

Observations of Black-necked Stork breeding in the Hunter Estuary at Tomago NSW

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In 2017 and 2018 a pair of Black-necked Stork *Ephippiorhynchus asiaticus* bred successfully near Newcastle NSW thus extending southwards the confirmed breeding range. The pair raised a single chick in both years. Attendance at the nest site, incubation and fledging commenced earlier than in northern NSW. The adults provisioned young at the nestling and post-fledging stages with eel and other species of fish. Young were observed taking food directly from adults' bills as well as eating regurgitated items.

INTRODUCTION

This paper documents consecutive breeding events of the Black-necked Stork *Ephippiorhynchus asiaticus* in the Hunter Estuary in 2017 and 2018 and describes aspects of the behaviour of the young bird and its parents at the nest and post-fledging.

The Black-necked Stork occurs as two sub-species: *asiaticus*, found in India, Pakistan and parts of south-east Asia; *australis*, present in northern Australia and the southern parts of New Guinea (BirdLife International 2016). In NSW it is mainly confined to coastal and sub-coastal areas extending as far south as Sydney, with some records from the west of the state (Clancy 2010a). In 2006 the NSW population was estimated at 200-220 birds including 75 breeding pairs (Clancy & Andren 2010). It is classified as Endangered in NSW under the *Biodiversity Conservation Act 2016*.

A pair of Black-necked Stork breeds regularly near Bulahdelah c. 80 km north of Newcastle and is generally considered Australia's southernmost breeding pair (Clancy & Ford 2013). Breeding by the Black-necked Stork in the Hunter Estuary has not previously been confirmed although there have been recent instances of pre-breeding behaviour and of suspected breeding. A pair built a nest at Hexham Swamp in 2014 but there were no indications of them incubating or of the presence of any nestlings. A pair and two juveniles were regularly present at Hexham Swamp in 2015-16 but the nest location was unknown and might not have been within the estuary (Stuart 2016), although the age and behaviour of the juveniles suggested local breeding (G. Clancy pers. comm.).

On 13 March 2017, Tomago residents C. and B. Pascoe contacted Hunter Bird Observers Club Inc. (HBOC) to report that for two weeks they had been watching a pair of Black-necked Storks building a nest opposite their house. They later stated that a pair had also bred in the same area in 2016. I decided to undertake a behavioural study of the 2017 breeding event. The pair bred again in 2018 and I again spent many hours recording aspects of the birds' behaviour.

METHODS

Nest site and study area

The nest was located approximately 270 m south of Tomago Road, on private land. **Figure 1** shows the location of the nest and the main topographic features nearby, and **Figure 2** shows the location of the study area relative to the other parts of the Hunter Estuary that are mentioned in this report.

The nest was built in a Narrow-leaved Paperbark *Melaleuca linariifolia* approximately three metres tall, growing in wetland dominated by Common Reed *Phragmites australis*. The tree had multiple trunks and the crown was broad and flattened at the top. The nest structure was almost invisible from the observation point on Tomago Road because it was obscured by the tree's thick, upper foliage. Its presence was discernible when the adult birds were in attendance. From the observation point (see below) the nest appeared to be c.2 m above ground.

There were two Swamp Oaks *Casuarina glauca* to the east of the nest site, c. 33 m and 57 m from it. A set of powerlines (five lines, two above and three below) run east/west about 40 m to the north. Tomago Road is another 230 m further to the north. It is a busy two-lane

connecting road which also has powerlines on both sides (with a total of 15 individual strands). The presence of almost continuous traffic and associated noise did not appear to bother the birds but made it almost impossible for me to hear any calls made by them, if indeed they did call.

The northern side of Tomago Road has residences and several factories. Tomago House, an historic homestead surrounded by tall trees giving way to fenced open grassland, was 534 m to the west of the nest. There was a light industrial shed 224 metres to the north-north-east. All distances are derived from Google Earth 30/04/18.

From the nest site towards Tomago Road, the ground rises gently and Common Reed is replaced by exotic grasses. This open area, dubbed “Upland”, stretches between the shed to the east and Tomago House to the west. It played a prominent role in the 2017 and 2018 breeding events.

In 2017 after fledging, the young Black-necked Stork remained for a week in a paddock on the northern side of Tomago Road. The paddock was occupied by four horses during the day. On the southern boundary was a horse-riding area fenced by loose white tape and 100 metres further, a residence. The northern and western sides had barbed wire fencing and immediately adjacent, thick woodland. The eastern side had high fencing and light industrial area with trucks coming and going most of the day.

