Nest-Site Selection and Nest Predation in the Great Bittern Botaurus stellaris Population in Eastern Poland

Author: Polak, Marcin

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Nest-site selection and nest predation in the Great Bittern *Botaurus stellaris* population in eastern Poland

Marcin Polak[1]

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This study analyses the effects of nest-site selection on predation risk of Great Bittern *Botaurus stellaris* nests. The study was conducted in fishponds of eastern Poland during four breeding seasons (2003–06). The habitat characteristics of 84 nest sites were investigated. Nesting sites were found within *Phragmites, Typha, Carex* and *Scirpus* vegetation in the reed belt surrounding the fishponds. All nests were built at places having between 10 and 97 cm of water depth. Predation was the major cause of nest failure in the study population. However, no relationship between nest site vegetation type and daily nest survival rate was found. The survival of nests at edges and in the interior of reed beds was similar. A logistic regression model indicated significant effects of water depth and vegetation cover on nest predation in the Bittern population. There was a tendency towards better success for nests in dense emergent vegetation with higher water depth. The results have important implications for an effective conservation strategy for wetlands holding large and viable populations of this vulnerable species.

Key words: Great Bittern, *Botaurus stellaris*, predation, water depth, conservation biology, habitat selection

[1]Department of Nature Conservation, Institute of Biology, Maria Curie-Skłodowska University, Akademicka 19, 20-033 Lublin, Poland (mpolak@hektor.umcs.lublin.pl)

INTRODUCTION

The Great Bittern *Botaurus stellaris* is a non-colonial heron which breeds almost exclusively in flooded emergent vegetation in littoral eutrophic lakes, fishponds, river valleys, fen mires and other wetlands (Voisin 1991). Recently it has been shown to be well adapted to large variations in habitat availability (Puglisi & Bretagnolle 2005, Poulin *et al.* 2005, V. Bretagnolle *et al.* unpubl. data). The Bittern is an eclectic species, requiring relatively large reed beds, reed mace, rice, saw-sedge or bulrush in the first stage of succession and rich in food resources such as fish, crustaceans, amphibians and insects (Cramp & Simmons 1977, Alessandria *et al.* 2003, Gilbert *et al.* 2003, Puglisi & Bretagnolle 2005). Following the decline of reed beds in Europe in recent decades, the Bittern has been given a high conservation status in Europe (BirdLife International 2004). In Poland, the species is widespread with a marked population increase in the second half of the 1980s. The population in Poland has recently been estimated at 4100–4800 booming males (Dombrowski 2004).

Habitat choice is likely to vary regionally due to geographical variation in available vegetation and predation pressure. Quantitative data on habitat requirements and factors driving nest predation of Bitterns are limited to studies in Italy, England and France (Adamo *et al.* 2004, Gilbert *et al.* 2005a, Gilbert *et al.* 2005b, Poulin *et al.* 2005, Puglisi *et al.* 2005), with little or no information from the central distributional range (Eastern Europe) where the species is more likely to meet optimal habitat conditions (Adamo *et al.* 2004). These data are sorely required if we intend to propose an effective conservation strategy for wetlands holding large and viable populations of this vulnerable species.

The mating system of Bitterns differs from other north-temperate herons in that the female builds the nest, incubates the eggs and feeds her brood alone (Cramp & Simmons 1977, Voisin 1991). This mating strategy may affect the natural predation rate in Bitterns. In this paper I address the following questions: (1) Which vegetation types are chosen for nesting, and (2) Does microhabitat choice influence predation risk?

METHODS

Study site

In Poland, fishponds, eutrophic natural lakes and flooded river valleys are the most important breeding habitats for Bitterns (Dombrowski 2004). This study was carried out in 2003–06 at the fishponds of Samoklęski, Garbów, Kraśnik, Uścimów, Czesławice, Niedrzwica, Piaski, Chodel, Opole Lubelskie and Antopol located in the Lublin region, eastern Poland (50°55'–51°29'N; 21°58'–22°54'E; Fig. 1). Fishponds varied in size from 14 to 185.5 ha and were partially covered (range from 0 to 90%) by vegetation stands dominated by Common Reed *Phragmites australis*, Reed Mace *Typha angustifolia* and sedges *Carex* sp. (Fig. 2). Maximum water depth in emergent vegetations varied from 0 to 120 cm. Fish-rearing mostly involved Common Carp *Cyprinus carpio* (95–100% in biomass), and was characterised by extensive management with occasional reed cutting.

