rahmani, A.R., 2002. Foraging behaviour and feeding success of the Black-necked Stork (*Ephippiorhynchus asiaticus*) in Dudwa National Park, Uttar Pradesh, India. *Journal of Zoology*, *258*(2):189-195.

Maheswaran, G. and Rahmani, A.R., 2005. Breeding behaviour of the Black-necked Stork *Ephippiorhynchus asiaticus* in Dudhwa National Park, India. *Journal-Bombay Natural History Society*, 102(3)305.

Maheswaran, G. and Rahmani, A.R., 2007. Activity budget of the Black-necked Stork *Ephippiorhynchus asiaticus* during non-breeding season in India. *ZOOS Print Journal*, *22*(11):2875-2878.

Melo, A.M., da Silva-Filho, R.P., Poester, V.R., von Groll, A., Fernandes, C.G., Stevens, D.A., Sabino, R. and Xavier, M.O., 2020. Aspergillosis in free-ranging aquatic birds. *Medical mycology case reports*, *28*, pp.36-38.

Nawab, A. and Srivastava, A. K., 2008. Potential breeding records of the Black-necked Stork *Ephippiorhynchus asiaticus* in Corbett Tiger Reserve, Uttarkhand, India. *Indian Birds* 4(5):161-162.

Norton, T.M. and Whiteside, D.P., 2014. Ciconiiformes (herons, ibises, spoonbills, storks). *Fowler's Zoo and Animal Medicine*, *8*, pp.100-105.

NSW Department of Industry, 2019. General Standards for Exhibiting Animals in New South Wales. PUB19/23.

NSWDPIE (NSW Department of Planning, Industry and Environment), n.d. Black-necked Stork (*Ephippiorhynchus asiaticus*) – endangered species listing. https://www.environment.nsw.gov.au/topics/animals-and-plants/threatened-species/nsw-threatened-species-scientific-committee/determinations/final-determinations/1996-1999/black-necked-stork-ephippiorhynchus-asiaticus-endangered-species-listing#:~:text=The%20Scientific%20Committee%2C%20established%20under,to%20that%20species%20as%20a Accessed 3 August 2022.

Olias, P., Gruber, A.D., Winfried, B., Hafez, H.M. and Lierz, M., 2010. Fungal pneumonia as a major cause of mortality in white stork (Ciconia ciconia) chicks. *Avian diseases*, *54*(1), pp.94-98.

Serventy, V.N. (ed.), 1985. *The Waterbirds of Australia*. Angus & Robertson Publishers, North Ryde, Australia.

Species 360, 2018. Zoological Information Management System. Species holding report for: *Ephippiorhynchus asiaticus* / Black-necked Stork. https://www.species360.org

Sundar, K.G., 2004. Group size and habitat use by Black-necked Storks *Ephippiorhynchus asiaticus* in an agriculture-dominated landscape in Uttar Pradesh, India. *Bird Conservation International*, *14*(4):323-334.

Sundar, K.G., 2011a. Farmland foods: Black-necked Stork *Ephippiorhynchus asiaticus* prey items in an agricultural landscape. *Forktail*, (27):98-100.

Sundar, K. S. G., 2011b. Agricultural intensification, rainfall patterns, and large waterbird breeding success in the extensively cultivated landscape of Uttar Pradesh, India. *Biological Conservation* 144:3055-3063.

Sundar, K.S. G., Clancy, G. P. and Shah, N. 2006. Factors affecting formation of flocks of unusual size and composition in Black-necked Storks *Ephippiorhynchus asiaticus* in Australia and India. *Emu* 106:253-258.

Tamas, E. A., 2011. Longevity and survival of the Black Stork *Ciconia nigra* based on ring recoveries. *Biologia* 66(5): 912 – 915.

Tortosa, F.S. and Redondo, T., 1992. Motives for parental infanticide in White Storks Ciconia ciconia. *Ornis Scandinavica*, pp.185-189.

Warnock, R., 2014. Up-down display of Black-necked Stork at Hexham Swamp, Hunter Wetlands National Park NSW. *Whistler*, 8::54-55.

Whiting, S.D. and Guinea, M.L., 1999. Nocturnal foraging by the Black-necked Stork *Ephippiorhynchus asiaticus* on sea turtle hatchlings. *Emu-Austral Ornithology*, *99*(2):145-147.

Zootierliste, n.d. Vertebrate inventories in the EAZA area. Species holdings: *Ephippiorhynchus asiaticus asiaticus*. https://www.zootierliste.de Accessed 25 July 2022.

14. Bibliography

Clancy, G.P. and Andren, M., 2010. The habitat distribution and population size of the Black-necked Stork *Ephippiorhynchus asiaticus australis* in New South Wales. *Corella*.34(4):81-91.

Clancy, G. P. and Kingsford, R. T., 2015. The conservation status of the Black-necked Stork *Ephippiorhynchus asiaticus* in New South Wales. *Australian Field Ornithology* 32:108-112.

Dorfman, E.J., Lamont, A. and Dickman, C.R., 2001. Foraging behaviour and success of Black-necked Storks (*Ephippiorhynchus asiaticus*) in Australia: implications for management. *Emu*, *101*(2):145-149.

Edwards, H.A., Converse, S,J., Swan, K.D. and Moehrenschlager, A., 2021. Trading off hatching success and cost in the captive breeding of Whooping Cranes. *Animal Conservation*. 25(2022):101-109.

Ellis D. H., G. F. Gee, and C. M. Mirande (Eds.), 1996. Cranes: Their biology, husbandry and conservation. US Department of the Interior, National Biological Service, Washington DC and International Crane Foundation, Baraboo, WI, USA.

Ishtiaq, F.A., Rahmani, A.R., Javed, S.A. and Coulter, M.C., 2004. Nest-site characteristics of Black-necked Stork (*Ephippiorhynchus asiaticus*) and White-necked Stork (*Ciconia episcopus*) in Keoladeo National Park, Bharatpur, India. *Journal-Bombay Natural History Society* (1):90-95.

Lindsey, A., 2019. Movements of an immature Black-necked Stork taken into care and later released. *The Whistler*, 13:24-25.

Lindsey, A., 2019. Observations of Black-necked Stork breeding in the Hunter Estuary at Tomago NSW. *The Whistler*, 13:38-49.

Maheswaran, G. and Rahmani. A. R. 2008. Foraging technique and prey-handing time in Black-necked Stork *Ephippiorhynchus asiaticus*. *Integrative Zoology* 4: 274-279.

Parsons, H., 2007. Caring for Australian Native Birds (2nd ed). Kangaroo Press, Sydney.

Sundar, K. S. G. 2005. An instance of mortality and notes on behaviour of black-necked storks *Ephippiorhynchus asiaticus*. *Journal of the Bombay Natural History Society* 102(1):99-102.

Sutherland, W.J., Newton, I. and Green, R., 2004. *Bird Ecology and Conservation: A Handbook of Techniques.* Oxford University Press, Oxford.

Verma, A., 2003. Feeding association of Marsh Harrier (*Circus aeruginosus*) with Black-necked Stork (*Ephippiorhynchus asiaticus*) in Keoladeo National Park (Bharatpur, India). *Aquila* 109-110:47-50.

Weibel, C.J., Abreu, R., Becker, K.K., Solomon, M. and Ferrie, G.M., 2021. Assessing Saddle-billed Stork (*Ephippiorhynchus senegalensis*) pair-bonds and breeding behaviour using behavior observed during multiple breeding seasons. *Zoo Biology*, *40*(4):352-359.

15. Appendix

15.1 Appendix 1: Sample Observation Record Sheet

Sample observation record sheet used at Wildlife Habitat Port Douglas (R. Lynch, pers. comm.).

I/D Name		DOB
Species		Gender
Scientific name		Weight
Microchip #		

DATE	**Observations - Comments - Medications**	**Initials**

15.2 Appendix 2: Black-necked Stork Breeding Information Sheet

Breeding information sheet produced by Wildlife Habitat Port Douglas, Queensland and updated by R. Lynch in 2018.

Black-necked Stork Breeding Information Sheet

Wildlife Habitat (formerly Rainforest Habitat Wildlife Sanctuary) has had great success breeding the Black Necked Stork over a period since 2001. We attribute our success to a number of factors namely:

Compatible pairing.

Habituated to humans over time

Both free flying birds

Fresh fish particularly during breeding times

Large simulated habitat exhibit.

Other nesting water birds.

Acceptable nest site

Appropriate nesting material

Breeding Season

Breeding at Wildlife Habitat usually takes place during August/September however we have successfully bred the Black Necked Storks from between May to November.

Nest building/construction

What to expect during nest building (this is from their 1st nesting)

•During 1998 the male starting to bring nesting material in the form of sticks (400 mm- 800 mm 10 cm diameter) to show the female. Slowly but surely the female started to show interest. It was at this stage that the pair started to do the head up display. Wings outspread bills clapping and facing each other.

•For the next 3 years the pair bonding between the two grew stronger and stronger. It was not uncommon for the pair to show nest building behaviour all through the year, peaking during the end of the wet. This behaviour would entail the male presenting sticks to the female and then placing them randomly on top of low vegetation (<1m). The site might change during the day. The male protected these sites fiercely. The sites were always chosen by the male.

