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RESEARCH NOTE

Assessing the causes of breeding failure among the rough-legged buzzard (*Buteo lagopus*) during the nestling period

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Abstract

When food becomes scarce, the youngest nestlings in facultatively siblicidal raptor species typically die and such events are usually attributed to siblicide. Here we present results from an investigation in the Arctic tundra, in which rough-legged buzzard (*Buteo lagopus*) breeding success was monitored with regular visits to nests and time-lapse cameras that continuously recorded the activity of chicks and their parents. The study took place in the Nenetsky Nature Reserve (68°20′N, 53°18′E) in the Russian Arctic, in 2007–10. It included 26 cases of chick mortality in 19 nests. The camera monitoring led us to discover instances of scavenging of chicks that had died due to starvation or bad weather in two nests. Camera monitoring also led us to discover how a sequence of abrupt weather shifts, between hot and sunny conditions and heavy rain, probably caused the death of nestlings in two nests. Detailed nest monitoring is required to avoid the mistaken attribution of such deaths to siblicide. Such extreme weather events may become more common with climate change and represent a new potential factor affecting rough-legged buzzards breeding success in the southern Arctic.

Bird species that regularly produce more chicks than they can feed under sub-optimal conditions have adopted reproductive strategies allowing for adaptive brood reductions. For instance, hatching asynchrony leads to asynchrony in chick development (Lack 1947), older chicks become stronger than younger ones and can kill them or scavenge them after their death. Avian siblicide is defined as "juvenile mortality resulting from the overt aggression of siblings" (Mock et al. 1990: 236) and can be divided into two main groups: obligate, when more than 90% of last hatched chicks are killed by their siblings, and facultative, when incidence of siblicide varies with environmental circumstances (Simmons 1988; Mock et al. 1990; Margalida et al. 2004; Margalida et al. 2007). Facultative siblicide usually occurs when feeding of the chicks is insufficient, for instance, due to poor territory quality, low breeding experience of the breeding pair or scarcity of resources (Wiehn & Korpimäki 1997; Estes et al. 1999; González et al. 2006).

The rough-legged buzzard (*Buteo lagopus,* hereafter buzzard) is a raptor that specializes in preying on arvicoline rodents. Indeed, its breeding success is highly dependent on the phase of the small mammals' population density cycle (Osmolovskaja 1948; Mindell et al. 1987). Buzzards' brood size ranges from one to six nestlings and breeding success varies from 0 to 77% (productivity: 1.48 ± 1.63, $n = 29$; breeding success: 0.42 ± 0.44, $n = 29$), depending on food availability and weather conditions (Sokolov 2002). In the low phase of the rodent cycle, siblicide in buzzard populations has been reported to be common. Other causes of breeding failure are mostly predation, accidents (mainly associated with earth-slides caused by the intensive thaw of permafrost) and chilling (Potapov 1997). In most cases, siblicide is inferred from the disappearance of the

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youngest chick and more seldom from observations of chicks feeding on their siblings.

Here we present results from an investigation in Arctic tundra during which buzzard breeding success was monitored with regular visits to nests and time-lapse cameras that continuously recorded the activity of chicks and their parents. This led us to discover an alternative cause of rough-legged buzzard nestling mortality in tundra habitats which can be misidentified as siblicide without detailed observation at the nest.

Materials and methods

Study area

Our investigations were made during a study within the Arctic Predators project in the Nenetsky Nature Reserve (68°20′N, 53°18′E), Russian Arctic, from the second part of June to the second part of August in the years spanning 2007 and 2010. This region belongs to the low-shrub tundra zone (Walker et al. 2005). Our study area included the Sedyiyaha, Sengruyaha and Nyudiako-Pendermayaha rivers, hosting relatively deep (up to 70 m) and narrow (approximately 300 m wide) valleys. The surrounding tundra landscape is treeless and lacks the rock cliffs that, in other parts of this species' range, provide elevated and protected nesting sites. Buzzards therefore typically nest on the ground in this region (Kaljakin 1989). The small mammal community is dominated by tundra voles (*Microtus oeconomus*) and population fluctuations are of moderate amplitude (Hansson & Henttonen 1988; Ims & Fuglei 2005). Small rodent densities were relatively low in 2007, 2009 and 2010 but peaked in 2008 (unpubl. data).