Figure 1. Map of the study area showing the distribution of fishponds complexes: 1 - Uścimów, 2 - Samoklęski, 3 - Garbów, 4 - Czesławice, 5 - Antopol, 6 - Niedrzwica, 7 - Piaski, 8 - Opole Lubelskie, 9 - Chodel, 10 - Kraśnik.

Vegetation and water depth sampling

During each field visit, locations of booming males were plotted on 1:5000 maps. Particular attention was paid to recording positions of simultaneously calling birds on a cumulative map; booming areas of each individual male were delineated by use of Minimum Convex Polygons (Kenward 1987). Males occupied small, isolated patches of reed belt surrounding the fishponds, ranging in size from 2.1 to 9 ha (see map in Polak 2006). Nests were located by systematic walking across emergent vegetation. Special attention was paid to searching nests with-in or near booming areas of males. Most nests were found in the incubation period

Figure 2. A typical nesting habitat of Great Bittern on 'Wydra' pond (3.3 ha), Samoklęski Common Carp fishpond complex, eastern Poland (photo M. Polak). The emergent vegetation surrounding the open water pools is dominated by Common Reed and Reed Mace.

(55 nests), the egg laying period (24) and the nestling period (5). All 84 active nests were further visited at least once a week from the end of April to early July to get data on egg-laying, clutch size, hatching date and productivity (mean 4 controls, range 1–9). To reduce the impact of nest visits on predation risk, the number of controls was reduced to a minimum, especially in the incubation stage. In order to estimate observer effect, I compared the daily survival rate (see Data analysis) between highly disturbed (2–4 visits during incubation) and disturbed (one visit) nests. Survival rate of disturbed (97.68 ± 0.006%) and highly disturbed nests (98.71 ± 0.004%) did not differ statistically ($Z = 1.536$, $P = 0.124$).

Laying dates were determined from direct observation (28.6% of the nests) or indirectly by estimating the hatching date of the oldest nestling, assuming an incubation period of 25–26 days (Cramp & Simmons 1977, Mallord *et al.* 2000, Demongin *et al.* 2007). In six cases it was impossible to determine the date of laying. Micro-habitat selection of nest sites was assessed by measuring vegetation features and water level on 2 x 2 m plots centred on nests. The methodology was slightly different from that used in England (Tyler *et al.* 1998) and consisted of measuring habitat variables within a plot (Table 1). All measurements were taken in the early incubation period (from late April to late May). Distances of nests to

Table 1. Habitat variables used to characterise Bittern nest sites in the Lublin region. Group 1 refers to measures taken at each nest. Variables of group 2 were measured at nests in reed beds.

Group	Code	Description
1	WATER DEPTH	Estimated water depth (cm) at the centre of the plot with 1-cm precision
	% COVER	% cover of vegetation (*Phragmites, Typha, Carex, Scirpus*) in 4 m^2 by 20% categories
	DISTOW	Distance (m) to open water
	DISTTER	Distance (m) to nearest terrestrial habitat
2	MEAN STEM HEIGHT	Mean height of 5 dry flowering reed stems chosen randomly with 10-cm precision
	MEAN STEM DIAMETER	Mean diameter of 10 reed stems chosen randomly with precision of 0.1 mm (by calliper)
	OLD STEMS DENSITY	Number of dry stems within a 50x50 cm quadrat
	NEW STEMS DENSITY	Number of green stems within a 50x50 cm quadrat
	FLOWER	Number of flowering stems out of 50 stems selected at random within the plot

open water and the nearest terrestrial habitat (mainly dams) were estimated at 1-m intervals by using a measuring tape.

Data analysis

Nest survival was estimated with the Mayfield method (Mayfield 1975). Comparisons of daily survival rates *DSR* (= 1 – daily predation rate) and calculations of confidence intervals for Mayfield's maximum likelihood estimators followed Johnson (1979). Statistical analyses were performed with a Mann-Whitney test. A stepwise logistic regression model was used to estimate the effect of habitat variables on the probability of predation. Nest fate (predation - 0, successful - 1) was chosen as the dependent variable, and water depth, vegetation cover, distance to open water and terrestrial habitat as the independent variables. For nests in reed (n = 65), logistic regression analysis was also used to estimate the effect of reed characteristics (see Table 1: Group 2) on nest fate (predation/success). All variables were tested for autocorrelation, before being entered into a regression model. Nests were defined as being successful when at least one young had survived up to 7 days old. All nests were divided into two categories: placed at the edge (6–30 m from the nearest terrestrial habitat), and interior (>30 m) of emergent vegetation. Three possible replacement clutches were excluded from the analysis of nest survival during the breeding season (Dmitrenok *et al.* 2005). Unless otherwise stated, means are reported ± SD. Statistical computations were performed using STATISTICA 6.0, Statsoft Inc. 2001 package.