•Sometimes staff would have to move these piles of sticks as they were placed too close to paths and the male would defend the immediate area.

•To manage this problem, we tried to motivate the Storks to build in position we choose. So, we made nest bases and place them on top of tree houses within the exhibit. This did not work.

•Finally, in April 2002 (end of northern wet) the storks both choose a nest site 1.2 metres off the ground in the tangled roots of a fallen large dead tree that had been place directly beside the waterfall and pond.

• Both animals built the nest over a 7-day period and by the time they finished it measured 1.4 m in diameter and was 800 mm thick

The location of the site is very important for access for the birds and for sun exposure. Sun seems to be extremely important for these birds.

NOTE: Due to natural degradation of the tree stump over the past 16 years, a basic framework was built on top of the original stump and large branches of cut leafy vegetation placed upon it in 2018. The storks did not seem perturbed by this and began nest building within 2 weeks of continual branch placement and material supply.

Materials for nesting

The main construction is generally

- sticks of around 400-800mm and approx 10mm thick
- layered with reeds or sedges

As stated above we primarily begin the nest for the birds each year using similar sized materials by providing a sturdy base for them to establish the rest of the nest. Greatest success was achieved by using natural branches and sticks rather than an artificial platform.

The final stage for the nest development continues for the entire time the chicks are on the nest and this entails a layer of fresh reeds, or equivalent, daily.

(what we called changing the nappy).

Over the last few years, the storks have been able to be "encouraged" to use the same location, by the placement of browse on the stump, nesting materials being left alongside and…crucially, the pruning of over hanging branches to allow constant sunshine access to the nest area.

Special notation to ensure spiny leaves/reeds (eg pandanus) are removed from nest. If portions of these are accidently consumed by the chicks, it can cause internal lacerations and death of the chick.

Incubation/Egg laying

Both parent birds incubate the eggs taking it in turns throughout the day and the night.

Incubation period – 35 days
Interval between egg laying – 1.5-2.5 days
Interval between hatching – 1.5-2.5 days

Parents monitor egg temperature by using their feet and will regularly stand/sit and occasionally regurgitate water on the eggs to adjust temperature and humidity.

Diet:

- Meat mix - 50% roo & 50% beef mince plus other ingredients.
- Defrosted fish including Mullet/Pilchards/whitebait/barramundi

If the fish have been frozen the birds must be provided with seabird tablets daily

The fish availability is variable, so they are fed a range throughout the year

- Rats or day-old chickens
- Insects
- Crustaceans if available

Breeding diet

- Same as usual diet
- Plus, fresh fish and live fish

Just prior to the hatching of eggs we begin to feed live/fresh fish. This has been observed as being the success to raising offspring. The fresh fish are regurgitated for the offspring. We most often feed out baby barramundi.

Period of Nest life

Fledging occurs generally around 80 – 100 days after hatching.

Chicks have an extremely rapid rate of growth. Any younger chicks must be monitored closely to ensure that they are receiving enough food, as the older chicks can crowd them out.

Parents will regurgitate food onto the nest for the chicks to eat. It is crucial at this time to ensure they receive fresh fish as it is difficult to ascertain if the chicks receive sea tabs.

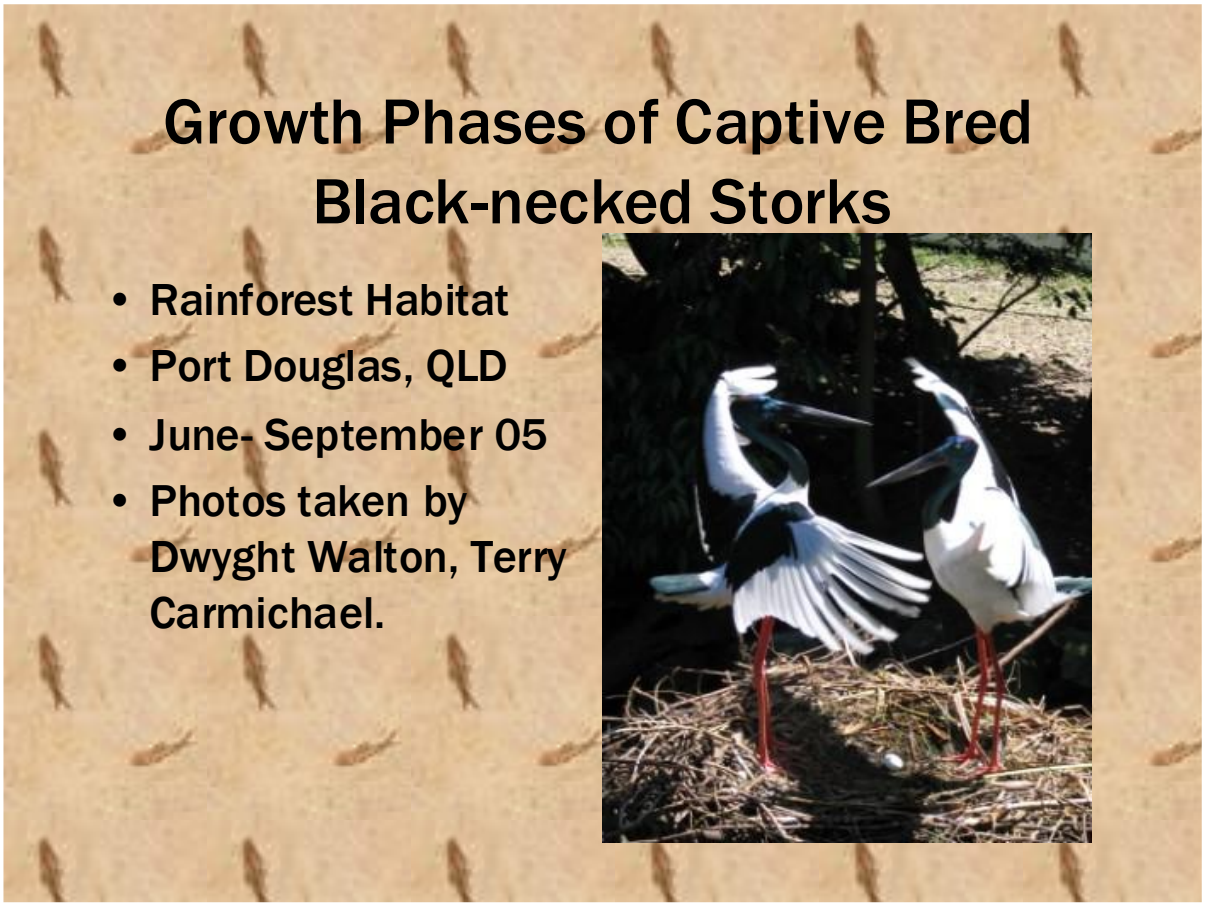
Parents will also regurgitate water onto the chicks for cleaning/hydration and cooling.

These young birds remain with the parents for around 150 days and sometimes more.

Note: Parents generally do not tolerate previous chicks being in the same exhibit when entering the next years breeding cycle and have been known to stab and kill offspring.

15.3 Appendix 3: Pre-Fledging Growth Phases 2005

PowerPoint presentation of growth phases of captive bred, Black-necked Stork chicks from hatching to fledging from June to September 2005 at Wildlife Habitat Port Douglas, Queensland (right- click to open presentation document).



The Ist egg is laid 19 May 2005.