Observing the nest

Permission to access the private land where the nest was located was sought from the landowners but not granted. The observation point was therefore on the side of Tomago Road approximately 270 m directly north of the nest (see **Figure 1**). I used Swarovski 10 x 42 binoculars and Swarovski x 20 telescope to make observations; most events occurring at the nest tree could be clearly seen using the telescope. Photographs were taken with a Canon 7D Mark 2 camera fitted with a 100-400 mm zoom lens (for example, **Figure 3** shows the nest photographed from the observation point). All observations were written in a notebook and later converted into typed notes. I identified the sexes of the adults based on iris colour, the female having a yellow iris and the male, dark brown (Clancy & Ford 2013). I was not able to identify fish species brought to the young and have used the word “fish” to describe species other than eel.

In 2017 I visited the nest on 40 occasions between 13 March, when the nest was first reported, and 7 August when the chick fledged. In that time, I spent 64 hours 40 minutes at the observation point, recording all the behaviours of the adults and chick at the nest or in the study area. The shortest watch period was 25 minutes and the longest 5 hours and 5 minutes. Eleven watch periods were of more than three hours. I chose different

times of the day to visit the nest but the majority of visits took place in the morning (27 watch periods).

After the chick left the nest, it stayed in the northern horse paddock (see **Figure 1**) for a week, until 15 August. In that period, I spent another 12 hours and 5 minutes on observations, often going twice per day.



Figure 1. The Black-necked Stork nest site at Tomago, also showing the observation point on Tomago Road and other nearby topographic features.

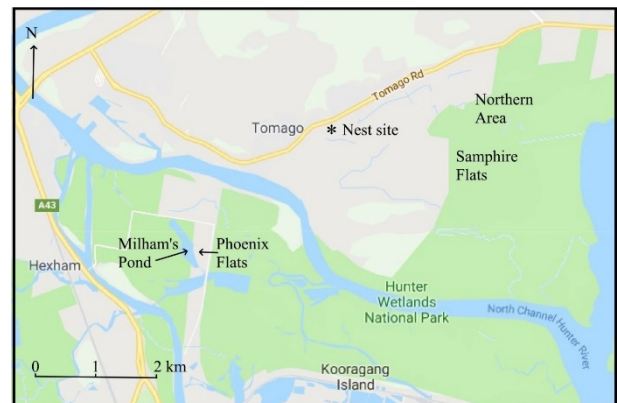


Figure 2. Location of the Black-necked Stork nest site within the Hunter Estuary.



Figure 3. Nest tree with both adults present, photographed 25 March 2017. Powerlines and the Upland area are in the foreground.

During the 2018 breeding event, I visited the nest on 24 occasions logging a total of 12.9 observation hours. The observation periods generally were shorter than for 2017, with the longest period being 80 minutes and the shortest one 10 minutes.

Although several HBOC members visited the study area in either the 2017 or 2018 breeding events and reported their observations to me, their time spent was not logged. If new or different information on the birds' behaviour was reported, it has been included in this report. L. Parashou made several recordings of various stork behaviours, using a Nikon Coolpix, P 900 video camera. She subsequently prepared an informative video which can be seen on YouTube posted 26 January 2018 <https://youtu.be/rtTPOET1oio>.

RESULTS

Nest building

From the beginning of March 2017 a pair of Black-necked Storks had been observed carrying branches from large trees around Tomago House to the nest. The pair continued to bring branches until the end of March. During this time smaller, softer vegetation, presumably for nest lining, was also brought in (for example, see **Figure 4**). The pair would spend up to three hours at a time arranging and rearranging the vegetation, picking up sticks and lining and laying them down again and then just standing around. On 26 March they were seen copulating on the nest. After this time, they were observed only once bringing in branches but they continued to carry in soft vegetation. Sometimes both adults were seen sitting on the nest at the same time and on occasions the birds were so hunkered down on the nest that they were barely visible.



Figure 4. Female bringing nest lining from the Upland, photographed 29 April 2017.

In 2018, observation of the nest commenced about three weeks earlier than in 2017. The pair was first

observed standing on the nest on 8 February. On thirteen out of fifteen visits until 20 March both adults were observed together on the nest. During that time some large branches were carried in but less often than in 2017. As in 2017, the pair would spend time rearranging vegetation or just standing around. On 5 March and 20 March they were observed copulating on the nest.

Behaviour at the nest and incubation

Because the bottom of the nest was screened from view it was not possible to see how many eggs were laid or if small nestling(s) immediately post-hatching were present. The early stages of the breeding event were therefore interpreted through the actions of the adults when attending the nest.

Several different behaviours indicating incubation were observed including persistent sitting down on the nest for long periods and regurgitation of water onto the nest. Adults had already been observed sitting for brief periods in late March in 2017 but sitting for longer periods began in earnest from 5 April and this continued into May. The sitting bird would sometimes continue to sit even while the other bird flew in and out with nest lining. On 7 April both birds were rearranging nesting material when observations commenced at 1000 h. When the female flew off the male sat down. She returned within five minutes with nest lining which she then organised while the male continued to sit. Again she flew off and returned with nest lining, clapping her bill as she landed. This time the male stood briefly, organised vegetation and quickly sat down again. The female stood preening for approximately ten minutes before flying off while the male continued to sit.