RESULTS

Nesting habitat

Five vegetation types were distinguished within a radius of 20 m around nests: (1) pure Reed beds *Phragmites australis* (48 nests, 57.1%), (2) pure stands of Reed Mace *Typha angustifolia* (17 nests, 20.2%), (3) mixed stands of *Typha/Phragmites* (13 nests, 15.5%), (4) mixed stands of *Phragmites/Carex* (5 nests, 6.0%), and (5) mixed stands of *Scirpus/Typha* (1 nest, 1.2%). Egg laying started in pure reed sites (median laying date of first egg was 1 May, n = 45), and three days later in pure reed mace habitats (median date was 4 May, n = 16); however, the difference was not significant (Mann-Whitney test, $Z = -0.230$, $P = 0.999$). Bitterns nested on average 21.3 ± 17.3 m (6–100, n = 84) from the nearest terrestrial habitat (Fig. 3A), and 22.3 ± 13.8 m (4–70, n = 84) from open water (Fig. 3B). Sixty-six nests (78.6%) were localised in

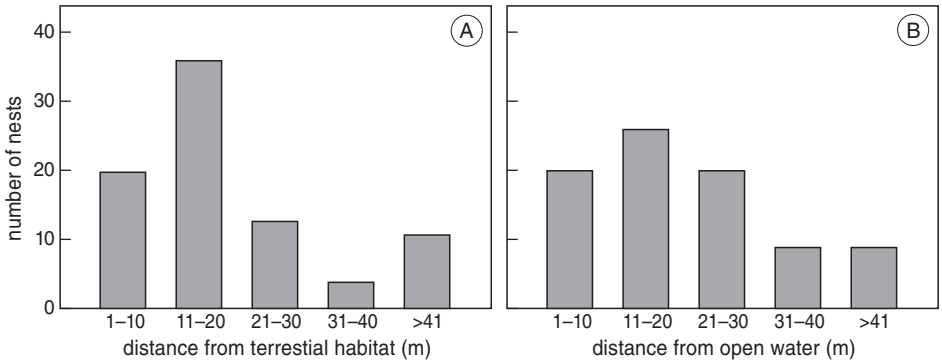

Figure 3. Location of nests in relation to the nearest terrestrial habitat (A) and open water (B) at the study site.

the 30 m wide vegetation belt adjacent to open water. Water depth at nest sites during egg-laying varied from 10 to 97 cm, with a mean of 44.7 ± 18.2 cm (n = 84).

Nest material and characteristics

Nests from previous years were not used by females; each year new nests were built. Four plant species (*Phragmites australis, Typha angustifolia, Scirpus lacustris, Carex* sp.) were used for nest building. Fifty-one nests were built from *Phragmites* material, 17 nests from *Typha*, 14 from mixed *Phragmites/Typha*, 1 nest from mixed *Phragmites/Carex* and 1 nest from *Scirpus*. Length and width of 84 nests were respectively 52.0 ± 7.7 cm (37–80) and 41.8 ± 6.1 cm (25–62). Nests were built on average 13.0 ± 5.6 cm (5–30) above the water at the early incubation stage. In four cases females built additional platforms during the late nestling period, on average 2.1 ± 1.3 m away from the main nests, possibly in response to damage inflicted on vegetation growing around nests.

Factors affecting nest predation

Predation was not directly witnessed during nest visits, but a total of 23 nests were found depredated: 3 nests in 2003, 13 in 2004, 6 in 2005 and 12 in 2006. In 13 cases, eggs or young had disappeared and in 22 cases eggshell or nestling remains were found. Two adult females were killed by predators, the first was predated on the nest during the incubation period, the second was found decapitated 40 m from her nest during the nestling stage (all five nestlings died of starvation).