Three eggs 19th May . James & Jabby “Up Down” Display

Four eggs rest in a deep cup formed in the middle of the nest

A one day old chick 17th June 05

A very fresh fish being dropped in front of a one day chick 18th June 05

Second chick hatches parts of the newly hatched egg evident 19.06.05

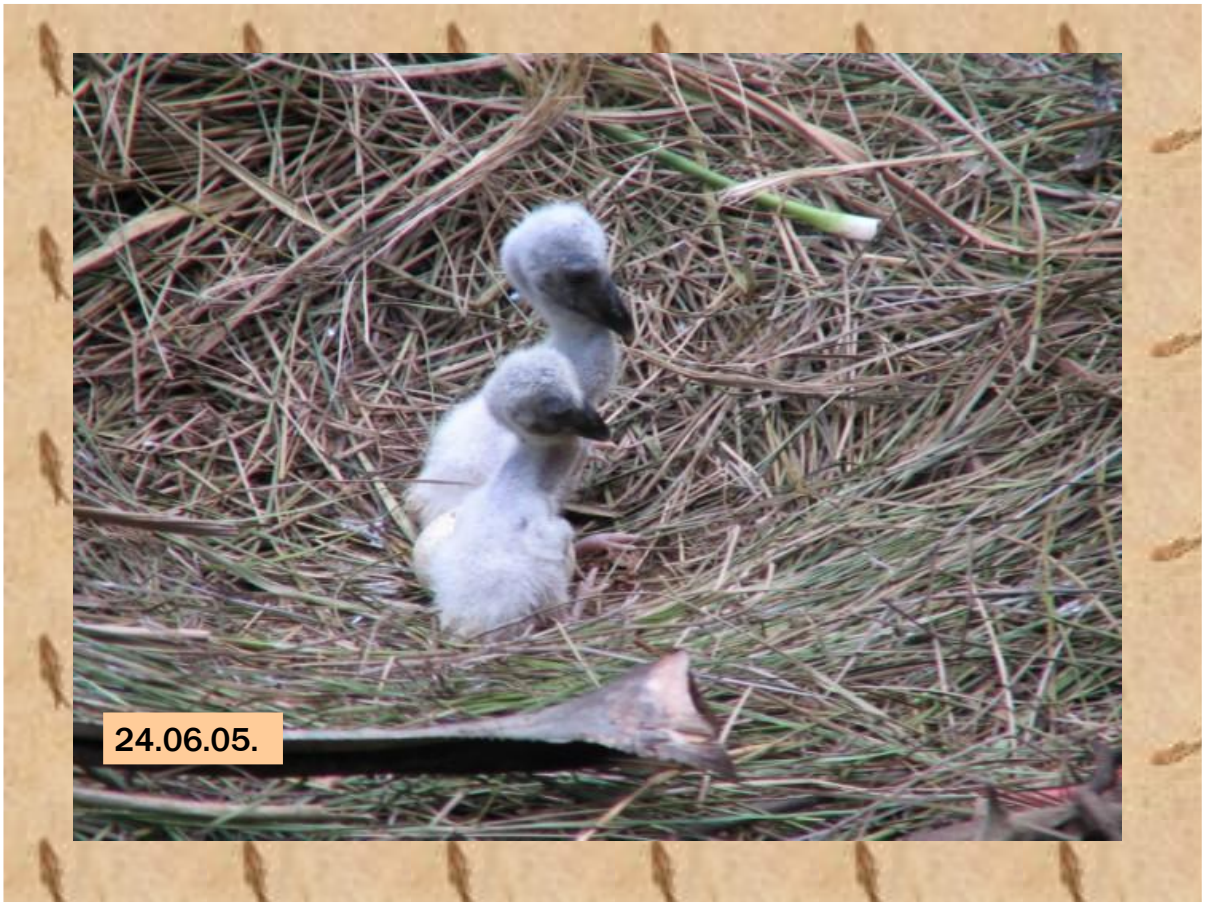
Notice newly hatched chick hasn't fully opened its eyes yet 19.06.05

Drenched after a bath 13.30 hrs 20.06.05


Dried out after the bath 15.30 hr 20.06.05


21.06.05


23.06.05


24.06.05.