Similar behaviour was observed on 29 April during a three-hour watch from 0900 h to midday. The male sat on the nest while the female flew back and forth collecting soft vegetation – green grass or black rotten vegetation. She did this eight times. The ninth time she brought only a little vegetation but she regurgitated a stream of water onto the nest. At 0956 h the male stood up and flew south, landing in the wetland about 100 m away, whilst the female arranged vegetation on the bottom of the nest before sitting down. He returned twice with vegetation and on the third return, he expelled water onto the nest twelve times in quick succession. The female then flew to the Upland while the male rearranged the interior bottom of the nest before sitting down. The female in the meantime collected a couple of larger sticks from Tomago House area and placed them in the nest

while the male continued to sit. She then flew off and the male stood up, reorganised the nest and sat down.

From 30 April 2017 there was a slight change in behaviour which may indicate that the birds were turning the egg(s). The adult on the nest was more restless, often just standing peering into the nest, or with small movements back and forth with the bill pointed vertically down, doing something in the bottom of the nest or standing up and turning around 180 degrees then shifting weight from leg to leg before gently folding down.

It was difficult to ascertain the length of the incubation period. In 2017, assuming a chick hatched on 9 May (see “Behaviour indicating that hatching had occurred” below) the incubation period would have been 33 days if counted from 5 April when persistent sitting was first observed. The male spent more time sitting than did the female, 71% of the total observation period compared to 29% (see **Table 1**). Note that on 8 April both adults were at the nest and I could not tell which of them was doing the incubating.

Table 1. Summary of incubation periods for male and female 2017.

Date	Period of observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
05/04/2017	10	10	0
06/04/2017	10	0	10
06/04/2017	10	0	10
07/04/2017	35	25	0
08/04/2017	35	35	35
29/04/2017	180	160	0
30/04/2017	115	115	0
02/05/2017	130	0	130
07/05/2017	75	75	0
08/05/2017	35	35	0
Total Time	635	455	185

Insufficient observations were carried out in 2018 to allow speculation as to the incubation period. Some observations of behaviour indicated that incubation was in progress on 30 April as the male was observed sitting tightly although he stood twice very briefly during the 80-minute watch, turned around and sat down again. The female was either foraging or collecting nest lining on the Upland and when she returned to the nest the male did not stir. On 6 May the male was sitting so low and tightly that he was invisible until he stood up on one occasion during that watch. Chick(s) may, however, have been present on 12 May (see “Behaviour Indicating that Hatching had Occurred” below) which means that incubation had

commenced well before 30 April. Even though observation time was limited, the male appears to have spent more time incubating, 73%, than the female, 27% of the total observation time.

Table 2. Summary of incubation periods for male and female 2018.

Date	Period of observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
30/04/2018	80	80	0
06/05/2018	85	85	0
12/05/2018	60	0	60
Total Time	225	165	60

It was found from observations of two nests at Tomago that out of a total of 860 observation minutes the male spent 620 minutes incubating, 72% and the female 245 minutes, 28 % (**Table 3**).

Table 3. Summary of total time spent incubating by male and female over two breeding events.

Year	Total observation (minutes)	Male incubating (minutes)	Female incubating (minutes)
2017	635	455	185
2018	225	165	60
Total Time	860	620	245

Behaviour indicating that hatching had occurred

On 9 May 2017 the female was seen swallowing fish stockpiled in the nest. It is known that adults will consume food deposited in the nest for the nestlings if the food remains uneaten (Clancy & Ford 2013). From this behaviour I assumed that a chick was now present.

When I arrived at 0800 h that day, the female was sitting. At 0915 h she stood and made small movements in the bowl of the nest with her bill. She then raised her bill and swallowed a silver item. She was seen to swallow three more items of food. At 0927 h the male flew in from the south and landed in the Upland where he stood and watched the nest. At 0932 h the female swallowed eight items including six small fish, identified by the silver gleam in the sun and ovoid shape. The female then sat down, remaining sitting until the end of the watch. At 0946 h the male flew from the Upland over the powerlines to the nest with a small amount of vegetation in his bill which he dropped into the nest. The female did not stir. At 0950 h he flew south to the wetland landing about 300 metres away but he returned a few minutes later and did

some minor rearranging of vegetation. At 1002 h he sat down beside the female.

On 16 May 2017 a chick was seen in the nest (A. Lindsey & G. Tong pers. obs.) thus confirming a successful breeding attempt. Between 1315 h and 1400 h, the female was observed to eat six eels (two longer than her bill as one hung out the end before she was able to swallow it) and five fish. She also regurgitated an unidentified item and a fish. During this time the chick was bobbing up and down swallowing food items. Subsequent observations confirmed that only one chick was present.

