

ANALYSIS OF REPRODUCTION INDICATORS OF THE YELLOW-BILLED STORK (*MYCTERIA IBIS*)

Zuzana Rečková¹, Radek Filipčík¹, Ladislav Máchal¹, Roman Horský^{1,2}

¹Department of Animal Breeding, Faculty of AgriSciences, Mendel University in Brno, Zemědělská 1, 613 00 Brno, Czech Republic

²ZOO and palace Zlín - Lešná, Lukovská 112, 763 14 Zlín, Czech Republic

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Abstract

The aim of the study was to supplement the original knowledge about the reproduction of one of four species of storks (*Mycteria*). The storks are classified by IUCN as endangered species with different degrees of extinction and their reproduction in human care is difficult. Therefore, it is necessary to continuously supplement and deepen the knowledge of their reproduction in captivity. The subject of the thesis was the analysis of reproductive indicators of the yellow-billed ibis (*Mycteria ibis*). By analyzing partial reproduction indicators, we wanted to supplement the knowledge that is needed to ensure the necessary degree of reproduction of the yellow-billed stork in human care. The monitoring was carried out in the ZOO Zlín – Lešná in these years 2011–2014. After laying, the eggs were measured and weighed, which was repeated in several-day intervals. In addition, hatchability, the number of reared young and the weight of the young after hatching were monitored. During the monitoring period, a total of 46 eggs of the yellow-billed stork by 8 parent pairs were evaluated. The average fertilized eggs ratio was 56.5 %. The average eggs length was 66.07 mm, the average eggs width was 47.02 mm and the average eggs weight was 80.46 g. The average eggs weight loss during their incubation was 5.60 g. The average hatchability was 52.2 % from all laid eggs and 92.3 % from fertilized eggs. Altogether, 24 young of the yellow-billed stork hatched during the monitoring period. The average weight of young yellow-billed stork on the day of hatching was 58.14 g. Throughout to the reference period, were reared 15 individuals of the yellow-billed stork.

Keywords: *Mycteria ibis*, yellow-billed Stork, ciconiiformes, water bird reproduction

INTRODUCTION

The yellow-billed stork is a large wading bird belonging to the Ciconiidae family. Its specific features are its black tail and long neck. The yellow-billed stork's coloration is pink-white, with a black tail and plumage. Its cheeks are glabrous

and reddish in color. The bird's characteristic beak is long, yellow and curved downwards, which makes it perfectly suited for hunting prey, its feet are deep pink (BirdLife International, 2016; Wildscreen Arkive, 2016). Sexual dimorphism in the yellow-billed stork is not significant – the male is only slightly larger than the female (Burnie,

2008). Females lay 2–3 eggs, which incubate for the period of 30 days (Listebarger, 2005).

The yellow-billed stork can be found in the wild in Africa, south of the Sahara, from Senegal in the east and Mauritania in the west and south to South Africa, and also in Madagascar (BirdLife International, 2018; Wildscreen Arkive, 2016).

While the yellow-billed stork belongs to the more numerous representatives of storks, the number of storks has decreased significantly in recent years. In Africa, this species irregularly migrates to areas, where the changing water level increases the availability of fish. Nesting is seasonal and starts whenever the most nourishment is available depending on local environmental conditions. The yellow-billed stork lives in colonies, often with other bird species, usually in small groups of 10–20 pairs (BirdLife International, 2016). In accordance with the International Union for Conservation of Nature (IUCN), the degree of extinction of the yellow-billed stork is classified as LC – Least Concern species (BirdLife International, 2016; Wildscreen Arkive, 2016). The aim of the study was to analyze the reproductive abilities of the yellow-billed stork. Particularly the analysis of partial reproduction indicators, such as: laying, the size and weight of laid eggs, monitoring of the weight loss of eggs during incubation, hatchability the weight of the young at hatching.

MATERIALS AND METHODS

The monitoring was carried out in the zoological garden in Zlín – Lešná. Between 2011 and 2014, reproduction and related indicators of the yellow-billed stork were being identified. Altogether, 11 individuals the yellow-billed stork, who created 8 different parent pairs within four years, were being monitored during that period.

The yellow-billed storks were reared seasonally. From April to October (the summer period) they were reared in outdoor aviaries and from November to March (the winter period) they were placed in internal aviaries. In outdoor aviaries were

placed on the trees, for better nesting, platforms (60 × 60 cm), they were used for construction of the nests.

After laying, the eggs were measured and weighed, which was repeated in several-day intervals. The weighing interval ranged from 5 to 10 days, because it was necessary to consider the behavior of the birds and not to disturb their nesting activities more than it was necessary. It was impossible to perform an inspection of the nest without having the parent pair vacate it, but it was always returned within a few minutes after each weighing and measuring of the eggs.