25.06.05

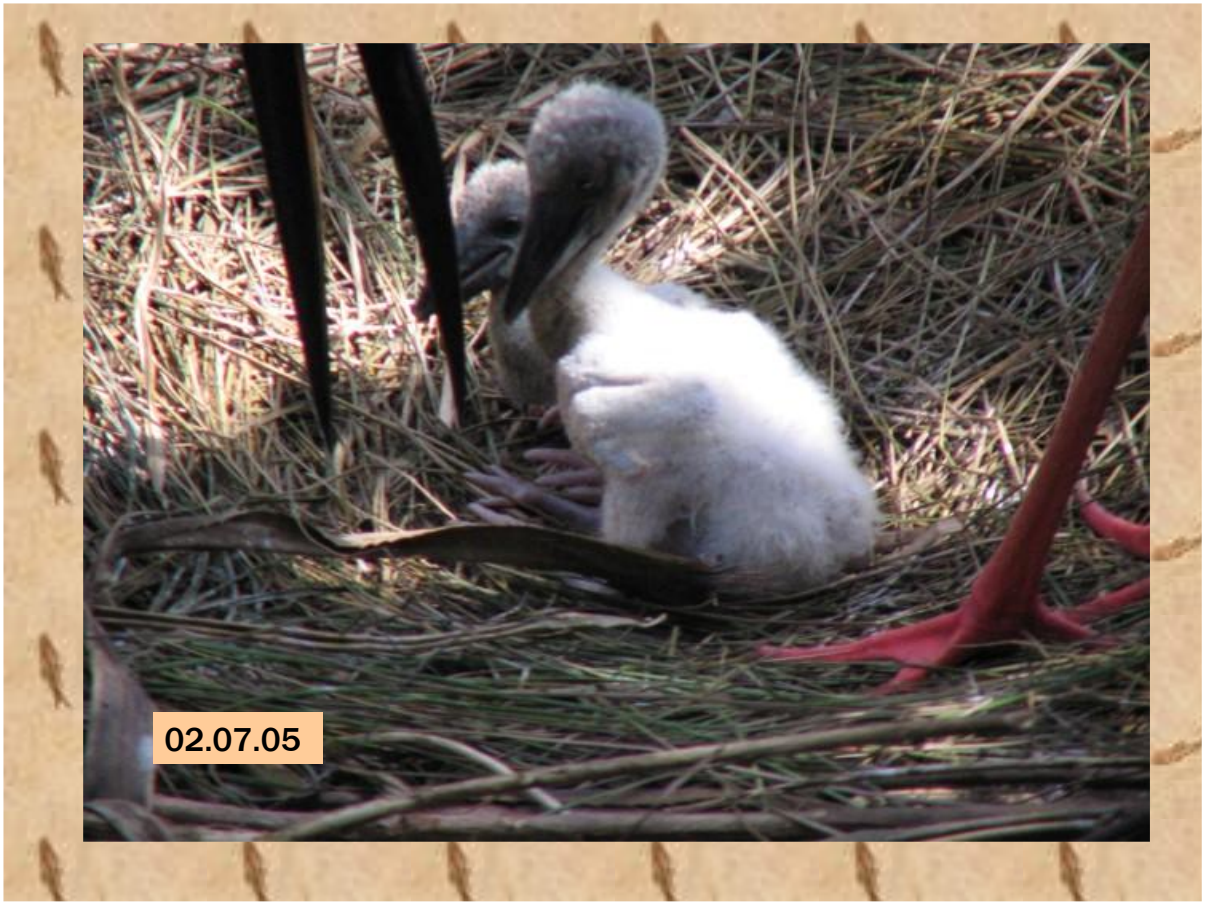

26.06.05

27.06.05 The unhatched egg is removed to reveal a fully formed still born chick.

28.06.05

30.06.05

01.07.05 Note size difference.


02.07.05


04.07.05

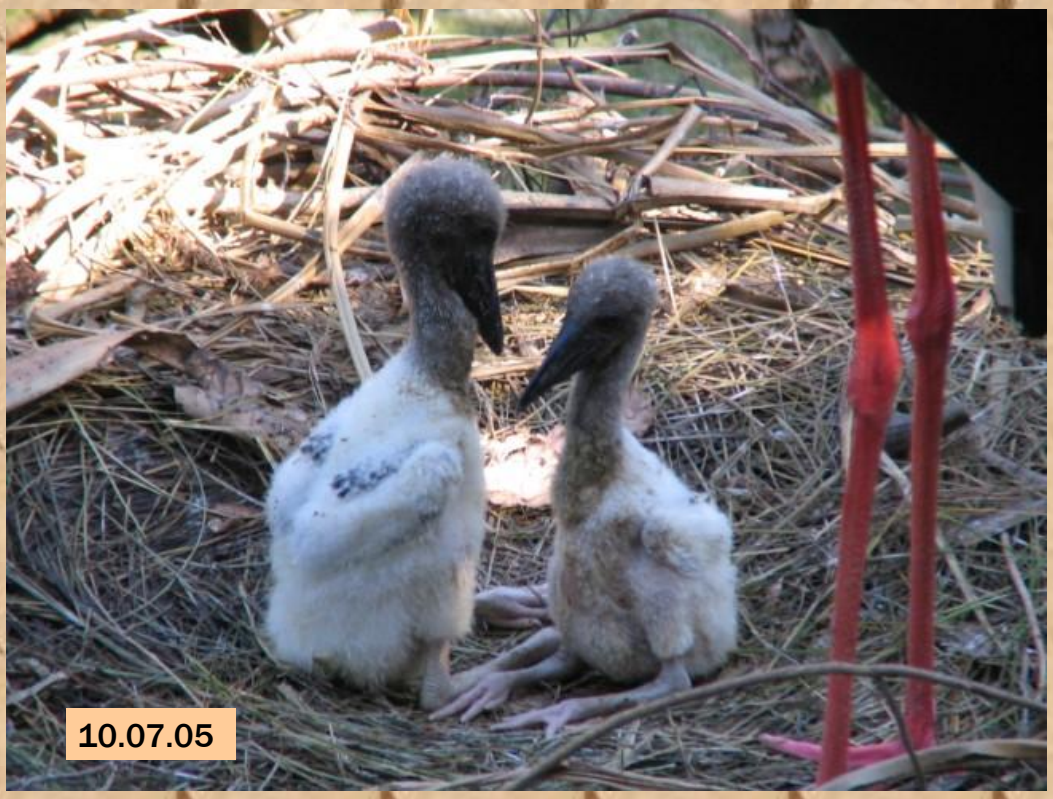

05.07.05


06.07.05

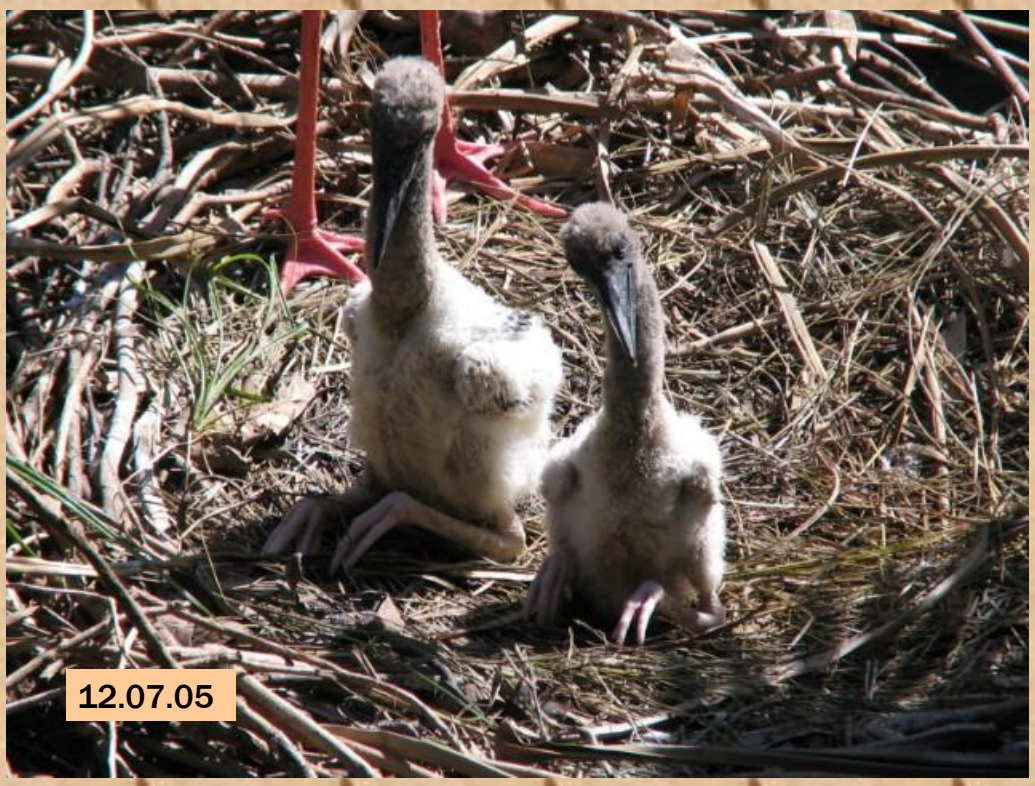

07.07.05


08.07.05

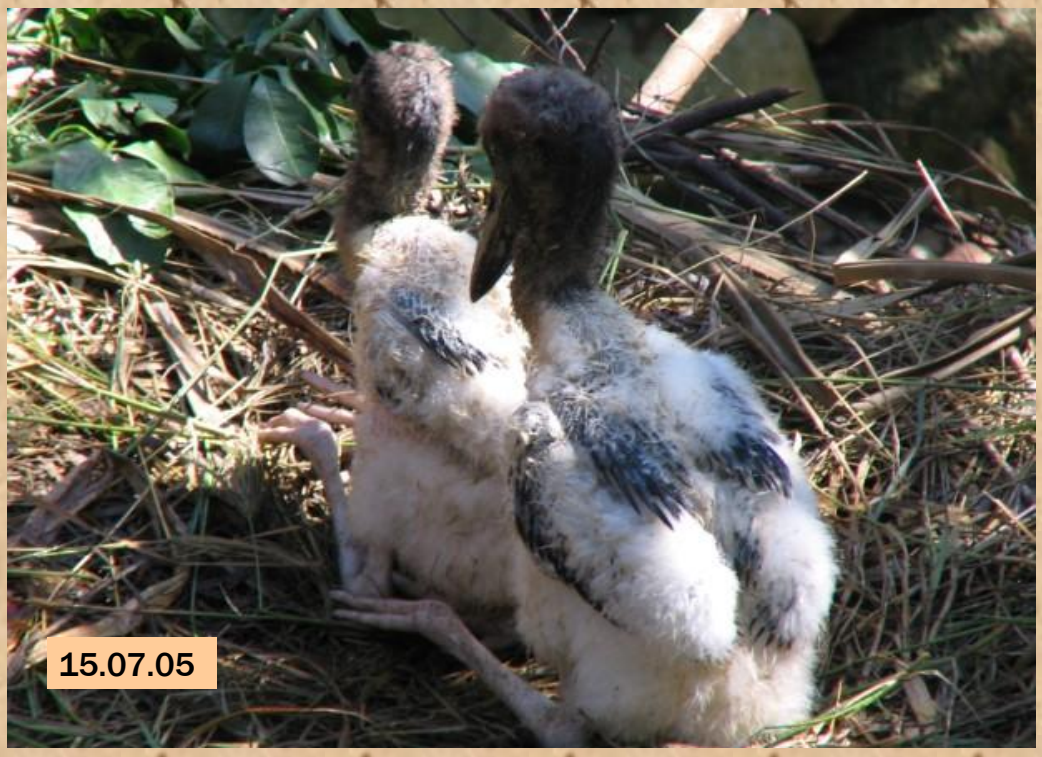

09.07.05


10.07.05


11.07.05


12.07.05

13.07.08



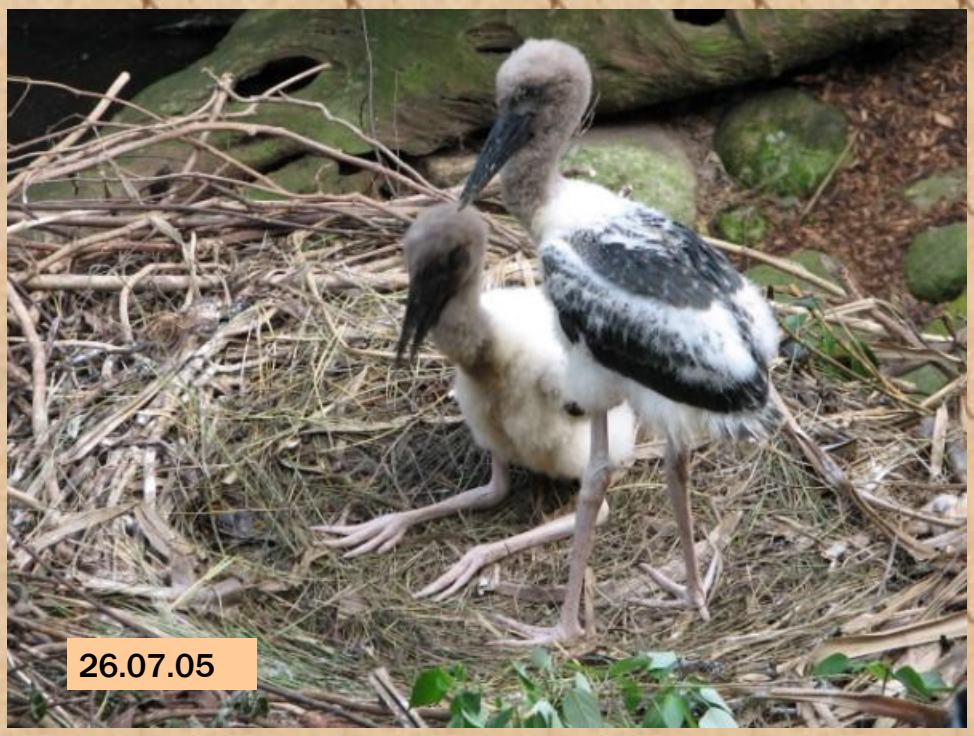
15.07.05


22.07.05


23.07.05


24.07.05