Buzzard nest search and observations

We monitored an area of ca. 150 km^2, targeting river and lake banks with walking excursions and using 8–10 power binoculars. We found and monitored six, 10, 14 and four buzzard nests in the years 2007, 2008, 2009 and 2010, respectively. We visited nests regularly (about every 10 days) and recorded the number of live and dead chicks. In addition, we measured the wing, tarsus and culmen length as well as the weight of all nestlings.

In 2008–10, we installed automatic cameras (Digital Ranger W50 RB with Sony Cyber-shot DSC-S700 cameras; Camtrak South Inc., Watkinsville, GA, USA) nearby nests, taking one picture every 5 min. To record parent and offspring activity, this camera monitoring was used on four of 10 nests during 958 h in 2008, three of 14 nests during 262 h in 2009 and all four nests during 1942 h in 2010.

Results

Nest visits

During all four years, we found a total of 34 active buzzards' nests (Table 1) and registered 26 cases of chick mortality in 19 different nests (Table 2). On the basis of the presence of fox faeces or foot prints, we assumed that three chicks were predated or scavenged by foxes (*Vulpes vulpes* or *V. lagopus*). Nine chicks were observed dead in or close to the nest. Among these, one chick was partly eaten by siblings (its remains were found in the pellets from this nest), another had a damaged eye, possibly due to harassment from its siblings, eight days before it was found dead. In both cases, the dead chicks were the youngest in nests with three nestlings in total; and in both of them we registered a decrease of nestlings' weight prior to death. From 31 July to 8 August, their weight decreased from 880 to 750 g and from 660 to 550 g respectively.

In the seven other cases, which happened between 5 and 19 July, the chicks (approximately 7–15 days old) were found dead approximately five m from the nest and showed no signs of physical injury. We had not registered any lag in these chicks' development in terms of the different body measurements we had made. These seven cases were preceded by an abrupt weather change from hot conditions to rainy and cold (personal obs.). Two chicks in two different nests were observed scavenged by siblings using time-lapse photographic monitoring and their remains (down and feathers) were found at the

Table 1 Number of nests and brood size of rough-legged buzzards, 2007–10, Nenetsky Nature Reserve, Russia.

		Nestlings			Fledglings		
Year	Number of nests	Number	Mean ± SD	Range (min–max)	Number	Mean ± SD	Range (min–max)
2007	6	14	2.33 ± 1.21	1–4	6	1.00 ± 1.26	0–3
2008	10	18	1.80 ± 1.14	0–4	10	1.00 ± 0.82	0–2
2009	14	20	1.43 ± 1.09	0–3	15	1.07 ± 0.83	0–2
2010	4	10	2.50 ± 0.58	2–3	5	1.25 ± 0.50	1–2

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Table 2 Chick mortality in rough-legged buzzards, 2007–10, Nenetsky Nature Reserve, Russia. For chicks that disappeared from their nest, we had no information about the exact cause of loss or mortality. The number of nests is given in parentheses.

Year	Total cases of chick mortality	Chicks predated by fox	Chicks found dead in the nest	Chicks disappeared from the nest	Chicks observed scavenged by siblings
2007	8 (5)	0	2 (2)	6 (5)	0
2008	8 (6)	1	1	6 (6)	0
2009	5 (4)	2 (2)	3 (3)	0	0
2010	5 (4)	0	3 (2)	0	2 (2)

next nest visit. Despite our monitoring, we could not determine any cause of loss or mortality for 12 other chicks, of which 10 disappeared in the period between 8 and 17 July (in the early stage of chicks' development when they have no feathers yet) and two between 18 and 30 July.

Time-lapse photography

During camera monitoring in 2008, we photographed only one case of nestling mortality. Unfortunately, clear pictures could not be acquired because of the surroundings of the nest. Therefore, we could only document that a chick disappeared from the nest on 24 July, without any details about the circumstances. On this day, the temperature reached 29°C at noon (the mean summer temperature in this area is ca. 10°C). At 10:10 that day, the last picture with two chicks (15–17 days old) was taken. Forty minutes later, it started to rain and an adult arrived at the nest. Staying in the nest for ca. 60 minutes, the adult provided protection to the nest and after the rain stopped, it flew away. After its departure, there was no single picture showing the presence of two chicks in the nest. Moreover, no picture in which an adult fed the chick with another dead chick was recorded. At the next nest visit, on 30 July, we found only one chick and did not find any remains of the other one.