During the monitored period, the following indicators were evaluated:

- Laying in the individual years of monitoring (number of laid eggs, ratio of fertilized, unfertilized and damaged eggs).
- Length, width and weight of the eggs in the individual years of monitoring.
- Egg weight losses during their incubation in the individual years of monitoring.
- Hatchability and the number of young reared in the individual years of monitoring.
- Weight of the young during at hatching in individual years of monitoring.

The data obtained were statistically processed using the statistical program STATISTICA 12.0, where Anova was used to evaluate the effect of the laying year on the monitored reproduction indicators. To determine the conclusiveness between the individual years of monitoring, the LSD test was selected to be used out of the post hoc. tests.

RESULTS AND DISCUSSION

Laying evaluation of the yellow-billed stork

In total, 46 eggs of the yellow-billed stork were evaluated during the monitoring period. In terms of the number of laid eggs, the most successful year was 2012, when 18 eggs were laid. On the contrary, the least eggs were laid in the year 2013 – only 6 eggs (Tab. I).

I: Laying evaluation of the yellow-billed stork

Factor	Laying [n]	Fertilized eggs [%]	Unfertilized eggs [%]	Damaged eggs [%]
Total	46	56,5	37,0	6,5
Year	2011	10	80,0	10,0
	2012	18	61,1	27,8
	2013	6	66,7	33,3
	2014	12	25,0	75,0

The average fertilized eggs ratio for the whole period reached 56.5 % of fertilized eggs (26 eggs). The lowest fertilized eggs ratio was found in the year 2014, when only 25.0 % of the eggs (3 eggs) were fertilized. On the contrary, the highest fertilized eggs ratio was discovered in the year 2011, when 80.0 % of the eggs were fertilized (8 eggs).

Damaged eggs occurred only in the first two years of monitoring and their average ratio was 6.5 % (3 eggs). In the last two years of monitoring, there were no cases of damaged eggs all.

Evaluation of the dimensions and weight of the eggs of the yellow-billed stork

Throughout the monitoring period, the average length of the eggs of the yellow-billed stork was 66.07 mm, the average egg width was 47.02 mm and the average weight of the eggs reached 80.46 g (Tab. II).

The longest eggs were discovered in the year 2011, when the average length of the eggs reached 66.41 mm. On the contrary, the shortest eggs occurred in the year 2013, when the average length of the eggs was 65.22 mm, which is by 1.19 mm less than in the year 2011. Brehm (1926) states that the average length of the eggs of the yellow-billed stork is 62.70 mm, which is 3.37 mm less than what we have discovered in our study. When compared to the painted stork (Rečková *et al.*, 2017), the average length of the eggs of the yellow-billed stork is shorter by 2.50 mm, and Urfi (2011) also reports a longer average egg length in the painted stork - 69.58 mm. On the contrary, when comparing the eggs to those of the Storm's Stork from the same family (Danielsen *et al.*, 1997), the eggs of the yellow-billed stork were longer by 5.87 mm.

As far as the width of eggs is concerned, the widest egg was found in the year 2013, namely 47.43 mm. The narrowest eggs were found in

the year 2011, when their width was narrower by 1.5 mm than in the year 2013 and its average value reached 45.98 mm. Between the individual years, statistically significant differences in the width of the eggs were discovered. A between the year 2011 and the remaining years was found statistically significant difference ($p < 0,01$), the eggs being significantly wider. Brehm (1926) states that the average width of the eggs of the yellow-billed stork is 41.50 mm, which is less by 5.52 mm than what we found in our study. When compared to the width of the eggs of the painted stork (Rečková *et al.*, 2017), the average width of the eggs of the yellow-billed stork is 0.59 mm wider, thus almost identical. Urfi (2011) reports 43.72 mm as then average width of the eggs of the painted stork, which is less by 3,10 mm than what we found in the yellow-billed stork in our study. When comparing the eggs to those of the Storm's Stork (Danielsen *et al.*, 1997), the eggs of the yellow-billed stork were wider by 5.12 mm.

Quite interestingly, in the year when the eggs were the longest, they were also the narrowest, and in the year when the eggs were the shortest, they were also the widest. This is also documented by the egg shape index, which was the highest in the year 2011, namely 1.44, and the lowest in the year 2013, when the value of 1.38 was determined. The egg shape index expresses the shape of the egg and is determined by the ratio of the length of the egg and its width (Halaj and Golian, 2011).

