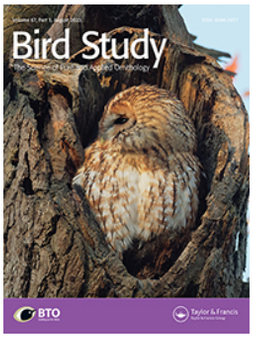

Bird Study

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/tbis20

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To cite this article: Adam Flis, Robert Gwiazda & Wojciech Krztoń (2020) Sex differences in Little Bittern *Ixobrychus m. minutus* parental care: a pilot study, Bird Study, 67:3, 393-397, DOI: 10.1080/00063657.2020.1863334

To link to this article: https://doi.org/10.1080/00063657.2020.1863334

Published online: 21 Jan 2021.

BIRD STUDY
2020, VOL. 67, NO. 3, 393–397
https://doi.org/10.1080/00063657.2020.1863334

SHORT REPORT

Sex differences in Little Bittern *Ixobrychus m. minutus* parental care: a pilot study

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ABSTRACT
We present preliminary results on the sexual differences in Little Bittern *Ixobrychus m. minutus* parental activities during the pre-hatching and post-hatching phases. Both sexes were engaged in all nest attendance activities, but not in equal proportions.

ARTICLE HISTORY
Received 5 July 2020
Accepted 16 September 2020

In herons (family Ardeidae), pair bonds range from the most common monogamy, to opportunistic promiscuity and polygamy in a few species (Kushlan & Hancock 2005). The general pattern of parental care for the majority of monogamous heron species breeding in a colony is that both sexes participate in nest building, incubating eggs, care of nestlings, and sharing of feeding duties (Voisin 1991). Sexual differences in these fundamental parental activities depend mostly on the breeding strategies of particular species, and if they exist, they may vary with time of day and between different phases of breeding (Kushlan & Hancock 2005). From over 60 heron species, the various aspects of the sex differences in parental care activities have been studied only by visual observations from hides for a few species (Weller 1961, Werschkul 1982, van Vessem & Draulans 1986, Fujioka 1989, McKilligan 1991, Kushlan & Hancock 2005), including the two subspecies of Little Bittern *Ixobrychus minutus* (Groebbels 1935, Langley 1983).

The Little Bittern nominate subspecies *I. m. minutus* is a very secretive bird with a predominantly crepuscular and nocturnal activity pattern (Voisin 1991). It is a territorial species inhabiting areas of dense marsh vegetation, which makes it very difficult to study (Kushlan & Hancock 2005). The Little Bittern is a monogamous and non-typical heron, because it is a non-colonial nesting species that breeds mainly solitarily (Voisin 1991). Furthermore, the Little Bittern has an unusual mating strategy that distinguishes it from other heron species, where the male can build two nest types during courtship displays (Flis 2016). Moreover, it belongs to a group of 'small bitterns' which exhibit strong sexual dimorphism in plumage (the female has more cryptic and dull plumage than the male), whereas other heron species generally have no visible differences between the sexes (Kushlan & Hancock 2005).

In this paper, we present the preliminary results of a study of the sex differences in Little Bittern parental care during the pre- and post-hatch phases using a method based on camera trapping. Based on what we already know about Little Bittern breeding biology, we predicted that some nest attendance activities would be mainly carried out the males or females, while other tasks would be more equally divided between the parents. We hypothesized that (1) males would be more engaged in territory defence, mate guarding and nest-site improvement; (2) females would be more involved with incubating eggs and brooding the chicks, and (3) the sexes would feed nestlings equally.

The material for this study was gathered during the breeding season of 2013 (June–August) at the Stawy Małe fishpond complex, situated in the Lasy Janowskie Landscape Park, SE Poland (50°60'N, 22°40'E). For a detailed description of the study area, see Flis (2016).