In 2009, we were able to thoroughly document a case of nestling mortality, which happened in a nest with two chicks (12–14 days old) located on a flat spot in shrub tundra. On 15 July at 07:54 in sunny and hot weather (the temperature reached 25°C at noon), two chicks moved out of the nest. One of the two siblings (chick 1) hid in the shadow near the nest and the other (chick 2) moved 3–4 m away from the nest and hid there in the shrubs. During 4 h, chick 1 was sitting near the nest and chick 2 was moving in the shrubs approximately 4 m away from the nest. At 12:00, a heavy rain shower started, and shortly after an adult arrived at the nest. After 20 min in the rain, chick 1 moved under the adult. The adult left the nest when the rain stopped 1.5 h later. Chick 2 did not appear at all after July 15. We found it dead (intact and not consumed) in the shrubs on 18 July at 18:00. The series of photographs documenting this event can be seen on our project website (http://www.arctic-predators.uit.no/Rough-legged-buzzards.html).

In 2010, we observed two cases of chick mortality due lack of food and/or cold, rainy, weather conditions. In one of the nests, there were two chicks with large difference in development; at each nest visit, one chick was 2.3–3 times heavier than the other. On 22 July, their weights were 1100 and 600 g, respectively. On 23 July, at 06:30, one of the parents fed the chicks before a rainstorm started at 18:30, which continued for more than a day, ending on 25 July at 02:00. During this period, the adults did not feed their chicks. The smallest chick apparently died on 24 July at 19:30 and 1 h later its sibling started to eat it. The other case happened in a nest with three chicks. On 19 July at 8:00, the two largest chicks weighed 800 g while the smallest weighed 360 g. During this nest visit, we observed that the smallest chick did not move and its eyes were closed, though it was still alive. After our departure, we recorded no movements of this chick with the automatic camera. On 20 July at 04:00, we got a picture showing the smallest chick being fed to its siblings by a parent.

Finally, in nine of the 11 nests equipped with automatic cameras during 2008–10, chicks moved out of the nest during hot days (when the temperature was 23–34°C), but our camera monitoring did not document any case of aggression between siblings within nests hosting two or more chicks.

Discussion

Although adult buzzards protect nestlings from inclement weather conditions such as rain and cold wind, they do not seem to care about chicks if they are out of the nest. Why, then do chicks leave the nest, as we documented using camera monitoring? One reason is that they seek shelter from the sun in hot weather. When the chicks are small, such movements are risky since weather conditions can quickly deteriorate owing to rapidly incoming thunderstorms on the tundra. For a young chick outside of the nest, without adult protection,

even a rather moderate thunderstorm could be fatal. Therefore, we suggest that abrupt weather transitions on very hot days can cause additional chick mortality.

Previous observations of weather-induced mortality in raptors in the Arctic have been related to unusually long and cold storms in summer (Bradley et al. 1997). Photographic monitoring allowed us to document two cases of chick mortality associated with hot weather that was interrupted by short thunderstorms, which we infer to be the most likely cause of mortality in chicks that had left their nests (the case in 2009 was clearer than the one in 2008). It seems likely that small-bodied young chicks without protective feathers exposed to heavy rain storms and the associated drop in temperature are the most likely to succumb owing to hypothermia. It is also possible that such events are more common in years of low food abundance (i.e., low phase of the small rodent cycle) as parent birds may be spending more time finding prey than protecting the young from exposure to both hot and cold, rainy or windy weather. As young chicks are most likely to suffer from lack of protection during such conditions their losses could be erroneously attributed to siblicide if no direct observations of the nests are made. The two cases of scavenging in 2010 suggest that true siblicide can be inferred only when signs of aggression are documented.

To conclude, lack of food may be one of the main causes of nestling mortality of young chicks in nests of the rough-legged buzzard. However, one should not underestimate the importance of other sources of nestling mortality, especially when the cause of mortality can not be inferred from direct observations. Indeed, weather-induced nestling mortality due to a rapid change from unusually high temperatures to a thunderstorm may become even more important as the Arctic climate warms and heat waves become more frequent (Washington et al. 2009).

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