The logistic regression tested the hypothesis that nest success was independent of water depth, vegetation cover, distance to open water and terrestrial habitat. The only significant variables entering the model were water depth and vegetation cover (Table 2). All nests that were located over water deeper than 70 cm were successful (Fig. 4). For reed characteristics none of the variables were significant within the logistic regression model. The daily survival rates of nests located in *Typha* (98.50%, SE 0.01, n = 17) and *Phragmites* (97.70%, SE 0.01, n = 48) nest sites were similar (Z = 1.019, P = 0.308). The daily survival rate of nests did not differ throughout the breeding season: 98.5% in 12–22 April, 98.6% in 23 April – 2 May, 97.7% in 3–12 May, 97.9% in 13–22 May (χ^2

Table 2. Probability of nest success in Bittern explained by habitat variables (forward stepwise logistic regression). Only significant parameters are shown.

Variable	Estimate	SE	Wald χ^2	P
Constant	–3.572	1.238	8.317	0.004
WATER DEPTH	0.051	0.016	9.887	0.002
% COVER	0.347	0.167	4.325	0.038

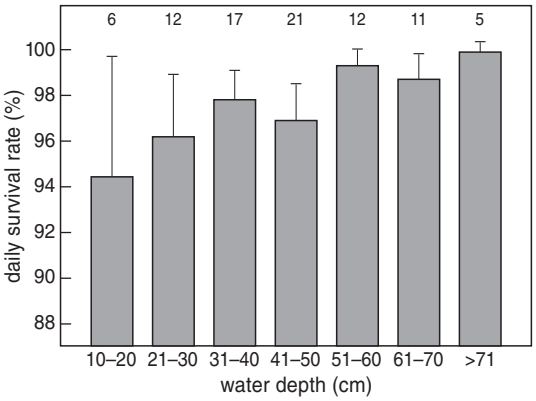

Figure 4. Daily nest survival rate (with 95% confidence limits) in relation to water depth. Numbers above bars indicate sample size.

= 0.0063, $df = 3$, $P = 0.999$). Nest predation was not different for 'edge nests' (*DSR* 97.77%, SE 0.01, $n = 69$) as compared with 'interior nests' (98.85%, SE 0.01, $n = 15$, $Z = 1.558$, $P = 0.119$).

DISCUSSION

Predation was the major cause of nest failure in the present Bittern population. Potential predators of Bittern broods in the Lublin region are Otter *Lutra lutra*, Red Fox *Vulpes vulpes*, American Mink *Mustela vison*, Raccoon Dog *Nyctereutes procyonoides*, Eurasian Marsh Harrier *Circus aeruginosus* and Common Magpie *Pica pica*. Which part of the predation can be attributed to each of these predators is, however, unknown. Since the 1990s, the impact of these predators on bird populations has markedly increased in Poland (Tryjanowski *et al.* 2002, Gromadzki 2004, Panek 2005). Monitoring changes in Bittern reproductive success in the face of increasing predator numbers will be a conservation priority for this species in Poland.

Studies carried out in wetland habitats showed that nest predation was significantly higher in edge habitats (review in Caro 2005). It is possible that the lack of edge effect on nest predation in the present study was due to the small size of vegetation patches used for nesting, i.e. essentially representing edge habitats only (0.5–4 ha, M. Polak. unpubl. data). To prevent penetration of habitat interiors by predators, reed beds larger than 13 ha are deemed necessary (Báldi & Batáry 2005).

Dense vegetation and increased structural heterogeneity can affect habitat choice by reducing risk of predation in aquatic ecosystems (Martin 1993, Kristiansen 1998, Graveland 1999). These studies would suggest that vegetation structure and vegetation density should play an important role in nest site choice of female Bitterns, providing cover and improving nest survival. However, predation rate was not influenced by reed stem size or density.

The results of this study have serious implications for the conservation and management of Great Bittern populations, because the presence of deep water was associated with high daily survival rates of Bittern nests, possibly reducing nest accessibility by terrestrial predators. Additionally, female Bitterns depend on food resources near nests associated with water; fluctuations in water level may therefore influence reproduction by affecting availability and abundance of these food resources (Adamo *et al.* 2004, Poulin *et al.* 2005, Polak 2006). It has been suggested earlier that the presence of deep water is an important barrier to nest predation in Bitterns (Adamo *et al.* 2004, Gilbert *et al.* 2005a) and other wetland birds (Honza *et al.* 1998, Sanchez-Lafuente *et al.* 1998, Barbraud *et al.* 2002, Hoover 2006). The maintenance of suitable and stable wet emergent vegetation is crucial for breeding Bitterns. The question arises as to why not all female Bitterns breed in deep water sites in the study area. Fishponds are ecosystems with an unstable hydrologic regime (like other wetlands, especially flooded river valleys). In some regions in Poland water deficits occur and ponds remain unfilled; only 56% of all ponds are sufficiently water-filled to be suitable as breeding habitat (Dobrowolski 1995). Moreover, pond-emptying as part of fish management is an important threat during the breeding season. Normally, in fishponds and natural wetlands the