In 2018 the behaviour of the female indicated that a chick may have been present on 12 May. The female was sitting and during the observation period she stood three times and sat down again.

While standing, she spent some minutes just peering into the nest and/or making small bill movements as observed the previous year. On 19 May 2018 a nestling was observed in the nest (A. Lindsey, N. Fraser & L Huxtable pers. obs.).

Attending the nest between hatching and fledging

From 16 May 2017, the first date that the chick was seen, to 19 June when the chick was seen alone for the first time, both adults attended the nest for similar amounts of time (**Table 4**). The male spent 49% and female 53% of the total observation period at the nest. Both were present on the nest on three occasions.

Table 4. Summary of time spent on nest by male and female after chick had hatched until seen alone on nest. Data includes three occasions when both birds were present on the nest.

Date	Period of observation	Male attending nest	Female attending nest	Nestling alone on nest
16/05/2017	65	0	65	0
18/05/2017	15	15	15	0
21/05/2017	200	05	200	0
24/05/2017	90	0	90	0
27/05/2017	105	90	15	0
04/06/2017	210	210	0	0
14/06/2017	30	0	30	0
17/06/2017	60	60	0	0
Total Time (min.)	775	380	415	0

Table 5. Summary of amount of time male or female spent attending the nest after chick had been left alone for first time and presence of adult(s) on the Upland.

Date	Period of observation	Male attending nest	Female attending nest	Upland
19/06/2017	10	0	0	Male
23/06/2017	20	0	0	0
24/06/2017	40	0	0	Female
01/07/2017	30	0	0	0
03/07/2017	30	0	13	0
05/07/2017	80	80	0	0
20/07/2017	30	0	0	0
21/07/2017	20	0	0	Male
22/07/2017	45	0	0	Male & Female
23/07/2017	80	0	0	0
23/07/2017	30	0	0	0
24/07/2017	20	0	0	0
25/07/2017	60	0	10	Male & Female
28/07/2017	160	46	88	0
29/07/2017	210	02	97	Male & Female
30/07/2017	215	0	33	Female
31/07/2017	180	20	61	Male & Female
02/08/2017	215	03	32	Male & Female
03/08/2017	120	0	0	0
04/08/2017	240	0	0	0
05/08/2017	260	0	219	Female
05/08/2017	50	20	0	Male
07/08/2017	75	0	0	0
Total Time (min.)	2,220	171	553	

However, after 19 June the chick was left alone on the nest for long periods and the adults seemed to attend only when provisioning the chick or refurbishing the nest. They would then fly to the Upland and watch the nest. I did not record the amount of time adults spent on the Upland but I noted whether they were present there or not. The female attended the nest *c.* 3 times more often than the male, approximately 25% and the male 8% of the total observation period (Table 5).

The female attended the nest more often than the male in both the hatching and fledging phases; 31% and 19% of total observation time, respectively (Table 6).

Table 6. Summary of amount of time spent by male and female attending nest post-hatching.

Date	Period of observation (minutes)	Male attending nest	Female attending nest
16/05 to 7/08/17	2930	546	903

Provisioning the chick

When the chick was very small it was assumed to be eating when either it was bobbing up and down or it was actually seen to swallow an item of food. As the chick grew and became more visible, it was possible to identify food items, which consisted of small fish and eel. No other type of food was seen. The usual method of feeding nestlings is for the adult to regurgitate food into the nest (Clancy & Ford 2013). On nine occasions adults were seen to regurgitate food into the nest, four times by the female and five times by the male. On four of these occasions, food was identified as eels and once, fish. When an adult landed on the nest regurgitation would not necessarily take place immediately even if the chick started begging behaviour. Sometimes both would stand around for several minutes until the chick started begging behaviour again and then feeding would take place. The adults appeared to be efficient hunters. In 2018 on one occasion the female flew in three times within twenty minutes and regurgitated food. On another occasion the female produced a large eel, twice as long as the chick's bill. The chick proceeded to swallow it whole and 13 minutes later the male regurgitated items and the chick swallowed three black, thin items as long as its bill one after another.

A seldom observed method of feeding was recorded on 2 August 2017. The chick, in begging mode, put its bill into the male's bill three times.

The fourth time this happened, the adult regurgitated an item of food and the chick took it straight from the bill and swallowed.

