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SHORT REPORT

Diet and feeding of nestling Little Bitterns *Ixobrychus minutus* at fishponds: testing a new method for studying a difficult-to-monitor species

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ABSTRACT
Capsule: The diet and feeding of nestling Little Bitterns *Ixobrychus minutus* was studied using trail cameras. Little Bitterns nestlings were mostly provisioned with amphibians and small fish. They were fed in the morning and evening, but not during the night, and both parents provided similar amounts of food.

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The Little Bittern *Ixobrychus minutus* is a widespread and highly adaptive heron species, which shows great tolerance for occupying different natural and artificial habitats (Bauer & Glutz von Blotzheim 1966, Cramp & Simmons 1977). This sensitive reed bed species is included in the European Red List of Birds due to loss of wetland habitats and a large decrease in its population in many areas of west Europe (Voisin 1991, Kushlan & Hancock 2005, BirdLife International 2015). The European population size is estimated at 63 100–111 000 pairs (BirdLife International 2015). In Poland, the Little Bittern population size is estimated at 1000–1400 pairs, mostly in fishponds in the southern and eastern part of country (BirdLife International 2015, Flis 2016).

Little Bitterns specialize in feeding on littoral prey such as fish, amphibians and invertebrates (Cramp & Simmons 1977, Voisin 1991) and is active mostly in the morning, evening and at night (Kushlan & Hancock 2005). The diet of the Little Bittern has been well investigated on wetlands, natural reservoirs and river deltas (Dementiev & Gladkov 1951, Langley 1983, Holmes & Hatchwell 1991, Martínez-Abraín 1994, Kayser 2010, Pardo-Cervera *et al.* 2010, Samraoui *et al.* 2012), but has been poorly studied in artificial habitats such as fishponds (Melikyan 2008). Here, we present the results of a study of the diet of Little Bittern nestlings in a fishpond habitat. We also investigated changes in the amount and size of prey according to chick development, and the frequency of nest visits by feeding parents.

The study was conducted in 2013 (June–August) at the Stawy Małe fishpond complex (60 ha), situated in the Lasy Janowskie Landscape Park, SE Poland (50°60′N, 22°40′E). The area of eight ponds in the study complex varied from 3.3 to 19.5 ha. Common Carp *Cyprinus carpio* was the most abundant species reared in these fishponds (95% of biomass) (local fishponds manager pers. comm.). In 2013, eight to ten pairs of Little Bittern nested on these fishponds (A. Flis unpubl. data).

In many studies, the diet of herons has been quantified by assessing spontaneously regurgitated food samples (boluses) of nestlings (Polak 2007, Kim & Yoo 2012), because young herons usually eject food when they are disturbed (Voisin 1991, Kushlan & Hancock 2005). During our research (30 controls in 5 nests), the nestlings did not regurgitate boluses at all, so we tested a new method to identify their diet, using a high definition trail camera (SGN-6210 HD model without MMS module, lens $f = 3.1$, 32GB memory card and infra-red lamp 940 nm), which was camouflaged and placed approximately 60 cm from the nest. The memory card lasted for a minimum of three full days and was always changed together with batteries. The trail camera was set to start recording video for one minute, triggered by motion, and between trigger events it would enter sleep mode. Little Bittern nestlings leave the nest completely at 17–18 days after hatching (Cramp & Simmons 1977), but from day 13, they are mostly fed outside the nest (A. Flis, unpubl. data). Five nests were monitored and 129 hours 36 minutes of video were analysed. One nest was monitored from the start of hatching to day 13 and four nests were monitored on different days during the same period. Each day was divided into three different 5 hours periods, according to the daily activity of the Little Bittern: morning 05:00–10:00, evening 15:00–20:00 and night 22:00–03:00. Recorded prey were

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counted and assigned to a category: fish, amphibian, invertebrate or mammal. If it was possible, the prey was identified to species, however, some prey items (especially partially digested and small insects) were difficult to recognize. Prey size was estimated against the bill length of adult birds (culmen length approximately 50 mm), a common method in heron diet research (Bayer 1985), and divided into five classes: <0.5×, 0.5–1×, 1–1.5×, 1.5–2×, >2× of bill length. Methods of feeding nestlings (food on the nest floor, food into the beak) and size of prey items were compared for nestlings in four different age classes (1–3, 4–6, 7–9, 10–12 days after hatching). The number and frequency of feeding by both sexes were compared in three 12-day periods (morning, evening and night). To avoid confusion about double feeding by one parent in a short period of time, one feed was defined as one parent feeding chicks after another parent and/or one parent left the nest for at least 30 minutes and then returned to the nest with a new item of food.