highest water level occurs in early spring, then declines slowly due to lack of water supply until water depth around nests is very low during the nestling period and predation risks increase due to higher accessibility and a decline in nest attendance by the female that starts foraging far from the nest. The latter has been assumed to conflict with the time needed for guarding and defending nestlings against predators (Martin 1992). Another anti-predator adaptation is that Bittern chicks may leave the nest early in their life and escape potential predators by walking on reed stems (Demongin *et al.* 2007).

In conclusion, habitat management and conservation actions that attempt to stop or reverse these negative hydrological processes will be especially beneficial to protect Bittern populations breeding in wetlands.

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SAMENVATTING

De Roerdomp *Botaurus stellaris* mag zich het laatste decennium in een levendige belangstelling verheugen, vooral in Groot-Brittannië, Frankrijk en Italië. Als echte rietbewoner is hij tot boegbeeld getransformeerd voor het kwijnende Europese waterriet. Deze Poolse studie geeft inzicht in nestsucces en predatierisico's in optimaal habitat in de kern van het verspreidingsgebied. Als zodanig vormt het een noodzakelijke toevoeging op de studies die in perifere populaties werden uitgevoerd. De visvijvercomplexen in het gebied rond Lublin, Oost-Polen, zijn 14–185 ha groot en deels begroeid met Riet *Phragmites australis*, Kleine Lisdodde *Typha angustifolia* en zeggen *Carex* spp. De waterdiepte varieert er van 0 tot 120 cm, afhankelijk van seizoen en visbeheer (voornamelijk kweek van Karpers *Cyprinus carpio*). Er werden in totaal 84 actieve nesten gevonden, de meeste tijdens de broedtijd of in de eilegfase. Nesten die 2–4 keer tijdens de broedtijd werden bezocht, verschilden niet in overleving van nesten die slechts één keer werden gecontroleerd.

Ruim de helft van de nesten bleek in puur riet te zijn gebouwd, gevolgd door nesten in lisdodde, gemengd riet/lisdodde en – zelden – in zeggenvegetaties. De eileg begon in rietvelden enkele dagen eerder dan in de andere vegetatietypes, maar het verschil was niet significant. Gemiddeld lagen de nesten 21 m (spreiding 6–100 m) van het dichtstbijzijnde vasteland, en gemiddeld 22 m (spreiding 4–70 m) van het open water. Ruim driekwart van de nesten lag in de 30 m brede vegetatiegordel grenzend aan open water. De waterhoogte onder de nesten varieerde van 10 tot 97 cm (gemiddeld 45 cm). De nesten waren gemiddeld 13 cm boven het wateroppervlak gebouwd (variatie 5–30 cm).

Hoewel rechtstreekse predatie niet werd vastgesteld, bleken toch 23 nesten te zijn gepredeerd (leeggehaald, of resten van eieren of jongen aangetroffen). Tweemaal werd een volwassen vrouwtje door predatoren gedood. Waterdiepte en vegetatie waren als enige variabelen gecorreleerd met het nestsucces. Van de nesten boven water dieper dan 70 cm werd er geen enkele gepredeerd. De dagelijkse overlevingskans van nesten in riet en lisdodde ontliep elkaar niets. Evenmin was er een seizoenseffect op de overlevingskans. Predatie van nesten in de randzone was gelijk aan die van nesten dieper in de rietvelden gelegen.

De belangrijkste uitkomst van deze studie ligt in de bevinding dat predatie voor de grootste verliezen zorgt. De eenvoudigste manier om dat te voorkomen is een hoge waterstand gedurende de hele broedcyclus aan te houden. De meeste visvijvers, alsook natuurlijke moerasgebieden, kennen vaak wel een hoge waterstand in het vroege voorjaar, maar gaandeweg het voorjaar en de zomer zakt het water, waardoor nesten makkelijker bereikbaar worden voor grondpredatoren. (RGB)

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