Behaviour of the adults on the nest and on the Upland

In the early stages of brooding, either the male or female attended the nest or both. Typically, an adult would stand or sit low in the nest. Sometimes both adults would be standing or both sitting when the watch started. If only one adult was standing on the nest and the other flew in, they would stand or both sit down. The sitting adult would often stand, walk around and sit down again facing a different direction. There did not appear to be any physical display on arrival and departure but on one occasion the male clacked its bill on returning to the sitting female. On another occasion I saw the female clack her bill on arrival. The adults frequently reorganised vegetation by lifting up sticks with the bill and laying them down. Sometimes, but not often, wing stretching and preening took place.

From the very beginning of the nesting event, the Upland played an important role even though it was very close to a busy road and power lines stretched east west 40 metres north of the nest separating it from the nest. The adults would negotiate the power lines several times a day flying over them at a point just west of the nearest power poles. Only on three occasions were the adults seen to fly under them, the female twice and the male once. Both adults roosted on the Upland, alone or together, sometimes standing but also sitting on their hocks, sometimes preening. Although a couple of times, soft vegetation, presumably nest lining, was brought from the Common Reed bed to the south, most was gathered from the Upland. The adult would walk along with head down, picking up pieces of material in the bill until the bill was quite full. The vegetation was sometimes black, perhaps damp and rotten or it appeared dry – pale green to yellowish. The adult then flew directly back to the nest and dropped the vegetation onto the nest. Most often the bird collecting the vegetation then arranged it in the nest even when the other adult was present. During the early incubation period when the male spent more time incubating, the female spent her time collecting nest lining. During one observation period on 29 April the female collected vegetation and returned to the nest with it nine times in three hours. Although the male occasionally collected nest lining, it was more often the female that

refurbished the nest even up to two days before the nestling fledged.

In 2018 the adults exhibited similar patterns of behaviour at the nest and on the Upland as in 2017. The only different behaviour I observed was on 11 July when the ‘up-down display’ was performed. (Figure 5). During the ‘up-down display’ the birds mirror each other’s actions which may involve shaking their wings, stretching their necks and bill clapping. The display may take place for a variety of reasons (Clancy & Ford 2011). The adults were roosting on the Upland, sitting on their hocks and apparently dozing in the warm sun. The chick was similarly on its hocks dozing on the nest. At 1428 h both adults suddenly stood up and faced each other, with wings outstretched quivering and clacked their bills. After a couple of minutes they returned to standing position. They performed this display four times before the male flew off towards the west at 1450 h. It was the only time this behaviour was observed.



Figure 5. Adults performing the up-down display on the Upland, photographed 11 July 2018.



Figure 6. Chick practising flying three days before fledging, photographed 4 August 2017.



Figure 7. The young bird clearing the powerlines on its first flight, photographed 7 August 2017.

Behaviour of the chick at the nest 2017

When the chick was still small it was not possible to see much activity other than the chick’s head bobbing around. Sometimes it could be seen to swallow an item of food. By mid-June, although it was still spending most of the time sleeping, it was standing up more often or sitting on its hocks looking around. From 19 June it was observed for 1,496 minutes out of 2,220 alone on the nest (67% of total observation time).

Table 7. Summary of time chick spent alone on nest

Date	Period of Observation	Nestling alone on nest
19/06/2017	10	10
23/06/2017	20	20
24/06/2017	40	40
01/07/2017	30	30
03/07/2017	30	17
05/07/2017	80	0
20/07/2017	30	30
21/07/2017	20	20
22/07/2017	45	45
23/07/2017	80	80
23/07/2017	30	30
24/07/2017	20	20
25/07/2017	60	50
28/07/2017	160	26
29/07/2017	210	111
30/07/2017	215	182
31/07/2017	180	99
02/08/2017	215	180
03/08/2017	120	120
04/08/2017	240	240
05/08/2017	260	41
05/08/2017	50	30
07/08/2017	75	75
Total Time (min)	2,220	1,496

By 5 July the chick’s body was as tall as the top of an adult’s legs and it was about half the size of the adult when standing. As the chick grew it began to move around more and spent less time sleeping. Activities included wing-stretching and flying

practice, walking around the nest platform, preening, watching the adults organise vegetation. When an adult returned to the nest with vegetation it would sometimes take part in the arrangement of the material. On 28 July it took a short stick from the bill of the male and placed it in the nest. Similarly, it grasped the loose end of a reed stalk held by the female in her bill and together they placed it in the nest.

Flying practice which commenced during the first week of July ranged from simple wing-stretching and gentle flapping to vigorous flapping and lifting high off the nest, legs dangling, sometimes to a point where it looked like it would miss landing back on the nest again. **Figure 6** shows an example of the chick's flying practice. Apart from one occasion this activity took place when the adults were either absent or watching from the Upland.