25.07.05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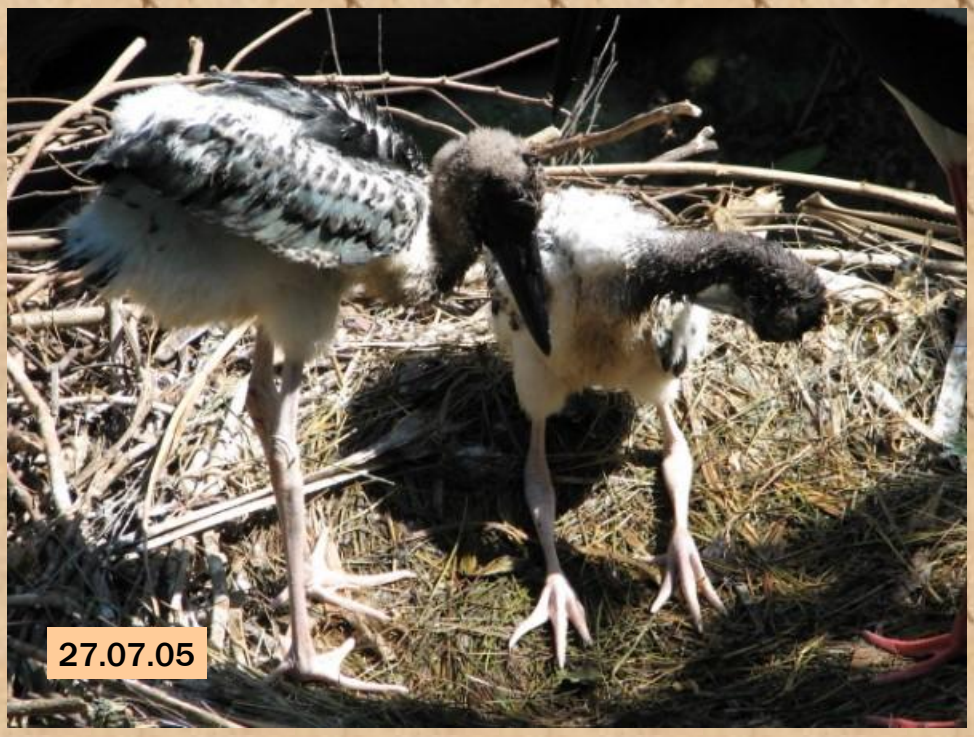
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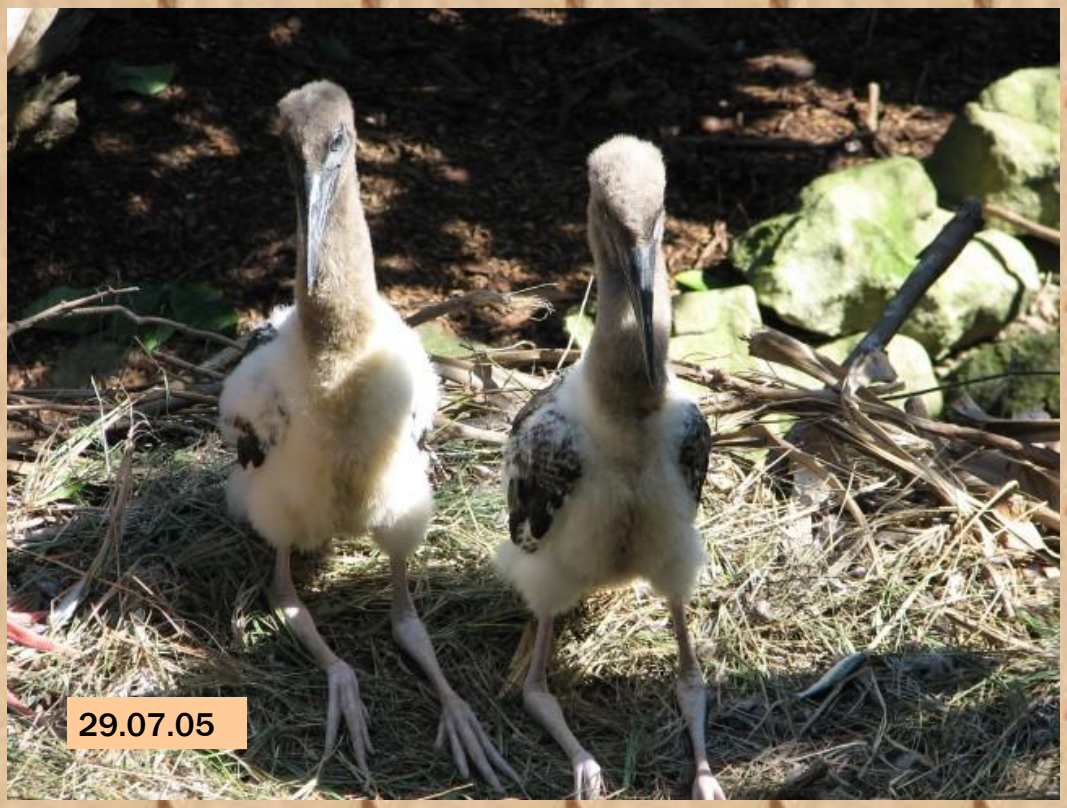
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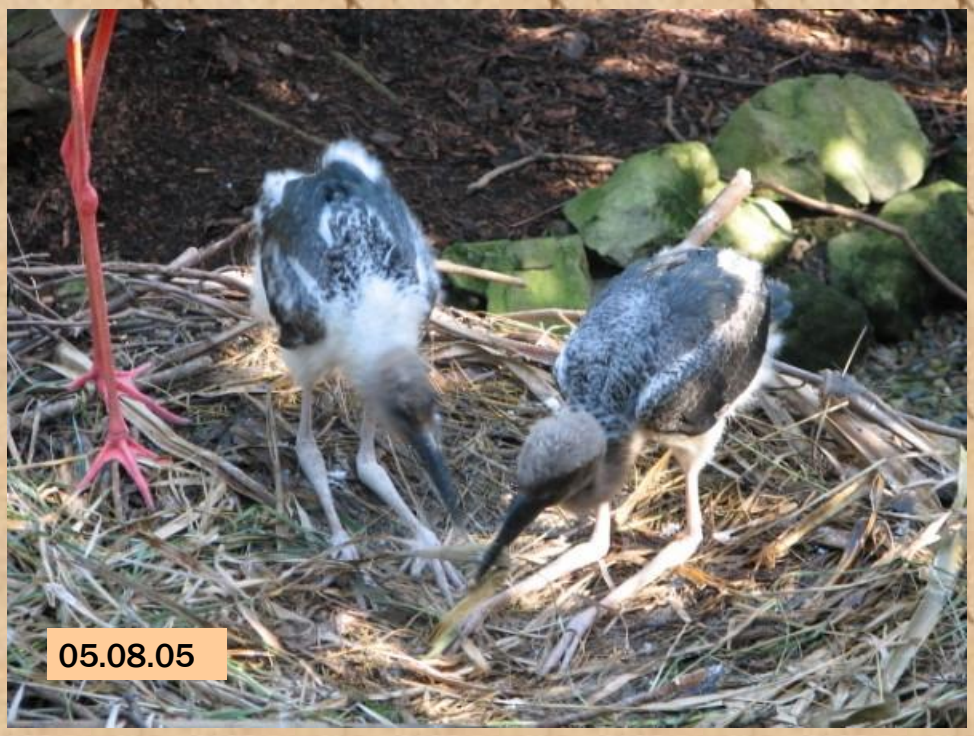
02.08.05

03.08.05

04.08.05



05.08.05

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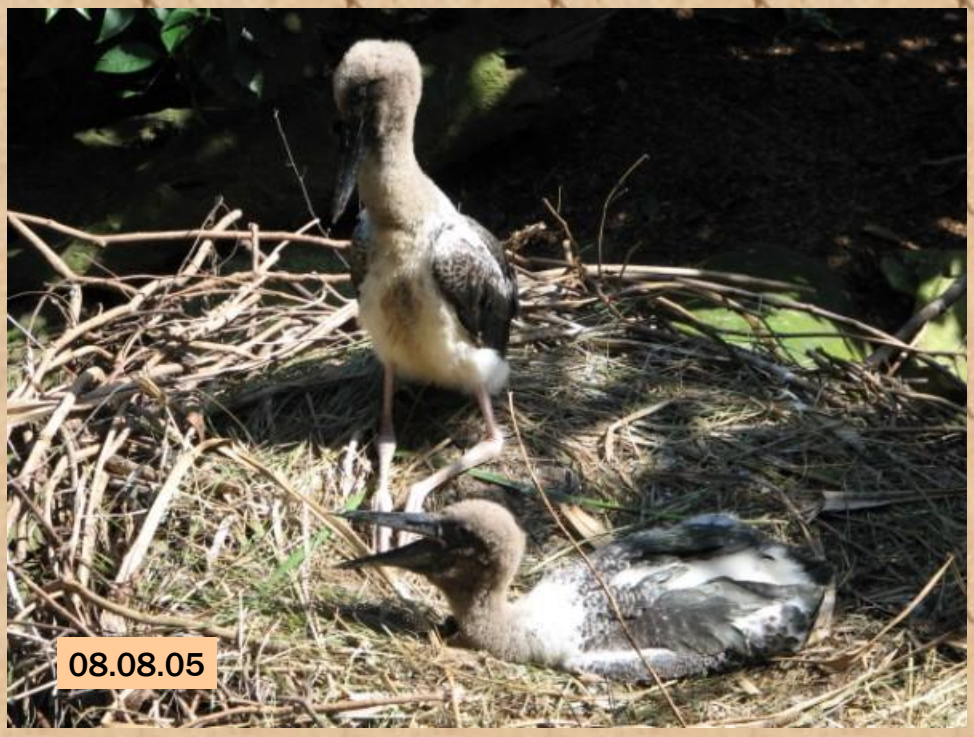
07.08.05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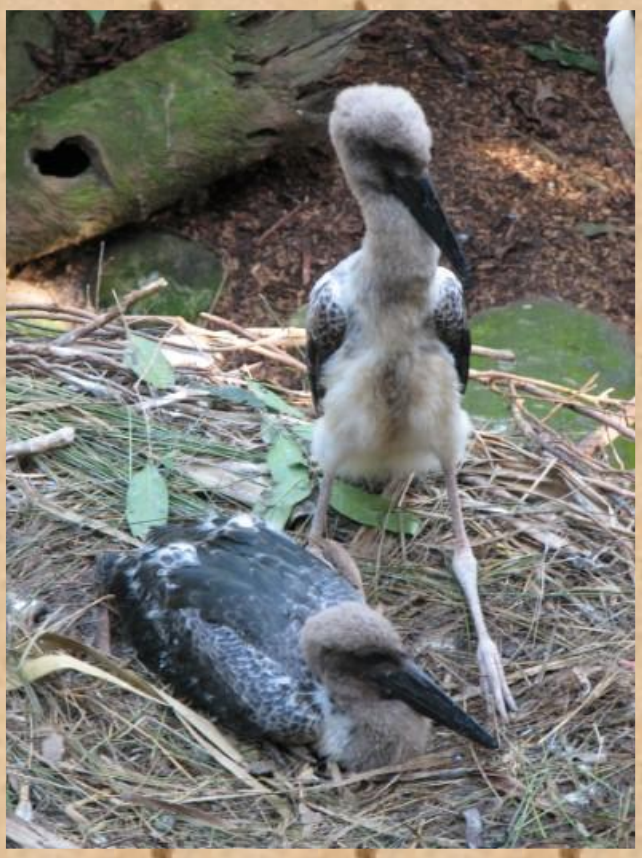

