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Filial cannibalism in the Black Stork (*Ciconia nigra*)

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Abstract

Filial and sibling cannibalism have never been documented in Black Storks (*Ciconia nigra*). We gathered information on 34 breeding events in 10 Black Stork nests from Estonia (three nests), Hungary (two nests), Poland (two nests) and Spain (three nests) being monitored with camera surveillance, live streaming webcams or intensive monitoring control of nests. Overall, we recorded 16 cases of filial infanticide and two cases where the nestlings died by natural causes and were later cannibalized by either their siblings or their parents. Four nestlings were killed by their parents without any attempt of cannibalism. In the remaining 12 cases of infanticide (66.7% of the total losses), 8 nestlings were consumed by one of the parents while in 4 cases the parents were not able to swallow the previously killed nestlings. All victimised nestlings were the youngest, weakest or smallest in their brood. Eight of 14 cases were identified as being associated with environmental stress or an exceptional matter during the breeding season. In at least five cases, one of the mates was new to the nest. Females committing filial infanticide swallowed or tried to swallow the chicks in five out of nine episodes where the parent's sex was known.

Keywords: *Ciconia nigra*, filial cannibalism, nest webcams, citizen science

Introduction

In the past, cannibalism (predation on conspecifics) was considered an aberrant behaviour in the animal kingdom (Dawkins 1976; Dellatore et al. 2009). However, this view has changed dramatically in zoology over the past few decades, and it is now recognized to be adaptive, phylogenetically widespread and relatively common in nature (Elgar & Crespi 1992; Soler et al. 2022). Also, different forms of cannibalism have been widely documented (Bose 2022). Filial cannibalism (Fitzgerald 1992) or kronism (Schüz 1957) is the killing of nestlings by parents who then eat the nestling. Partial filial cannibalism occurs when parents eat only part of the brood (Sargent 1992;

Manica 2002). Cannibalism in birds is most common in raptors (Ingram 1959; Allen et al. 2020), colonial waterbirds such as cormorants (Gubiani et al. 2012), gulls (Brown & Lang 1996), pelicans and ibises (Smith & Munro 2008; Silva-E-Silva 2017). In the family *Ciconiidae*, filial cannibalism is only described in White Storks (*Ciconia ciconia*) (Schüz 1957).

Among the 20 species of the family *Ciconiidae* (Winkler et al. 2020), the Black Stork (*Ciconia nigra*) has the widest geographical range of any stork species, but at the same time, is not common in any country (Strazds 2011). It is an elusive species that commonly breeds as single pairs in old forests; thus, it is very difficult to continuously

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observe many nests of this species (Zieliński 2002). However, during the last two decades, camera surveillance and cameras for streaming technologies, as well as different national monitoring programmes in Europe, have resulted in new findings on the species (Kalocsa & Tamás 2005, 2016; Cano & Sundar 2018; Cano-Alonso et al. 2021; Janic et al. 2021). This has been accompanied by a valuable increase in citizen science in different ways, for instance, forums with high numbers of members who became recorders by live streaming webcams at Black Stork nests as well as voluntary European programmes to monitor Black Stork nests in the field (e.g., <https://www.looduskalender.ee/forum/>, <https://forums.dabasdati.lv/index.php>, <https://www.ciconianigra.sk/>). In this short note, we gather information on events and attempts of filial cannibalism recorded in four countries across the Black Stork's distribution range in Europe (Cano Alonso & Strazds 2020).

Methods

We compiled information on four monitoring programmes of Black Stork's nests from Estonia, Hungary, Poland and Spain (Figure 1). We used data from detailed observations of a total of 10 Black Stork nests. Three nests were monitored in Estonia (1 in Karula National Park and 2 in Jogeva County), 2 in Hungary (Gemenc Region of the Danube-Drava National Park), 2 in Central Poland (Lodz Voivodeship), and 3 in Spain (2 in the Extremadura region and 1 in Salamanca province). The nests were selected based on their suitable locations for following the entire breeding period (from the adults occupying the nests till the fledglings leave the nests definitely, mainly from April to August) without any disturbance affecting the monitoring. We considered video-recorded events 1) when we observed a parent attempting to swallow a nestling, irrespective of the outcome, and 2) when we had information about the breeding season outcome for a nest, including