Fledging

On 7 August, it was 10 degrees C with a light north-west breeze when observations began at 0710 h. The chick was standing on the nest, left leg sometimes tucked, occasionally preening or stretching a wing, fiddling with the vegetation and giving no indication that it was about to fly. The adults were nowhere to be seen. At 0825 h without preamble, it simply flew straight out of the nest, circled once and flew high over the power lines just north of the nest. Flying strongly, it circled three times above the Upland during which time it dropped a little height. At 0832 h it flew across Tomago Road with its two sets of power lines, over a house and landed behind the house in a paddock with four horses. It stood around until 0930 h when it flew to the northern edge of the paddock. Between then and 1215 h it took five short flights around the paddock. Between flights it walked to and fro picking up sticks and dropping them or resting on its hocks. The horses appeared to ignore it. In the meantime the female was standing on the nest at 0840 h (N. McNaughton pers. obs.). I saw her leave at 0910 h and return at 0938 h. She remained on the nest until 1205 h at which point she flew to the Upland and landed in direct line of sight with the fledgling. Mid-afternoon both adults were observed in the paddock (residents' pers. obs.) but when I arrived at 1705 h only the fledgling was present. The female arrived at 1715 h and, in response to begging behaviour by the young bird, regurgitated food onto the ground. By then it was too dark to see further actions.

The 2018 chick probably fledged on 12 August as it was present on the nest the day before but not the day after. It is likely that this chick remained hidden in long grass in the vicinity of Tomago House as the adults were seen on the Upland on 13 and 14 August. No interaction between it and adults was noted.

On the morning of 5 September a juvenile stork was observed standing in the middle of Tomago Road adjacent to Tomago House (B. Kinsey pers. obs.). As traffic approached it flew off to the north narrowly avoiding being run over. Despite a further search the bird was not located again. It seems likely that this juvenile bird was the 2018 fledgling. This report was followed up immediately and although the male bird was found on the western side of Tomago House no juvenile was observed. On 8, 10 and 11 September, the juvenile was seen with the adult male on the far western side of the Upland but it disappeared after those dates.

Post-fledging period in the horse paddock 2017

The young bird remained in the horse paddock from 7 to 14 August. During that time, between feeding bouts the fledgling would spend the time standing, walking around or resting on its hocks. Because it mostly chose a position against the fence adjacent to the woodland it was well camouflaged. Apart from the first day when the newly-fledged bird made five short flights, it was seen to make only four short flights around the paddock. On occasions, after food had been provided, the adults would remain on site either standing around or sitting on hocks, but not close to the fledgling or each other. They were usually 50 to 100 m apart.

The open aspect of the paddock allowed unobstructed observation of feeding bouts. An adult would fly in and the young bird would assume a begging position, sitting on hocks, flapping half-extended wings, shuffling around to position itself in front of the adult so that it could put its bill into that of the adult (see **Figure 8** for an example). Both adults provided food, mostly eels but on 14 August I saw the female in one regurgitation bout disgorge an eel followed closely by a fish. On one occasion the fledgling took five minutes to swallow the huge eel provided by the male. The eel was very fat in the middle and three times longer than the fledgling's bill. Other eels provided were smaller and more readily dispatched. On two occasions, the young bird took

an eel directly from the female's bill. The video by L. Parashou, shows the juvenile taking an eel from the female's bill and flipping it until it could be swallowed head-first.



Figure 8. The female feeding the juvenile in the Horse Paddock; she is about to regurgitate an eel. Photographed 14 August 2017.

Interaction with other animals in the paddock

The fledgling remained in the paddock despite considerable surrounding activity. For instance, the horses were removed from the paddock each evening and returned next morning. Whilst the horses showed no interest in the young bird, they were constantly wandering around grazing. There were minor interactions between the adults and one of the horses. On two occasions a horse showed some aggression to the male by purposefully walking towards it. The male walked off quickly in the other direction. Once the male walked towards the group of horses as the female came in to land nearby. She took up position much further away and sat down. For the next fifteen minutes the male remained in the vicinity of the horses but when they stopped grazing suddenly and approached him at a fast pace, he moved off. A few days later the female was similarly approached and she responded by moving off.

The resident pair of Masked Lapwings *Vanellus miles* ignored the young bird apart from one occasion when it presumably walked too close to their nest.

Dispersal

After fledging there is circumstantial evidence that juveniles remained in the vicinity of Tomago Precinct of Hunter Wetlands National Park (HWNP) for several months.

The 2017 fledgling left the paddock on the afternoon of 14 August and was not seen there again but early on the morning of 15 August, N. McNaughton found a female with a very young bird on Northern Flats in HWNP approximately 2.1 km away, undoubtedly the same family. In September a juvenile bird was seen flying over HWNP Samphire Flats adjacent to Northern Flats and in December 2017, January and April 2018 an immature bird in the company of an adult(s) was observed on Samphire Flats. Then on 19 May an immature bird, later diagnosed as suffering from acute starvation, was captured at the site known as Smart Gates in HWNP, a short distance from Samphire Flats, and taken into care. Proximity to the natal area and plumage suggest that this was the 2017 chick. Its rehabilitation and release are documented (Lindsey 2019).