A Kruskal–Wallis test was used to examine the relationship between the age of nestlings and prey size, and between the age of nestlings and the method of food delivery. Differences in the number of feeding events of both sexes were determined using a G test. The Mann–Whitney test was used to study differences in the frequency of nestlings feeding. The results were considered statistically significant when the probability of type I error was equal to or less than 0.05. Mean values were presented with a standard deviation (±sd). The statistical analysis was performed using Statistica 13.

A total of 394 prey items were distinguished, but only 264 were classified to the main prey categories. Amphibians (50.4%) and fish (46.2%) were the main components of the diet in the Lasy Janowskie fishponds. The amphibian species were represented by Common Frog *Rana temporaria* and water frogs *Pelophylax* spp. The most common fish prey was Common Carp (37.9%), which was probably related to the proportions of fish species reared in the ponds. In addition, three other fish species were identified in the diet: Perch *Perca fluviatilis* (4.1%), Roach *Rutilus rutilus* (3.4%) and Pike *Esox lucius* (0.8%). The diet of Little Bittern nestlings also included a small number of invertebrates (3%) such as dragonflies (Odonata), beetles (Dytyscidae), annelids (Hirudinae) and one mammal (0.4%), which was a Water Vole *Arvicola amphibious*. Moreover, adult birds were observed catching insects directly from the nest eight times during care of the chicks. It was also observed that a male Little Bittern ate a dead chick (two days old) from one brood.

The nestlings were mostly fed with two prey size classes: <0.5× (41.9%) and 0.5–1× (45.9%) of bill length. Other sizes of prey were delivered in small numbers (1–1.5× was 6.9%, 1.5–2× was 3.8%, >2× was 1.5% of bill length, respectively). The largest prey items in the diet were Roach and Water Vole (approximately 15 cm in total length). The number of prey items larger than 0.5–1× bill length increased with the age of nestlings, and only in these cases were the differences statistically significant (Table 1). The methods of feeding chicks changed according to their development and were related to the age of nestlings (Table 1).

Adult birds provided food to chicks only in the morning and evening periods. At night, one parent always stayed at the nest with young, and the adult bird and chicks slept. Nestlings tended to be fed more

Table 1. Distribution of size of prey items and mode of delivery, in relation to nestling age, in Little Bitterns.

	Age of nestlings (days)				Kruskal–Wallis test (n = 24)	
	1–3 (n = 6)	4–6 (n = 6)	7–9 (n = 6)	10–12 (n = 6)	H	P
Prey size classes in terms of bill length						
<0.5×	3.3 ± 2.1 (1–7)	3.8 ± 4.1 (0–11)	1.7 ± 1.2 (1–4)	3.3 ± 3.6 (0–9)	1.817	0.611
0.5–1×	6.7 ± 3.4 (4–13)	5.7 ± 3.6 (1–9)	5.3 ± 3.4 (2–12)	2.7 ± 2.0 (1–6)	5.353	0.148
1–1.5×	0.5 ± 0.5 (0–1)	0.2 ± 0.4 (0–1)	1.5 ± 1.0 (0–3)	1.8 ± 1.3 (0–4)	9.938	0.019
1.5–2×	0	0.2 ± 0.4 (0–1)	0.5 ± 0.8 (0–2)	1.2 ± 0.8 (0–2)	10.047	0.018
>2×	0	0	0.8 ± 0.8 (0–2)	0.2 ± 0.4 (0–1)	10.563	0.014
Method of chicks feeding						
Food on the nest floor	8.7 ± 2.7 (5–12)	6.2 ± 2.8 (1–9)	0.8 ± 1.6 (0–4)	0	18.778	<0.001
Food into the beak	1.8 ± 2.2 (0–5)	3.7 ± 3.3 (0–8)	9.0 ± 1.8 (6–11)	9.2 ± 2.6 (6–13)	15.920	0.001

Note: Mean values per nest are shown ±sd.