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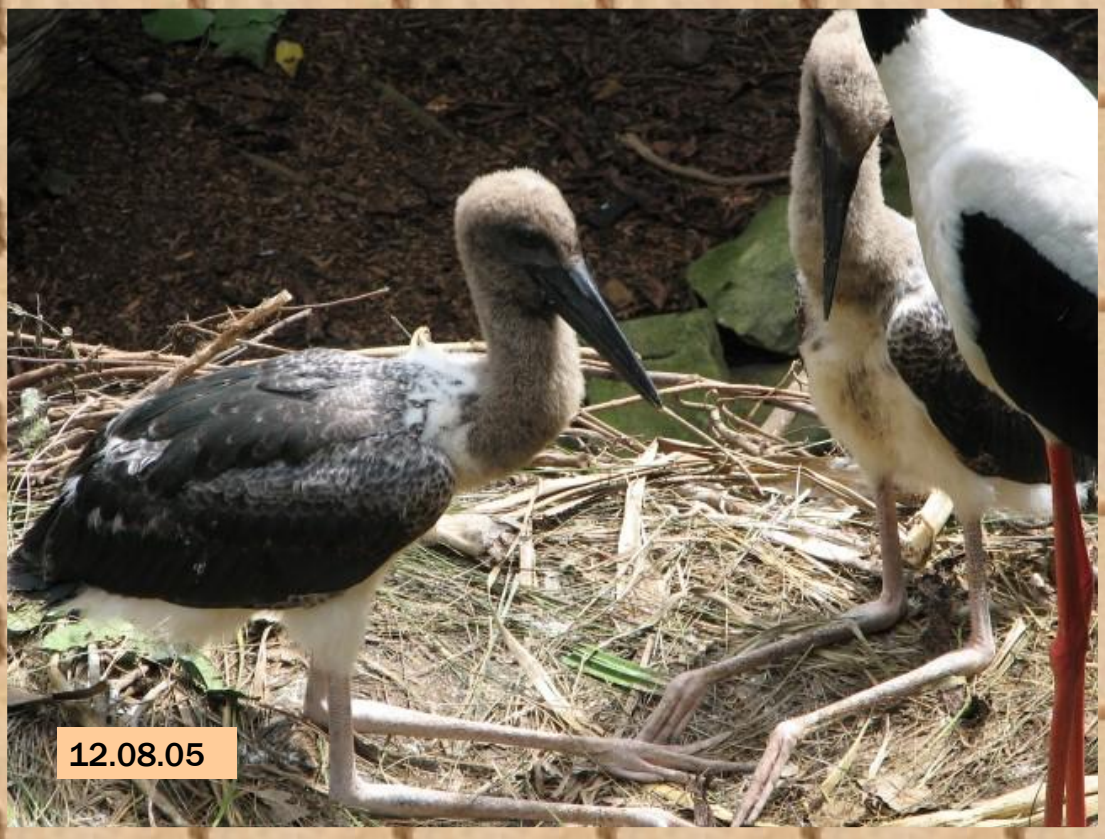

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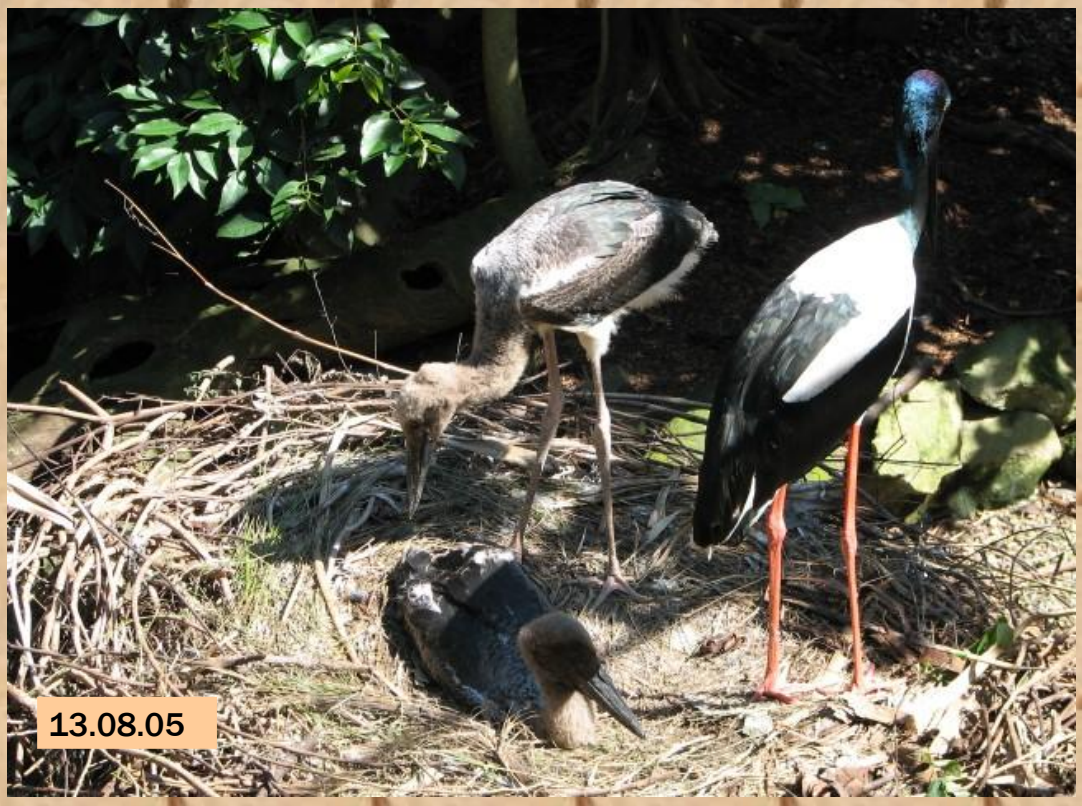

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16.05.05

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19.08.05

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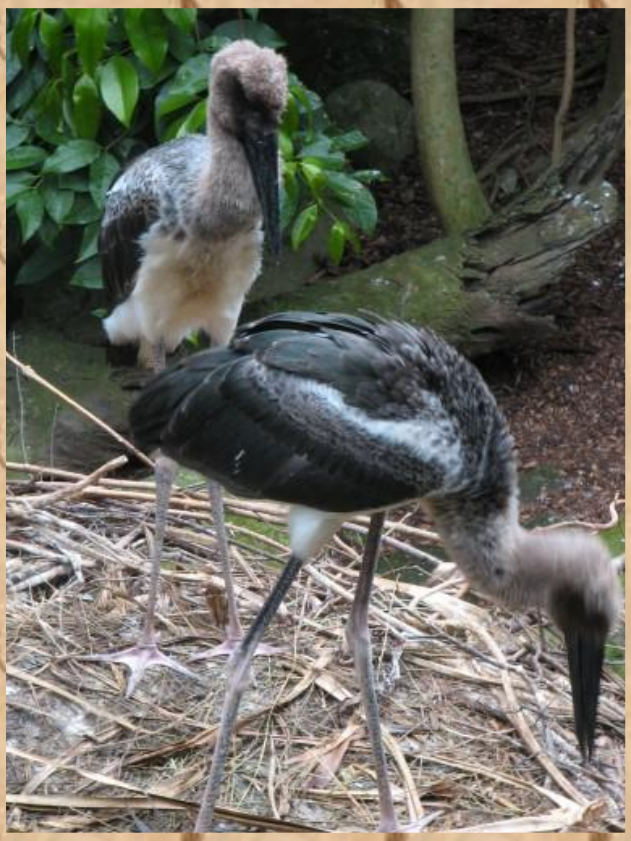
25.08.05