The 2018 fledgling remained in the vicinity of Tomago House until 11 September. From October 2018 to April 2019 a juvenile bird was seen seven times in the company of an adult male, once with an adult female, and six times alone, on Milhams Pond/Phoenix Flats complex, Ash Island approximately 3.3 km south-west of the nest site. On 18 January 2019 an adult male and a juvenile and on 8 February 2019 a juvenile were seen in the same general area on Little Bittern Pond on Kooragang Island 3.5 km south-east of Milhams Pond and 5 km south of the nest site. It is likely that this juvenile was the Tomago 2018 chick.

Adults continued to visit the nest after fledging had taken place in both 2017 and 2018 and in March 2019 adults were seen frequently on the Upland.

DISCUSSION

According to Clancy (2010a), breeding extended as far south as Bulahdelah in the Upper Hunter although most breeding was in the Northern Rivers and Mid-north Coast Regions. There was one breeding record west of the Dividing Range and unsuccessful nesting events took place in the 1960s and 70s in the Shoalhaven district and at Castlereagh and there is a record of "adults with young" at Wyong in the 1990s (Clancy 2010a) but there is no further detail. Clancy & Andren (2010) state that there was no confirmed breeding south of Bulahdelah during their study. In August 2014, on Hexham Swamp near Newcastle, NSW, an adult stork was observed carrying a large branch to a nest on which another adult was standing. Subsequently, adults were observed standing on the nest on several occasions; however breeding

was not confirmed. A pair, accompanied by two juveniles, was regularly present at Hexham Swamp in 2015-16; there is no evidence that breeding took place within the Hunter Estuary (Stuart 2016), although the age and behaviour of the juveniles suggested local breeding (G. Clancy pers. comm.).

The Tomago breeding events therefore extend the confirmed breeding range of this species by approximately 80 km southwards.

Breeding at Tomago started earlier than in northern NSW in both 2017 and 2018. Nest building was in full swing from the beginning of March in 2017 and from 8 February 2018. Both dates coincide with nest observation period and it may be that attendance at the nest had commenced even earlier. In 1980s in the Richmond River area breeding behaviour commenced in mid-March (Gosper & Holmes 2002), earlier than was otherwise noted in northern NSW where it started from May, but mostly June (Clancy 2008). Fledglings did not appear in the Richmond River district until late September/October (Gosper & Holmes 2002) whereas, at Tomago, fledging took place in the first two weeks of August, 7 August in 2017 and probably 12 August in 2018.

The choice of the nest site at Tomago is largely consistent with other nest sites observed – coastal location, on or adjacent to floodplain, in or less than 100 metres from water and more than 200 metres from a road or house (Clancy & Ford 2011). Although situated in a wetland, the nest site was relatively close to an industrial area. A study of breeding Black-necked Storks in India revealed that nests were often in areas of intense human activity but so long as there was no direct interference storks were able to breed successfully (Sundar 2003). The height of the Tomago nest did not fall within the typical range being only approximately three metres above the ground. Observations on the north coast show that 75.7% of nests were at a height of between 10 and 30 metres (Clancy & Ford 2011) and the height of nests in India ranged between 9 and 16 metres (Sundar 2003). In 2018 nest building did not appear to be as intensive as in 2017. I saw adults carry in large branches occasionally but less often than in 2017. I speculate that they were repairing the nest rather than building it.

Powerlines in the vicinity of the nest were a cause for alarm as they are a major hazard for both adult and immature storks. Collision with powerlines is the principal man-made cause of mortality (Clancy 2010b). While the chick was in the nest the adults

negotiated the powerlines several times a day as they flew between the nest and the Upland. After the 2017 chick fledged, they had to clear the additional two sets of powerlines along Tomago Road several times a day if foraging in wetlands to the south.

In accordance with assumptions made by Clancy & Ford (2013), I assumed that, in 2017, incubation started from 5 April when an adult commenced sitting for long periods. From then until the first week of May either the male or female was sitting for long periods on the nest. I further assumed that the birds were still incubating on 29 April when both adults regurgitated water onto the nest which is also known behaviour during incubation. This activity may be a strategy to increase moisture rather than to regulate temperature (Clancy & Ford 2011). On 29 April it was not particularly hot, only 22 degrees Celsius at midday ([Time and date.com](http://Timeanddate.com)). Because of the long distance between the observation point and the nest and because the nest platform was screened by foliage, it was difficult to establish with certainty exactly when egg(s) hatched. A chick was almost certainly present on 9 May when the female was seen swallowing fish cached in the nest. It is known that storks eat food that has been deposited in the nest and not eaten by the chicks (Clancy & Ford 2013). If counted from 5 April to 8 May 2017, the incubation period would have been 33 days which corresponds with the accepted incubation range of 32 to 38 days (Clancy & Ford 2011).