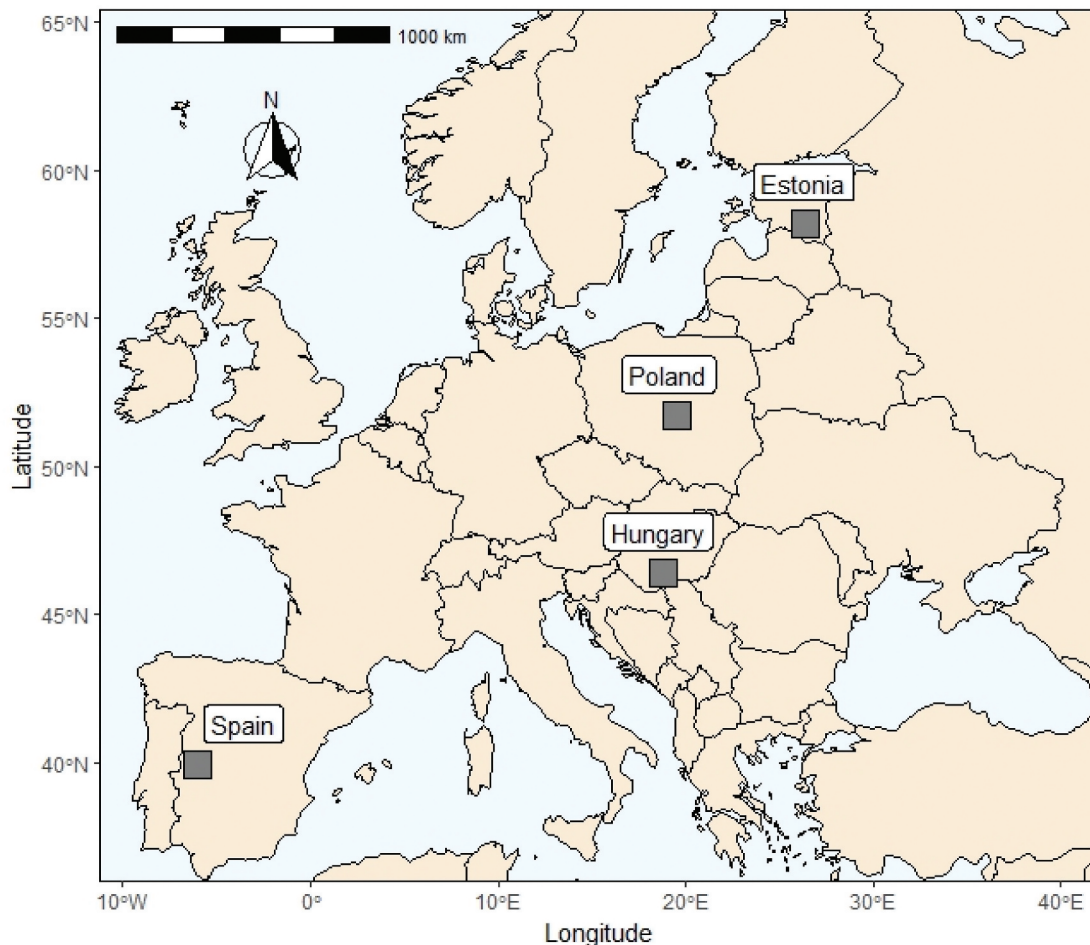


Figure 1. Locations of the study areas (filled squares) in Europe.

whether the fledglings successfully flew and the number of fledglings. Additionally, we documented the occurrence of other phenomena, such as siblicide, non-parental infanticide, conspecific strife, and conspecific scavenging.

For each country programme, we wrote down 1) the number of breeding episodes monitored that reached the hatching stage with camera surveillance, live streaming webcams or intensive monitoring control of nests by volunteers with the possibility of recording a video of the nest during the breeding season; 2) the number of chicks hatched in these nests; 3) the total number of broods with filial infanticide cases that were monitored; 4) the total number of victimised chicks recorded; 5) the filial cannibalism attempts after filial infanticide and 6) the filial cannibalism cases recorded. For each case recorded, whether the chick was finally swallowed or not, we recorded 1) date, 2) country, 3) the number of hatchlings, 4) age (days) of the killed sibling/s when the filial cannibalism—or attempt—case happened, 5) whether the victimised chick was the youngest or weakest one in the brood, 6) whether or not it was swallowed, 7) whether or not the chick was regurgitated, 8) the number of fledglings at the end of the breeding season, 9) any known environmental stressor around the nest, 10) sex of the parent that committed the filial cannibalism or attempt, 11) the mean number of fledglings per nest with fledglings in each country, 12) hatching period in each country and 13) whether the pair was new (first-year breeders in a particular nest) or not. Heavy rains or food shortages during the breeding season, as detected by the monitoring team, or the videos confirming the disappearance of an adult were considered environmental stress.