The sampling methodology for determining the sex differences in parental care was based on the tested method using a high definition camera trap, which was camouflaged and placed near the nest (Flis & Gwiazda 2018). The camera trap used infrared light and was set to start recording video for one minute when triggered by a motion detector. Between triggering events the camera entered a 'sleep mode'. We assumed that each one-minute recording event could be treated independently. All other settings of the camera trap followed the methods in Flis &

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Gwiazda (2018). Four different nests were monitored: two with seven eggs in each nest in the pre-hatch phase, and two with five chicks in each nest in the post-hatch phase. A total of 118 h and 31 min of video were recorded (7111 minute sessions) for analysis. The nest attendance activities were compared between sexes in four two-day periods in the pre-hatch phase (1–2, 5–6, 10–11, 15–16 days before hatching), and in three two-day periods in the post-hatch phase (1–2, 5–6, 10–11 days after hatching). The incubation period of the Little Bittern lasts 16–20 days (Kushlan & Hancock 2005) and the nestlings leave the nest completely at 17–18 days (Voisin 1991), but from day 13 they spend most of their time outside the nest (A. Flis unpubl. data). Recordings from two-day study periods were further divided into one of three 5 h time periods, according to the daily activity of the birds: morning (M) 05:00–10:00, evening (E) 15:00–20:00, and night (N) 22:00–03:00. We selected four nest attendance activities: egg incubation, care of chicks (brooding and guarding), feeding of nestlings, and nest-site improvement. Each minute recording was analysed and the occurrence of parental activities was recorded (score 0 or 1) in the particular two-day periods in the breeding phases. Each nest attendance activity was assigned to one sex only once in minute recording.

To examine the sex differences in Little Bittern parental care we used generalized linear mixed-effects models (GLMMs) using the package *lme4* (Bates *et al.* 2015) in R v.3.4.3 (R Core Team 2017). Predicted values were each of the four parental care activities: egg incubation and nest-site improvement before hatching (pre-hatch phase), and care of chicks, feeding of nestlings, and nest-site improvement after hatching (post-hatch phase). As a predictor we used 'period' which represents time before and after hatching, and 'sex' which was a categorical variable. We also included an interaction of both these predictors to examine if the sex differences between parental care changed in time before and after hatching. The categorical variable of 'nest' was used as a random effect to exclude the sex differences in parental care among the four studied pairs. We used a Poisson distribution model because the data were counts of incidents in a period of time. The results were considered to be statistically significant when the probability of type I error was equal to or less than 0.05.

Males and females participated in all studied nest attendance activities. The GLMMs showed differences in the egg incubation behaviour between the sexes (Table 1). Female participation was lower at the beginning of the studied period, but increasing closer to hatching. The opposite situation occurred in the male engagement in this activity, which was higher at the beginning of the studied period, but decreasing closer to the hatching. In the pre-hatch phase, the male participation in nest-site improvement was higher than that of the female at the beginning of the period (Table 1). The time that both sexes spent on this nest attendance activity decreased as the time of hatching approached. At the beginning of the post-hatching phase, the females were engaged more than males in the care of chicks (Table 1). The analysis also showed that time spent by the females on care of nestlings decreasing over time, while time spent by males increased. We did not find any sex differences in participation in the nest-site improvement and feeding of nestlings in the post-hatch phase (Table 1).

Both parents showed similar engagement in egg incubation during the night period, but during the morning and evening periods the female was more engaged in this activity (Figure 1). Neither sex spent time improving the nest-site during the night period in the pre-hatch phase (Figure 1). Time spent on this nest maintenance activity by the males and females during the morning and evening periods was nearly equal. In the post-hatch phase, the male engagement

Table 1. Generalized linear mixed-effects models used to explain variation in nest attendance activities between female and male Little Bitterns in the pre-hatch and post-hatch phases.

	Estimate	Standard error	*Z*-value	*P*-value
Pre-hatch phase				
Egg incubation				
Intercept[a]	3.811	0.064	59.640	**<0.001**
Period	0.181	0.022	8.320	**<0.001**
Male[b]	0.936	0.089	10.560	**<0.001**
Period:Male	−0.516	0.034	−15.170	**<0.001**
Nest-site improvement				
Intercept[a]	2.172	0.193	11.230	**<0.001**
Period	−0.165	0.076	−2.168	**<0.050**
Male[b]	1.578	0.238	6.634	**<0.001**
Period:Male	−0.541	0.104	−5.214	**<0.001**
Post-hatch phase				
Care of chicks				
Intercept[a]	4.989	0.077	64.590	**<0.001**
Period	−0.223	0.030	−7.460	**<0.001**
Male[b]	−0.732	0.087	−8.380	**<0.001**
Period:Male	0.448	0.041	11.030	**<0.001**
Nest-site improvement				
Intercept[a]	1.446	0.326	4.433	**<0.001**
Period	0.107	0.124	0.866	0.386
Male[b]	0.290	0.357	0.811	0.417
Period:Male	0.071	0.159	0.447	0.655
Feeding of nestlings				
Intercept[a]	1.941	0.229	8.479	**<0.001**
Period	0.044	0.105	0.418	0.676
Male[b]	0.005	0.327	0.015	0.988
Period:Male	−0.032	0.150	−0.214	0.830

Note: Values that are statistically significantly different are shown in bold type.
[a]Intercept: female nest activity at the beginning of phase.
[b]Male nest activity at the beginning of phase.

