Breeding Biology of the Great Bittern

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Abstract.—Available information on the breeding biology of the Great Bittern (*Botaurus stellaris*) is poor. New data are presented on nest description and distribution, breeding phenology, clutch and brood sizes, egg biometrics and breeding success, based on 27 nests at one French and three Italian sites. Nest shape and breeding phenology appeared at least partially linked to environmental factors. Breeding success was studied for the first time to the fledging stage using radio-tagging young. About 30% of eggs produced fledging young, and it is suggested that starvation was the main cause of chick death. Young moved away from the nest when about 15-days old and extensive dispersal occurred within 2-3 weeks from independence. A survey of the literature indicates variability in several breeding parameters and suggests that the Great Bittern is an adaptable bird. *Received 24 November 2004, accepted 18 April 2005.*

Key words.—Great Bittern, *Botaurus stellaris*, breeding biology, wetland, breeding success, conservation

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The Great Bittern (*Botaurus stellaris*), with a current estimated breeding population of 10,000 pairs (Russia and Ukraine excluded), is a species of conservation concern. It is currently declining throughout most of western Europe (BirdLife 2000), although it may be increasing in Denmark and Finland (Kushlan and Hafner 2000). Numbers in eastern Europe are not known in detail but may be declining (Kushlan and Hafner 2000). The species is listed as a conservation priority in the annex of the European Union 79/409/CEE "Birds" Directive. The progressive reduction of habitat availability due to the destruction of marshes with extensive wet vegetation cover has been the main factor affecting bittern numbers in the past two centuries (Cramp and Simmons 1977; Voisin 1991). The deterioration of habitat quality (e.g., water pollution) is also suggested to have played a role in the bittern's recent decrease (Tucker and Heath 1994; Kushlan and Hafner 2000). In the UK, the bittern has been affected by ecological succession with sites becoming drier and covered by shrubs and trees (Bibby and Lunn 1982; Tyler *et al.* 1998). Water is obviously an important element for the bittern: both male survival rate (Gilbert *et al.* 2002) and double brooding (Mallord *et al.* 2000) appear to be influenced by rainfall and site hydrological management, while its distribution within a site depends on water level (Adamo *et al.* 2004).

The Great Bittern is a secretive species, because of its breeding habitat (tall marshy grass stands), its coloration and behavior provide efficient camouflage. As a consequence, information on many aspects of the bittern biology is poor, and so limits management and conservation action. Males appear to be polygynous, while females alone build the nest and care for eggs and young (Percy 1951; Dement'ev and Gladkov 1951; Gauckler and Kraus 1965; reviews in Cramp and Simmons 1977, and Voisin 1991). Published information is currently available for some demographic traits of males (Gilbert *et al.* 2002), habitat selection and distribution (Adamo *et al.* 2004; Puglisi *et al.* 2005). However, very little information exists on female behavior (Percy 1951; Mallord *et al.* 2000), nesting ecology including egg laying and hatching periods or clutch size (Gentz 1965, Gauckler and Kraus 1965, Hermansen 1972) and breeding success (Gauckler and Kraus 1965), the largest published data-set on egg laying and clutch size is based on information collected over 110 years (Hermansen 1972). Moreover, published studies on the breeding biology are largely restricted to Denmark and Germany. In this paper we report recent data on breeding biology (nest description, location, breeding phenology, clutch and brood sizes, egg biometrics, breeding success obtained from radio-tagged chicks) from three sites in Italy and one in France.

METHODS

Study Sites

Massaciuccoli marshes, Italy (43°49' N, 10° 21' E; 800 ha), surround Lake Massaciuccoli. Mixed beds of Sawsedge (*Cladium mariscus*, often dominant) and Common Reed (*Phragmites australis*) with scattered pools cover the area. Water level is 10-30 cm in spring within the vegetation beds, which usually dry up from early July until early October. Bitterns colonized the area in the early 1980s, and their numbers increased progressively until 1998 (up to 22-25 booming males), when they suddenly declined to five males (2002). The study took place in 1997-2001. Colfiorito, Italy (43°02' N, 12°57' E; 86 ha) is an upland marsh (750 m a.s.l.) covered by beds of Common Reed and Bulrush (*Schoenoplectus* [*Scirpus*] *lacustris*). Water is 30-160 cm deep in spring, with strong yearly variation (±1 m). Bitterns colonized this marsh in the early 1990s, and during 1996-2001, eight booming males were reported each year. The study was carried out in 2000-2001. In the rice-fields study area (Lomellina, province of Pavia, c. 9.000 ha), Italy (45°20' N, 8°33' E), data were collected on three small areas (1-2.5 ha) covered by Cattail (*Typha* sp.; one case) or Common Reed (two cases) surrounded by paddies. Spring water depth is about 10-40 cm within the natural vegetation cover, while in rice-fields it is 10-25 cm. Fields are flooded usually from early April until mid-August, even though they are dried 1-3 times for agricultural work. The number of booming males in the whole rice-fields area (western Po plain, c. 180.000 ha) is estimated at 10-25 individuals; a single male was heard every year in each of the three natural patches. The study was carried out in 1998-2000.

In Baie de Seine, France (49°27' N, 0°17' E), reed beds and ponds cover about 1,300 ha on the side of the River Seine estuary, almost completely included within a Nature Reserve. Every year, approximately 40% of the reed is cut between December and mid March. The average water depth is 15-80 cm in spring and is higher in winter than in summer, but strong daily variations also occur due to tides. Bitterns colonized the area in the early 1990s, and their numbers have progressively increased with up to c.25 booming males in 2001. Nests were monitored in 2001 and 2002 at this site.