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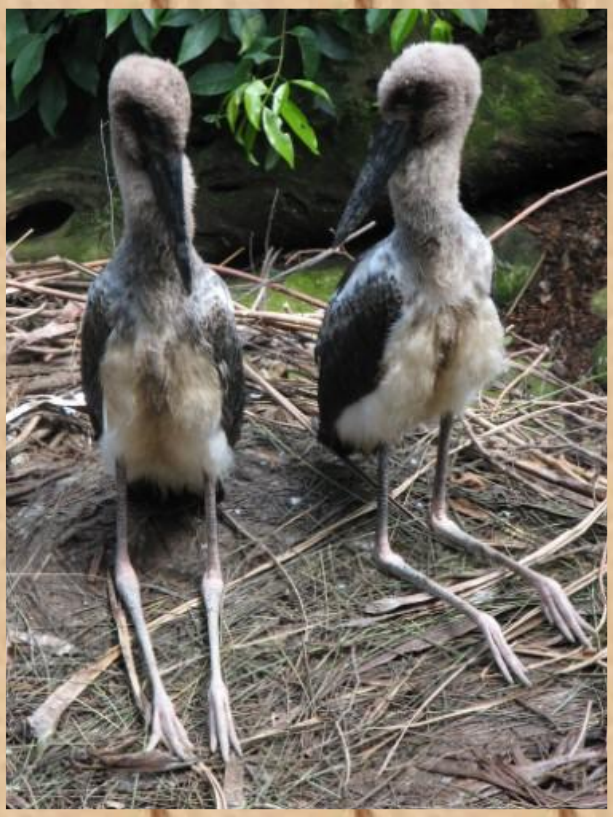
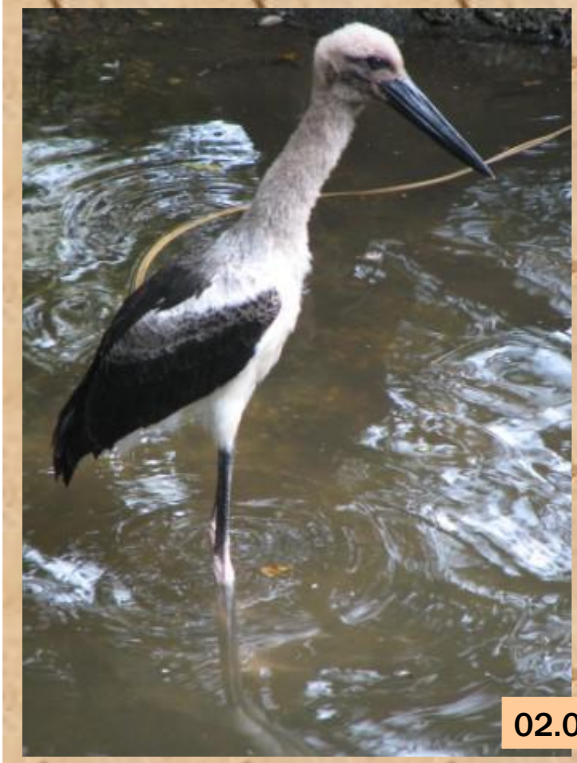


28.08.05

31.08.05

01.09.05



02.09.05

03.09.05

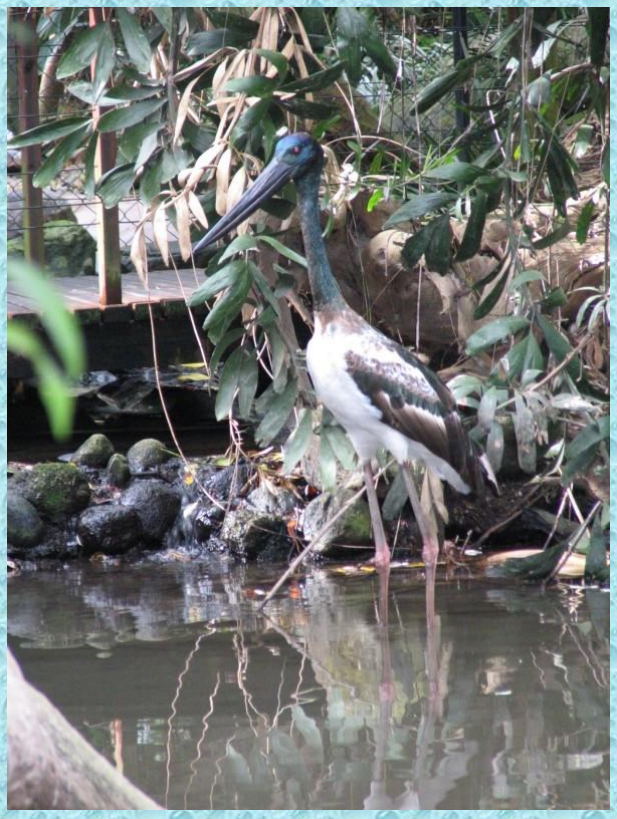
06.09.05

15.4 Appendix 4: Post Fledging Growth Phases 2004

PowerPoint presentation of fledging growth rates of Black-necked Stork chicks from 1 February 2004 to 14 November 2005 at Wildlife Habitat Port Douglas, Queensland.

01.02.04

28.09.04



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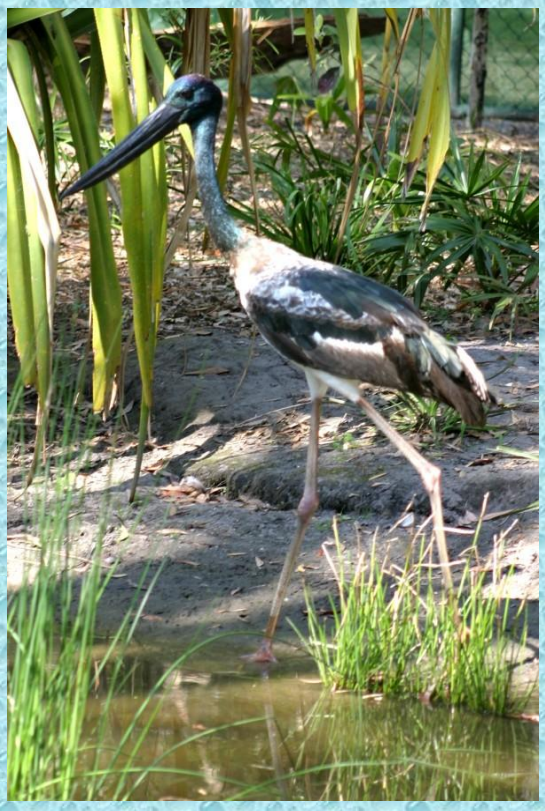
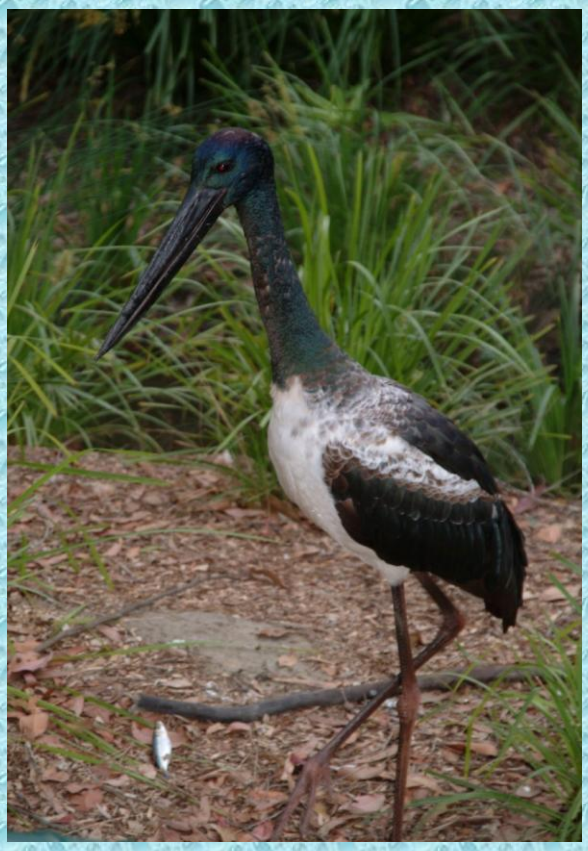
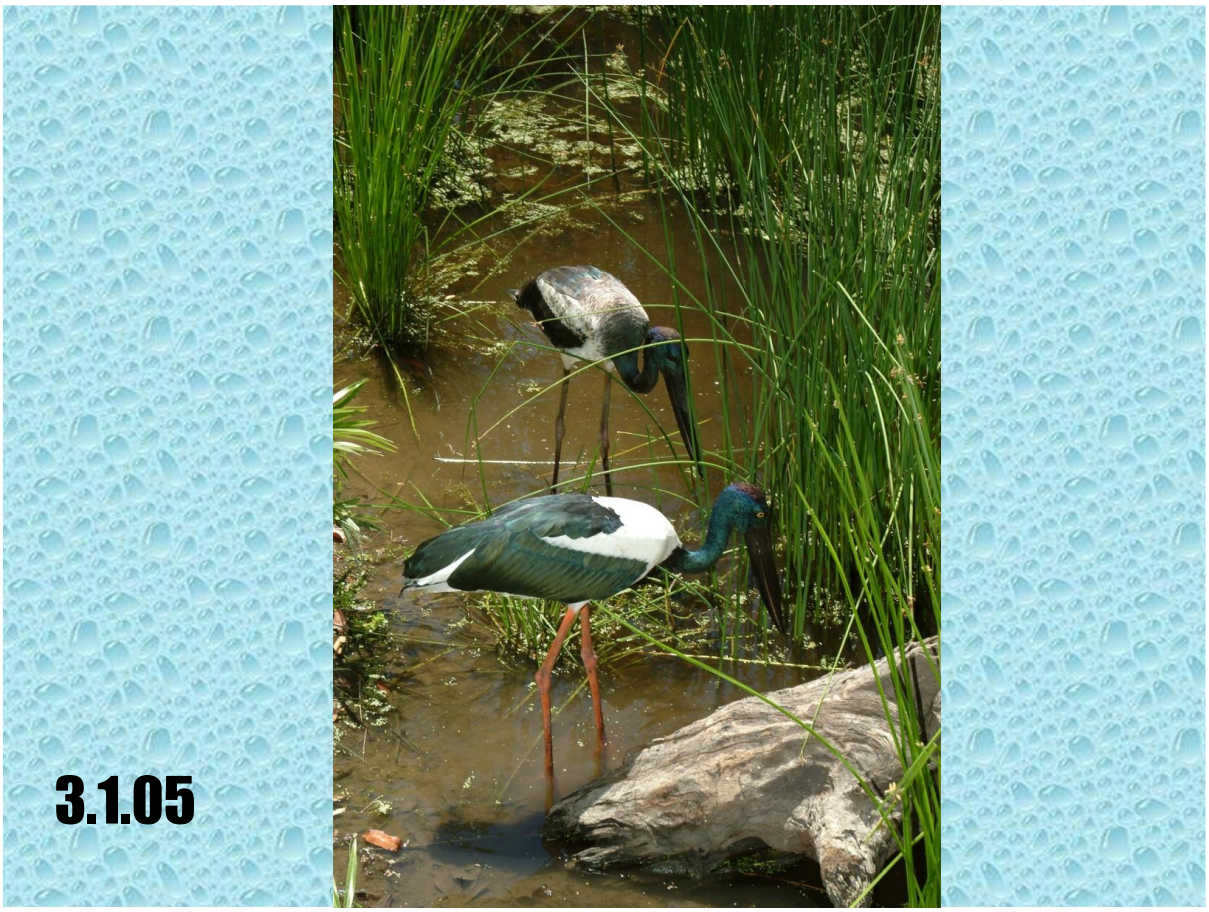