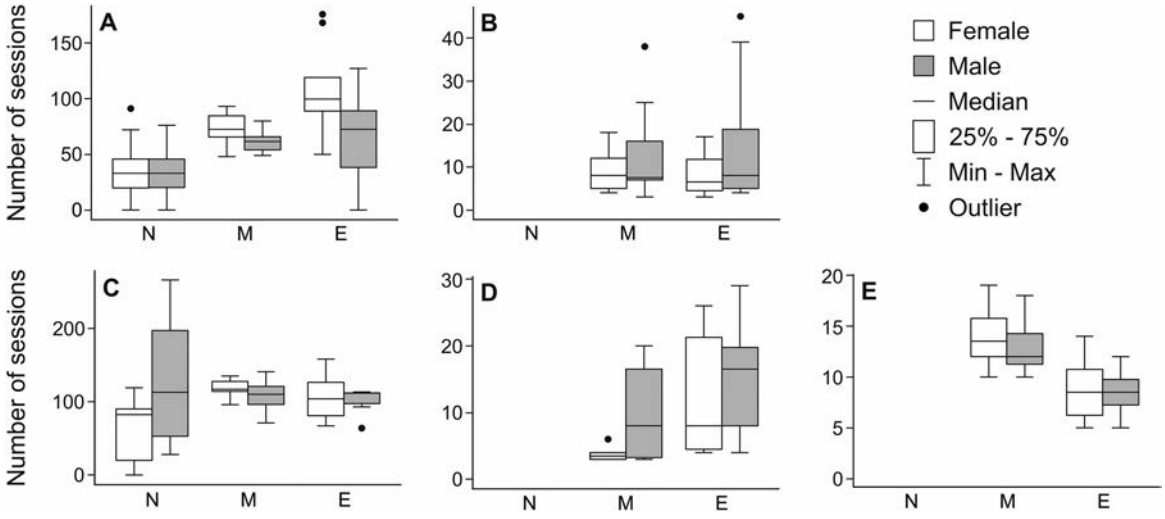

Figure 1. Comparison of female and male Little Bitterns for nest attendance activities in the daily activity periods (night (N), morning (M), evening (E)) in the pre-hatch phase: egg incubation (A), nest-site improvement (B), and in the post-hatch phase: care of chicks (C), nest-site improvement (D), and feeding of nestlings (E). Number of sessions refers to the one-minute recorded bouts of behaviour from the camera trap.

in care of chicks was significantly higher during the night period (Figure 1). In the morning and evening periods, the male and female participation in this activity was similar. In the post-hatch phase, neither parent spent time improving the nest-site during the night period (Figure 1). The male engagement in this nest activity was higher in the morning and evening periods. Both sexes did not feed the chicks during the night period (Figure 1). Adults provided food to nestlings only in the morning and evening periods, and the sexes did not differ in their provisioning effort.

In this paper, we present data on parental activities of Little Bitterns for both day and night, and for the incubation and chick-rearing periods. Previous research on this elusive species was based only on irregular observations during the day (Groebbels 1935, Langley 1983). We also realise that our data have deficiencies (a small number of studied breeding pairs), and should be treated with caution when considering the general pattern of the sex differences in Little Bittern parental care, but such data are rare and important enough to compare them with the nest attendance activities of other herons.

Both sexes of Little Bittern incubated the eggs, with slightly higher engagement of the female, which confirms our hypothesis. A very similar behaviour has been observed in the Little Bittern from previous studies (Voisin 1991) and in the Little Bittern subspecies *Ixobrychus minutus payesii* (hereafter *payesii*; Langley 1983). In the closely related Least Bittern *Ixobrychus exilis* the female also spends more time on this nest activity (Weller 1961). In this case the female cryptic plumage is an effective defence, and the sex that shows a more dull plumage often spends more time incubating, especially during daytime hours. However, in the larger heron species, such as Grey Heron *Ardea cinerea* or Intermediate Egret *Egretta intermedia plutnifera*, both parents also take part in the incubation, but the male is more engaged in this activity (van Vessem & Draulans 1986, McKilligan 1991). It appears that the prediction of nearly equal parental investment in egg incubation by both sexes is supported for most of the studied herons, except the genus *Botaurus* (Kushlan & Hancock 2005).