I was not able to approximate the incubation period for 2018.

Over the two breeding events in 2017 and 2018 the male appeared to spend more time incubating than the female: male 72% and the female 28% of total observation times. This result differed from observations from 10 nests on the north coast which revealed that the male and female spent similar amounts of time, 43% and 57% respectively, incubating (Clancy & Ford 2013).

The nestling period is not well known but for birds in captivity it ranges from 87 to 100 days (Clancy & Ford 2013). The nestling period for 2017 was 90 days assuming the chick which fledged on 7 August was present on 9 May. In 2018 adult behaviour suggested the presence of a chick on 12 May but the behaviour was not as persuasive as in 2017. However, assuming a chick was present, the nestling period of 92 days would be within known range. If counted from 19 May when a chick was seen, the nestling period would add up to only 85

days. In both nesting events chicks were probably present before assumed hatching dates.

Provisioning was observed only in 2017. The usual method of the transfer of food from adult to chick is for the adult to regurgitate food into the nest and for the chick to then pick it up and eat it. When the chick is small adults may re-swallow the regurgitated food several times so that it breaks up making it easy for the chicks to pick up small pieces (Clancy & Ford 2013). The incidence of young birds taking food directly from an adult's bill has been rarely reported. However in this study, it was observed on several occasions in 2017. On 27 July L. Parashou's video shows the chick taking food from the female's bill and on 2 August the nestling was again seen to take an item of food from the adult's bill and swallow it. This method was seen again on at least three occasions post-fledging. On the video the juvenile can also be seen taking an eel from the female's bill and flipping it until it could be swallowed head-first. It may be that bill-to-bill transfer is more usual when young birds have grown large enough to handle and consume prey whole.

According to observations in India, adults stopped provisioning their young when they reached 3 or 4 months of age and they were never observed to bring food to fledged young (Sundar 2003). However, according to Clancy & Ford (2013) adults regularly returned to feed juveniles left alone on wetlands. The 2017 Tomago chick was still being fed for at least a week post-fledging while in the horse paddock.

As Clancy identified only eels being delivered to nestlings (Clancy & Ford 2013), it is noteworthy that the Tomago female was eating fish deposited in the nest on 9 May and again on 16 May when a chick was definitely present. Fish including eel continued to be delivered to the juvenile post-fledging. A photograph taken on 13 August shows it with both a fish and an eel in its bill at the same time and on 14 August, another photograph shows it with a fish. It would appear that fish species other than eel were an integral part of the diet. Neither the species of fish nor the species of eels could be identified but it is likely that the eels were Long-finned Eel *Anguilla reinhardtii* which prefer estuarine water and are common in NSW (Anon 2010).

According to Sundar (2005) the 'up-down display' is rarely performed. There was no apparent trigger for the display observed in 2018. Such displays may occur at the nest during changeover or to

apparently to warn off a third adult or when other birds are in the area (Clancy & Ford 2011). This display has been reported from the Hunter Region only once before when it was photographed in May 2014 on Hexham Swamp; the display was performed in response to a third adult being present (Warnock 2014).

It has been found that fledglings may remain close to nest site (within 300-400 m) during the first month (Clancy & Ford 2013). The post-nesting site on the horse paddock in 2017 was approximately 450 m away and in an area of high activity. One can speculate that this high activity area afforded the young stork a level of safety from predators such as birds of prey or foxes. One might further speculate that, since the adults ostensibly made no attempt to relocate the chick for seven days, the site was deemed suitable. It is assumed that in 2018 the fledgling remained in the paddocks around Tomago House approximately 400 m to the west. The incident on the road outside Tomago House on 5 September 2018, when the juvenile was almost run over, bears witness to the dangers of this breeding area.

CONCLUSIONS

The Tomago breeding events have provided new or little-known insights into the life cycle of the Black-necked Stork. Even though there is circumstantial evidence of previous successful breeding events at Wyong in the 1990s and at Hexham in 2015-16 (adults accompanied by juveniles), the Tomago events are the first instances of nests with young observed as far south as the Hunter Estuary, extending the range south by approximately 80 km. Breeding commenced earlier, February/March, than in northern NSW, where breeding commenced occasionally, mid-March but typically May/June. Fledglings appeared at Tomago a month earlier than further north. The situation of the nest tree was unexceptional but its height was atypical being considerably shorter than other examples. Provisioning the young bird post-fledging was seen on many occasions in 2017. Direct removal of food from adults' bills by a young bird is uncommon behaviour but this method was seen on several occasions in 2017 both in the nest and post-fledging. Provisioning young with fish species other than eels was not seen in previous studies in Australia.

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