In terms of egg weight in the individual years of monitoring, eggs with the highest weight were laid in the year 2012, with an average weight of 82.73 g. On the contrary, the lowest weight was reached by the eggs in the year 2011 when their average weight was lower by 5.76 g than in the year 2012, and its value was 76.97 g. In the weight differences of eggs were also found statistically significant differences between the individual years of monitoring. A statistically significant difference

II: Evaluation of the dimensions and weight of the eggs of the yellow-billed stork

Factor	n	Eggs length [mm]		Eggs width [mm]		Eggs weight [g]		
		\bar{x}	s_{ix}	\bar{x}	s_x	\bar{x}	s_x	
Total	46	66,07	1,72	47,02	1,17	80,46	4,79	
Year	2011	10	66,41	2,16	45,98 ^A	0,96	76,97 ^{Aa}	4,47
	2012	18	66,21	2,06	47,35 ^B	1,02	82,73 ^B	4,08
	2013	6	65,22	0,71	47,43 ^B	1,57	78,00	4,55
	2014	12	65,96	0,96	47,16 ^B	0,92	81,18 ^b	4,31

$p \leq 0,01$: A-B, $p \leq 0,05$: a-c

($p \leq 0,01$) in the weight of the eggs was discovered between the years 2011 and 2012, when the eggs were a significantly higher weight. Moreover, a statistically significant difference ($p \leq 0,05$) was discovered between the years 2011 and 2014, when the eggs were higher weights again. In comparison to the painted stork (Rečková *et al.*, 2017), the average eggs weight of the yellow-billed stork is higher by 0.67 g.

Evaluation of the egg weight loss during incubation

Over the entire course of the monitored period, the average weight loss of the eggs of the yellow-billed stork during their incubation was 5.60 g. During the incubation, an average daily weight loss of 0.22 g was found (Tab. III). The energy stored in the egg is transformed into embryonic tissue. It gradually grows from a couple of cells into young birds capable of independent existence. This conversion requires oxygen and its products are carbon dioxide, water and heat (Ackerman, 2004). In accordance with Tazawa and Whittow (2000), through the egg shell pores, oxygen passes into the egg and carbon dioxide and water vapor exit at the same time. Because of this metabolic exchange, the eggs lose weight during their incubation. According to Burnie (2008), the embryo does not begin to develop until the parents start sitting on eggs. The adult birds play a key role not only in heat production, but also in creating the right microclimate during egg incubation (Turner, 2004).

The lowest average weight loss of the eggs during their incubation was 3.60 g and was found in the year 2013. The highest average weight loss of the eggs during their incubation was discovered in the year 2011 (6.23 g), which is more by 2.63 g than in the year 2013. Statistically significant differences were discovered between the individual years of

monitoring. There was a statistically significant difference ($p \leq 0,05$) between 2013 and the years 2012 and 2011, when the weight loss of the eggs during their incubation was higher. Etches (1996) states that acceptable hatchability of chickens occurs in case that the loss of egg weight ranges between 10–15 %. In the present work, the average weight loss of the eggs during their incubation was slightly lower, ranging from 4.6 % to 8.1 %. Rečková *et al.* (2017) also indicates a higher weight loss of the eggs during their incubation in the painted stork, ranging between 10.8 % and 15.3 %.

In the year 2013, the average daily weight loss during the eggs incubation reached the lowest value (0.15 g). On the contrary, the highest average daily weight loss during the incubation of eggs was obtained in the year 2011 (0.25 g), along with the highest total weight loss of eggs during their incubation. The average daily weight loss of eggs during their incubation did not reveal statistically significant differences between the individual years of monitoring.

Evaluation of the number of hatched and reared young of the yellow-billed stork

Throughout the monitoring period, the average hatchability of the yellow-billed stork was 52.2 % of all laid eggs. Average hatchability from fertilized eggs reached 92.3 % over the whole reporting period. Altogether, 24 young of the yellow-billed stork hatched during the monitoring period, of which 15 have been reared (Tab. IV).

The hatchability of laid eggs of the yellow-billed stork was higher by 24.4 % than the hatchability of those of the painted stork in the previous study (Rečková *et al.*, 2017). Similarly, hatchability of fertilized eggs was higher by 20.9 % in the case of the yellow-billed stork than that of the painted stork in the previous study.

III: Egg weight losses during the incubation of the yellow-billed stork.

Factor	n	Total weight loss [g]		Average daily weight loss [g]	
		\bar{x}	s_x	\bar{x}	s_x
Total	46	5,60	2,52	0,22	0,10
Year	2011	10	6,23 ^a	1,00	0,25
	2012	18	6,09 ^a	0,61	0,24
	2013	6	3,60 ^b	1,29	0,15
	2014	12	5,34	0,51	0,20

$p \leq 0,05$: a – b

The rearing of the young was also more successful in the yellow-billed stork, in the case of which 62.5 % of the hatched young were successfully reared, while only 47.8 % of the hatched young were reared in the case of the painted stork (Rečková *et al.*, 2017).