Results

We gathered information on 34 breeding episodes that reached the hatching stage with intensive monitoring from Estonia (13), Hungary (12), Poland (6) and Spain (3). The total number of chicks hatched in these 34 breeding episodes was 113 (Table I). Partial

filial infanticide (in which a portion of the hatchlings were killed by a parent) happened in 13 of the 34 breeding events with hatchlings (38.2%). Overall, we recorded 16 cases of filial infanticide and two cases where the nestlings died by natural causes and were later cannibalized by either, their siblings or the parent (Hungary, Table II). Four nestlings were killed by their parents without any attempt of cannibalism. In the remaining 12 cases of infanticide (66.7% of total losses), 8 nestlings were consumed by one of the parents, while in 4 cases the parents were not able to swallow the previously killed nestlings. No egg cannibalism was observed, and there was no non-filial infanticide in any case. Parents could not swallow chicks aged over 6 days old, and they only tried to swallow those aged under 11 days. The mean age of the victimised chick was 4.71 days ($SD = 3.29$; $N = 12$). In 13 of 14 cases of cannibalism recorded (Table II), the number of hatchlings were greater than the mean number of fledglings per nest with fledglings in each country study area (Table II). Still, the hatching period occurred during the normal phenology in their respective countries, and victimised nestlings were the youngest, weakest or smallest in their brood. Eight of 14 cases of cannibalism were identified as caused by environmental stress or an exceptional matter; in one case, a female disappeared, and in another case, the female killed one chick and swallowed it, the male disappeared three days later, and after two days, the female tried to swallow another chick (Table II). In at least five cases, one of the mates was new in the nest. Females swallowed or tried to swallow the chicks in five out of nine episodes where the parent's sex was known (Table II).

Discussion

In this observational study of reproductive episodes of Black Storks that reached the hatching stage with intensive monitoring programmes during the breeding episodes ($N = 34$), we found that not only did filial infanticide occur (described previously by Klosowski et al. (2002) and Zieliński (2002) but

Table I. Number of Black Stork broods (breeding episodes) monitored that reached the nestling stage, chicks hatched, filial infanticide and filial cannibalism (including attempts) cases in each country study area.

	Estonia	Hungary	Poland	Spain	Total
Number of Black Stork broods (breeding episodes)	13	12	6	3	34
Number of chicks hatched	47	33	23	10	113
Number of broods with filial infanticide cases	6	5	1	1	13
Total number of victimised chicks recorded	8	8	1	1	18
Filial cannibalism attempts after filial infanticide	1	2	1	0	4
Filialcannibalism recorded	3	6 ¹	0	1	10

¹Two chicks died naturally and were swallowed and regurgitated by parents.

Table II. Filial cannibalism (including attempts and dead hatchlings) episodes. References of mean number of fledglings per nest with fledglings in each country: ¹Váli et al. (2021); ²Kalocsa and Tamás (2002); ³Czuchnowski and Profus (2008); ⁴Del Moral (2018).

Case	Date (dd/mm/yy)	Country	Number of hatchlings	Age (days) of chick when the event happened	Smallest/weakest one	Swallowed/Attempt	Regurgitated	Number of fledglings	Environmental stress detected	Sex of parent that committed the episode	Mean number of fledglings per nest with fledglings	Hatching period	New pair
1	19/05/2008	Estonia	4	1–2 days	Yes	Swallowed	No	3	?	Female	2.51 ¹	Second half of May–June	Male is new
2	20/05/2008	Estonia	4	30 minutes	Yes	Swallowed	Yes	3	?	Female	2.51	Second half of May–June	Male is new
3	27/05/2012	Hungary	4	2 days	Yes	Swallowed	?	No	?	?	3.13 ²	May	?
4	30/05/2012	Hungary	4	5 days	Yes	Swallowed	Yes	No	?	?	3.13	May	?
5	25/05/2013	Hungary	4	6 days	Yes	Swallowed	Yes	No	Female disappeared	Male	3.13	May	No new pair
6	20/05/2015	Hungary	4	3 days	Yes	Swallowed	?	1	Food shortage	Female	3.13	May	No new pair
7	04/05/2017	Hungary	4	5 days	Yes	Attempt	?	3	Spring rain	Male	3.13	May	No new pair
8	10/05/2020	Hungary	3	10 days	Yes	Attempt	No	No	Food shortage	?	3.13	May	?
9	03/06/2021	Poland	4	8 days	Yes	Attempt	No	3	No	Male	2.79 ³	Second half of May	Female is new
10	28/05/2022	Estonia	6	2 days	Yes	Swallowed	Yes	3 rescued	?	Female	2.51	Second half of May–June	Female is new
11	03/06/2022	Estonia	5	10 days	Yes	Attempt	No	3 rescued	Male disappeared two days earlier	Female	2.51	Second half of May–June	Female is new
12	27/05/2023	Spain	3	4 days	Yes	Swallowed	No	2	Drought	?	2.4 ⁴	First half of May	?
Filial cannibalism without infanticide													
13	11/05/2019	Hungary	4		Underdeveloped, died	Swallowed	Yes	No	Spring rain	Both	3.13	May	
14	12/05/2019	Hungary	4		Underdeveloped, died	Swallowed	Yes	No	Spring rain	Both	3.13	May	