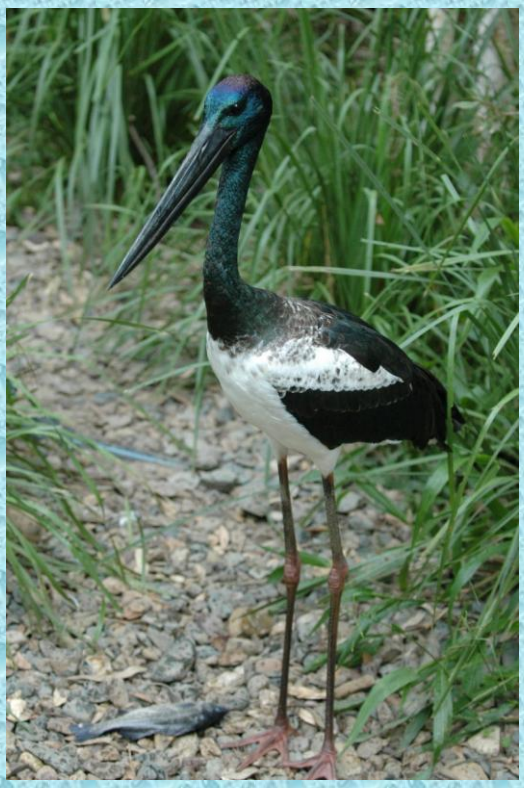
01.11.04

01.12.04

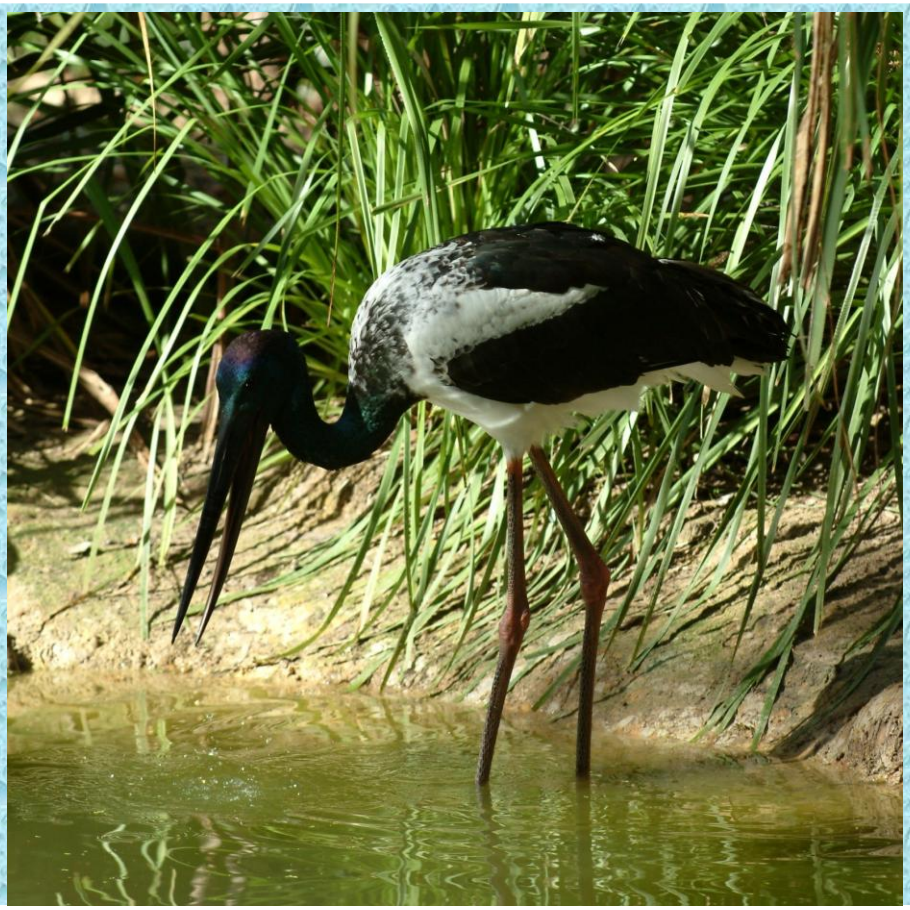
03.01.05



3.1.05



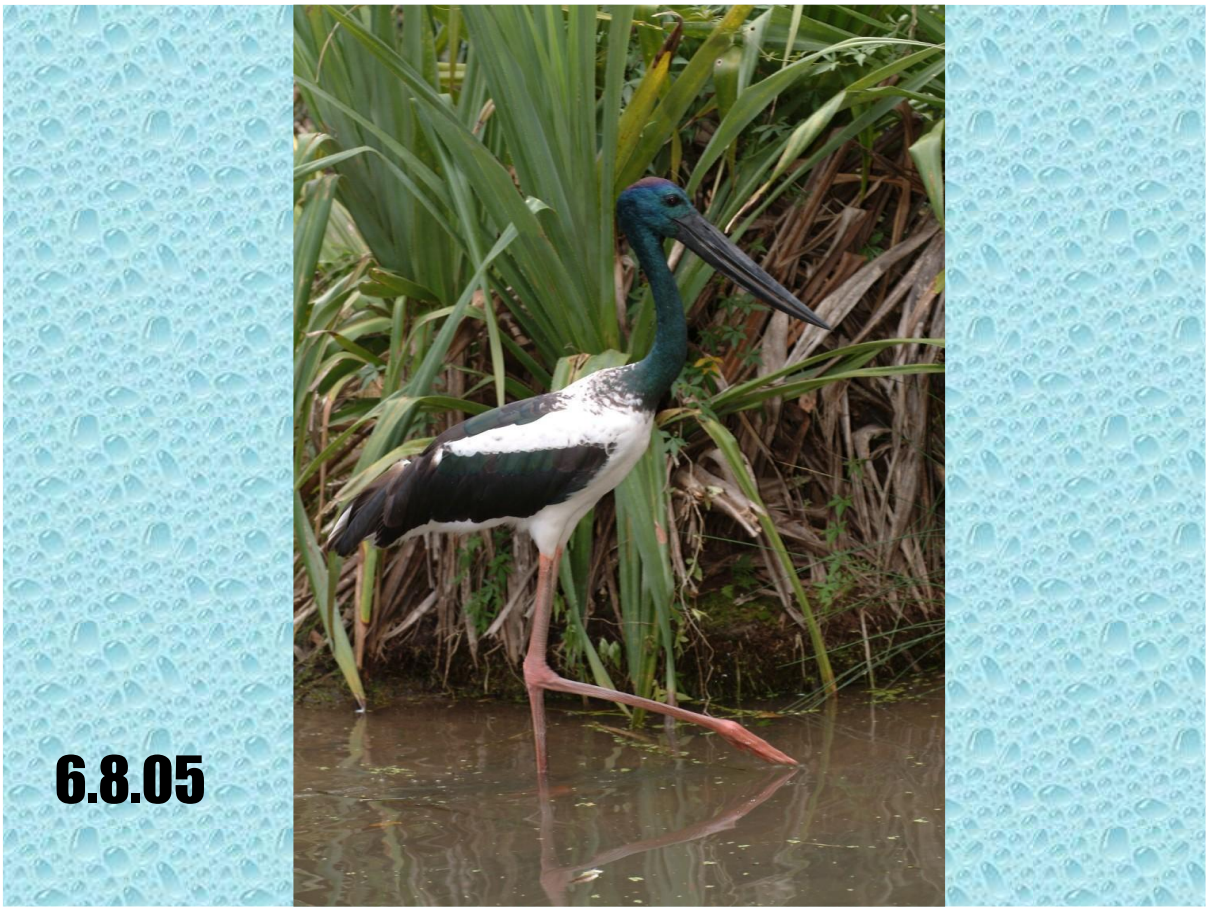
1.02.05



2.5.05


6.7.05


25.7.05


6.8.05


14.11.05


14.11.05