Regarding hatchability of laid eggs as a whole, the best year was 2011, when the percentage of hatching reached 80.0 % of all laid eggs. On the contrary, the least successful year was the year 2014, when the average hatchability of all laid eggs was 25.0 %.

The maximum, that is 100 % hatchability of fertilized eggs, was reached in the years 2011, 2013 and 2014. On the other hand, the least successful year in terms of hatchability of fertilized eggs was the year 2012, when the average hatchability reached 81.8 % of the fertilized eggs.

In terms of the number of hatched young storks, the best year was the year 2012, when 9 young of the yellow-billed stork hatched. On the contrary, the least successful year was 2014, when only three young hatched.

The most successful year in terms of the number of reared young was, once again, the year 2012, when 5 young were successfully reared. The least successful years in terms of the number of reared

young were the years 2013 and 2014, when only 3 individuals were successfully reared in both years. Yet even though the numbers of reared young were not the highest in the last two years of monitoring, the results were still very satisfactory in those years. In 2013, 3 individuals out of 4 hatched young were reared, which amounts to a 75 % success rate of rearing. In 2014, as many as 3 young out of 3 hatchlings were reared, which is a 100 % success rate of rearing of the yellow-billed stork, while in 2012, the rearing success rate was 55.6 %, although this year was the most successful one in terms of the number of reared young.

Weight evaluation of the young of the yellow-billed stork

During the monitoring period, the average weight of the yellow-billed stork young on the day of hatching was 58.14 g (Tab. V). The average weight of the hatched young of the yellow-billed stork is almost identical to that of the painted stork (Rečková *et al.*, 2017), which weighed 57.04 g on the day of hatching.

The highest average weight on the day of hatching was found in the year 2013, when the average weight on the day of hatching was 62.63 g. On

IV: The number of hatched and reared young of the yellow-billed stork

Factor	Hatchability [%]		The number of hatched young [n]	The number of reared young [n]
	of all laid eggs	of fertilized eggs		
Total	52,2	92,3	24	15
Year	2011	80,0	100,0	8
	2012	50,0	81,8	9
	2013	66,7	100,0	4
	2014	25,0	100,0	3

V: Weight of the young of the yellow-billed stork

Factor	Weight on the day of hatching [g]		
	n	\bar{x}	s_x
Total	24	58,14	7,08
Year	2011	8	50,81 ^{Aa}
	2012	9	62,61 ^B
	2013	4	62,63 ^B
	2014	3	58,27 ^b

p ≤ 0,01: A–B, p ≤ 0,05: a–b

the contrary, the lowest hatching weight was found in the young stork in the year 2011, when the average weight on the day of hatching was 50.81 g, which is less by 11.82 g than in the year 2013. Statistically significant differences were found between the individual years of monitoring. A statistically significant difference ($p \leq 0,01$) was

found between the year 2011 and the years 2012 and 2013, when the average weight of the young on the day of hatching was significantly higher. Furthermore, a statistically significant difference ($p \leq 0,05$) was found between the years 2011 and 2014, when the average weight of the young on the day of hatching was also higher.

CONCLUSION

Throughout the monitoring period, a total of 46 eggs of the yellow-billed stork from 8 parent pairs were evaluated. The average ratio of fertilized eggs was 56.5 % (26 pieces).

The following parameters were found in the eggs of the yellow-billed stork. The average eggs length was 66.07 mm, the average eggs width was 47.02 mm and compared to Brehm (1926), the eggs in our study were 3.37 mm longer and 5.52 mm wider. In consequence, the egg shape index changed, with an index of 1.41 in our work, and 1.51 according to Braham (1926). The average weight of the eggs of the yellow-billed stork was 80.46 g.

During the entire monitored term, the average weight loss of the eggs of the yellow-billed stork during eggs incubation was 5.60 g. The average weight loss of the eggs during their incubation ranged between 4.6 % and 8.1 %.

The average hatchability of all reared eggs of the yellow-billed stork was 52.2 %. The average hatchability of fertilized eggs was 92.3 %. Altogether, 24 young of the yellow-billed stork hatched during the monitoring period. The average weight of the young stork on the day of hatching was 58.14 g. During the monitoring period, a total of 15 individuals of the yellow-billed stork were reared. This study served to supplement the knowledge needed to provide the necessary degree of reproduction of the yellow-billed stork in human care.

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Contact information

Zuzana Řečková: zuzana.reckova@seznam.cz