also filial cannibalism occurred after the chick was victimised in a high percentage of cases (66.7%). Our results suggested that these episodes may be underreported and more prevalent than generally assumed in birds, as has also been suggested for other bird families, especially in those species with hatching asynchrony (Soler et al. 2022). Contrary to other groups of birds, such as raptors (Allen et al. 2020), we have found that filial cannibalism is the most common type of cannibalism in Black Storks compared to others, including sibling cannibalism (Soler et al. 2022). According to Tortosa and Redondo (1992), the reason might be related to the way storks feed nestlings by regurgitating a large amount of food onto the nest, making prey non-monopolisable and thus no aggression or siblicide instinct would be favoured among siblings at this age. Parents killed chicks until they were around 10 days old, and consequently, filial cannibalism happened before the parents entered the phase of maximum feeding stress (Tortosa & Redondo 1992), regardless of prior parent experience. In all cases, the victimised chicks were the smallest among the siblings as well and were found in broods where the number of hatchlings was higher than average for each country, as has been described before for White Storks (Tortosa & Redondo 1992; Klosowski et al. 2002). Thus, parents presumably select the least viable chicks among the siblings in large broods. Bose (2022) described different adaptive hypotheses for filial cannibalism. From these hypotheses, we speculate explanations for such behaviour in Black Storks. Our data suggest that there is no sexual bias in committing filial cannibalism, so the explanation of these episodes would not be related to paternity confidence, and the brood parentage hypothesis would not be plausible. Only one case was recorded where the parents swallowed two dead chicks, so we preliminarily discarded the non-viable offspring hypothesis. Considering the biological and population features of the species, we can also discard mate availability (there is reported low availability of mates in Black Storks, Konovalov et al. 2019), parental stress (this mainly occurs in captive or domestic individuals, Bose 2022) and parasitic hypotheses (there was no evidence of a high prevalence of parasites among siblings in the episodes recorded, Bose 2022). However, we might consider that filial cannibalism in Black Stork could be explained by a combination of the parental energy reserves hypothesis brood size hypotheses, brood survival prospects hypothesis and offspring age hypothesis. We speculate with the importance that energetic condition and phenotypic condition of parents explaining such frequent events

of cannibalism in Black Stork. “*Parents may cannibalise because their endogenous fuel reserves will become insufficient in the future to complete the ongoing bout of care or to succeed in subsequent breeding attempts*” (Bose 2022). In this case, parents could cannibalise earlier in the care period than parents who wait until their reserves are critically low (Bose 2022). On the other hand, smaller and weaker offspring in larger broods of Black Storks may be consigned to having lower fitness than others, and this can cause “*parents to cannibalise offspring and redirect the energy to the remainder of the brood for whom parental effort can be better translated into fitness benefits*” (Bose 2022). This connects with the offspring age hypothesis, which considers that younger offspring have lower reproductive value than older offspring. In this case, there is an important demographic implication in Black Storks. Hatching order is important for determining the sex in White Storks; the heavier (and assumed older) chicks were significantly skewed toward males (Tryjanowski et al. 2011), and delayed hatching date (day of the year) significantly increased the proportion of female nestlings in Black Storks (Kamiński et al. 2019). Moreover, there is a tendency to have a higher proportion of female Black Stork nestlings in larger broods (Konovalov et al. 2015). Speculating that the youngest victimised siblings are mainly females, partial filial cannibalism might allow parents to adjust the sex ratio of their broods and thereby invest more heavily into care for males over females, implying that mechanisms related to the brood sex ratio hypothesis might also operate in these cases of partial filial cannibalism. These episodes could have special impacts on populations of Black Storks in the periphery of their range distribution (Konovalov et al. 2019), where there are relatively high events of parental infanticide and a lack of partners.

In short, this study provides a proof that citizen science and long-term monitoring using remote cameras can give us valuable information on parental behaviours in threatened and hard-to-observe, species. More breeding seasons with these monitoring programmes will give us more episodes and may allow us to continue investigating the drivers of this behaviour in Black Storks.

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Supplementary material

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