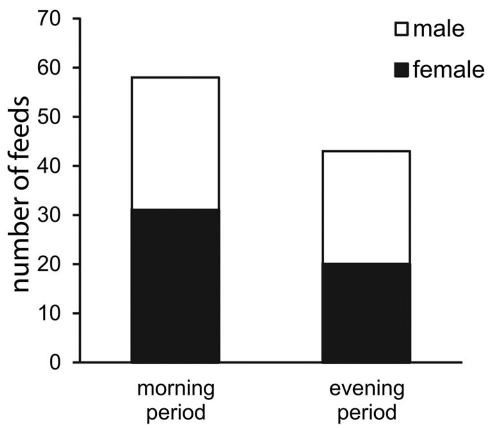

Figure 1. Mean share of provisioning visits by male and female Little Bitterns at five nests, for morning and evening time periods. Values are mean number of feeds per nest over a 12-day period.

frequently in the morning than in the evening (Figure 1), but the difference was not significant ($G = 2.236$, $df = 1$, $P = 0.135$). Mean feeding rate in the morning was $1\ h^{-1} \pm 0.2$ ($n = 58$) and in the evening was $0.7\ h^{-1} \pm 0.3$ ($n = 43$). Times between each feeding event in the morning and evening were similar (mean $= 45.7 \pm 32.1$ minutes, $n = 46$, and mean $= 56 \pm 34.5$ minutes, $n = 31$, respectively), and not significantly different ($Z = -1.397$, $P = 0.162$, $n = 77$). Both sexes fed the nestlings (Figure 1), and no differences in feeding rates were found between provisioning rates of the sexes in the morning ($G = 0.276$, $df = 1$, $P = 0.599$) nor in the evening ($G = 0.209$, $df = 1$, $P = 0.647$).

Little Bittern diet is varied, but fish and amphibians are the most common prey delivered to nestlings during the breeding season in different habitats (Holmes & Hatchwell 1991, Kayser 2010, Samraoui *et al.* 2012). Kim & Yoo (2012) found similar results in a study of Yellow Bitterns *Ixobrychus sinensis* in artificial wetlands of South Korea, where fish were the most important prey item during the nestling rearing period. Polak (2007) showed that Carp were the dominant fish species in the diet of nestling Great Bitterns *Botaurus stellaris* on fishponds in eastern Poland. For Little Bittern, previous studies have shown that invertebrates are often taken in large numbers and provided to nestlings, but probably only in short periods during the breeding season (Kushlan & Hancock 2005). Other prey, such as mammals, have been recorded in small numbers (Voisin 1991) and previous record reported the remains of an undetermined mammal species in a Little Bittern stomach in Hungary (Vasvári 1929) but this paper presents the first confirmed Water Vole recorded in the Little Bittern diet. Cases of dead young being consumed by other siblings or parents are known for other heron species (Kushlan & Hancock 2005, Polak 2007), but for this has not previously been recorded in the Little Bittern.

The most frequent prey size class delivered to the Little Bittern nestlings was a maximum 1× of bill length or approximately 50 mm in length. Prey items larger than twice the bill length (over 100 mm) were very rare in the nestlings' diet, and such prey was mostly left on the nest floor and swallowed again by adult birds. In our study, we showed that some prey size classes were related to the age of nestlings, but Kim & Yoo's (2012) study of the diet of Yellow Bittern nestlings, using regurgitated boluses, showed that fish size was not related to the age of chicks.

During our study, the nestlings were fed in the morning and evening, but not at night. Fazili *et al.* (2010) studied the partially sedentary population of Little Bittern in wetlands in Kashmir, India, and showed a similar twice daily peak of nestling feeding. The feeding rates of both parents were similar in each time period. Langley (1983) studied the Little Bittern subspecies *Ixobrychus minutus payesii* in South Africa and showed only small differences in feeding rates, with females feeding nestlings slightly more frequently than did males. Our cameras revealed that, at night, there was no feeding and one parent and the nestlings were completely inactive in the nest. We do not know what the second parent was doing during this time.

The use of a trail camera in our research provided a useful method to study the nest provisioning behaviour and nestling diet of the Little Bittern. On the other hand, even the best trail camera is not a perfect solution for studying heron diets because of the problems in identifying small prey items such as invertebrates. In that case, our results do not allow us to draw objective conclusions but as the chicks in our study did not regurgitate boluses which is typical in other heron species, the trail cameras provide an alternative opportunity to at least gather some useful data. In species where boluses can be collected, the combination of data could provide useful calibration of the methods and add value to the monitoring of diet and behaviour of otherwise cryptic species. Estimating the missing prey items that are unidentified in the trail camera work could be made by analysis of a small number of boluses from nests monitored by cameras.

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