The Little Bittern is a territorial species, where the male chases off all other males from the occupied breeding territory (Voisin 1991). We found that male participation in egg incubation was greater than that of the female at the beginning of pre-hatch phase, which can suggest less engagement in the territory defence after egg laying. It seems that the breeding male during this period is more focused on guarding and defending only the nest site than the whole area of its breeding territory, which is very similar to the behaviour of colonial herons (Kushlan & Hancock 2005). This could explain how, in favourable habitat conditions, Little Bitterns can breed in loose or semi-colonies, where nests are very close to each other (Flis 2016).

Both parents were engaged in care of chicks, but the female participated more in this activity at the beginning of the post-hatch phase. Langley (1983) found a similar behavioural pattern in *payesii*. Conversely, male Grey Herons spent more time on nest

attendance than the females when small chicks were present (van Vessem & Draulans 1986). Such behaviour is common in colonial herons, where the males are still focused on nest guarding after hatching (Werschkul 1982, McKilligan 1991). Fujioka (1989) showed that male Little Egrets *Egretta garzetta* attended their nestlings slightly longer than females in the daytime. We did not observe any sex-related differences in this nest activity in daytime (morning and evening periods), however, during the night period the male participation was greater in the care of nestlings. Moreover, male engagement in egg incubation was also high during the night period. One explanation for this might be that the cryptic plumage of females gives greater advantages of concealment during daylight hours, so males may take on more of the incubation role during the night because the risk of predation by visual hunting predators is lower in the dark.

Both sexes of Little Bittern fed the nestlings similarly to rates found during our previous work (Flis & Gwiazda 2018), in which we did not find any sex differences in this breeding activity. For comparison, Fujioka (1989) and McKilligan (1991) also did not find sex differences in nestling feeding frequency of Little Egrets and Intermediate Egrets. However, Langley (1983) showed that females of *payesii* fed nestlings more frequently than did the males. On the other hand, Weller (1961) found that the males in Least Bittern fed the young more often than did the females. The Little Bittern is active during the day and at night (Kushlan & Hancock 2005), but unexpectedly the chicks were not fed during the night period. Langley (1983) also found low nest activity during the night by *payesii* adults. In our study, only one parent spent the whole night with nestlings in the nest, while the second parent was not present, and its activity remained unknown. It could have been foraging, as many other herons do at night (Voisin 1991), but this behaviour was not recorded.

Most herons start to construct a nest platform when the breeding pair is formed, and the male is more engaged in nest building in the pre-laying period (Kushlan & Hancock 2005). The Little Bittern differs in this aspect from the behaviour of other herons because the male starts to build a nest alone during the display period (Voisin 1991). After pair formation, both sexes finish building the nest, and after egg laying both sexes also are engaged in the nest-site improvement. In our research the male took the lead in this nest activity in both the breeding phases, especially at the beginning of pre-hatch phase. Langley (1983) also found that the *payesii* males did considerably more nest maintenance than the female during egg incubation. According to Weller (1961), the Least Bittern males also performed nest-site improvement more often during the incubation period. Both *Ixobrychus* species usually build their nests in emergent vegetation, which is very susceptible to weather damage, especially strong winds. The structure of such nests is very fragile and they must regularly be improved during the incubation and chick-rearing periods (Weller 1961, Flis 2016). On the other hand, there is little information about this nest maintenance activity performed by other herons, possibly because the nests of colonial species situated on trees are more stable and they do not require frequent repairs.

In conclusion, the sex differences in Little Bittern parental activities differ only in some aspects from other monogamous heron species. Perhaps the differences arise from sex-related differences in foraging ecology. Our study did not confirm male activity in territory defence or greater female participation in care of chicks. More research is needed to explain the cause of differences in male and female parental activity at different times of day and night.

Acknowledgements

We would like to acknowledge the associate editor and anonymous reviewer for very important and helpful comments which only improves this manuscript. We would also like to thank Agata Flis for assistance with the field work. We greatly appreciate the cooperation of local fish farmers. The research methods meet all ethical guidelines and were carried out under permission of the Local Ethics Committee and General Directorate for Environmental Protection in full compliance with current Polish law.

Funding

This research was supported by statutory funds of the Institute of Nature Conservation, Polish Academy of Sciences.

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