Nests were found by up to three people walking a few meters apart in areas presumed suitable for breeding, either because of the presence of booming males and/or because they were covered by wet reed bed (Baie de Seine and rice-field area). At Colfiorito, deep water level necessitated the location the nests by observing females making foraging flights. At Massaciuccoli, some searches were unsuccessful and in the period 1997-2001 flying females were not regularly observed; in 1999, a nesting female was flushed by observers, and a nest found nearby.

Once discovered, nests were visited 1-4 times and their position taken with GPS (Garmin III plus® or Garmin 12®). Excepting the rice-fields, nest descriptions were made at the end of the breeding season to avoid unnecessary disturbance of broods. Water depth under the nest was estimated at the brood stage.

Egg width and length were measured with vernier calipers to 0.1 mm. Eggs were also weighed to 0.1 g. Laying date was either determined directly from nest visits (incomplete clutches as revealed by increased number of eggs at the following visit), or estimated by backdating from hatching date (assuming 25 days incubation for an egg; Bauer and Glutz von Blotzheim 1966; Dement'ev and Gladkov 1951). Laying dates were also estimated from nestling age. Direct estimate of laying date was obtained for 16 nests (three based on egg laying and 13 on egg hatching), plus eight for which chick age could be used (comparing the plumage development of the chicks with other chicks of known age).

Parameters relative to brood size and reproductive success were estimated from those nests with complete data sets. Breeding success is difficult to assess in bitterns, because when they reach 15-18 days of age, the young leave the nest as soon as they perceive the approach of an intruder, hampering the collection of data on their survival. We therefore studied post-fledging behavior using radio-tagged chick to measure survival. A total of 23 chicks at least 14 days old were fitted with radio-tags weighting 6 g or 18 g (Biotrack TW4 and TW3), according to their age, mounted on the leg with a leather strap (this method of fitting the radio tags to bittern chicks was developed by Glen Tyler and Biotrack).

RESULTS

Nest Distribution and Characteristics

A total of 27 active nests were found: one at Massaciuccoli in 1999; six in the rice-fields area in 1998-2000; one in 2000 and seven in 2001 at Colfiorito; three in 2001 and nine in 2002 at Baie de Seine. Another nest, almost certainly a bittern nest because of its shape, the presence of small feathers and an eggshell just under the platform, was found just after the breeding season in 1998 at Massaciuccoli. Nests were located within stands of Sawsedge at Massaciuccoli, Bulrush at Colfiorito, Cattail and Common Reed in the rice-fields area, and Common Reed in Baie de Seine, and they were all built with stems and leaves of the same plant species. Overall 4% of the nests were built within Sawsedge, 15% within Cattail, 30% within Bulrush and 52% within Common Reed (N = 27). One nest at Massaciuccoli, two in the rice-field area, and two in Baie de Seine were within vegetation re-growing after a fire or a cut; in these cases, the vegetation was less than 50 cm in height when females started building their nest. Water depth under the nest at egg laying or hatching time varied between 15 and 79 cm (52 ± 24 cm, N = 10) and only one nest was in a dry reed bed.

Nest shape varied from circular to slight oval. Maximum width varied between 30 and 60 cm, with significant difference in platform surface between sites (Baie de Seine: 0.41 ± 0.07 m^2, N = 9; Colfiorito: 0.78 ± 0.23 m^2, N = 6; Massaciuccoli: 0.26 ± 0.03 m^2, N = 2; Kruskal-Wallis test: $H_2 = 11.1$, N= 17, P < 0.01). This variation may be related to average water depth under the nest ($r_{10} = 0.88$, P < 0.001). The thickest nest platforms were those of Baie de Seine, the site with the highest and quickest water level variations (Fig. 1). Nest dimensions did not vary through the season.

The minimum-recorded distance between nests found in the same year and within the same study sites (data only from Colfiorito in 2001 and Baie de Seine in 2002), was 39 m. Overall, the mean distance between nearest found nests was 148 ± 179 m (N = 7) at Colfiorito, and 149 ± 112 m (N = 6) in Baie de Seine, when excluding three apparently isolated nests (more than 1.5 km from the nearest known nest).

Egg Size and Egg-Laying

Eggs were on average 51.7 mm (±1.8 SD) long and 38.3 mm (±1.3) wide (N = 27). Eggs hatched asynchronously at 1-2 day intervals (N = 5 nests). Using all data, egg laying was spread from early April through late May, the latest clutches being those laid in rice-fields. For the other areas, most clutches were laid in April, with a peak in the third week, although this was mainly due to high synchronization of egg laying in Baie de Seine in 2002 (Fig. 2).

Breeding Success

Clutch size, number of hatched eggs and number of young at 14 days did not differ statistically between sites (Table 1). Five eggs out of 32 did not hatch (16%), and one clutch disappeared, probably predated by Magpies (*Pica pica*). Another clutch had been already partially predated when found, and afterwards was destroyed. This nest was in a dried up area by the late incubation period.

Chicks were tagged when 14 to 19 days old (3 in 2000 and 13 in 2001 at Colfiorito, and 6 in Baie de Seine in 2002). The signals from four tags were lost when the young were 20-30 days old. Young bitterns started to move from the nest during the third week after hatching, moving progressively further distances, and after the fifth week, some abandoned the nest area, moving up to 300 m (Fig. 3a). Age of independence could not be accurately assessed, but females stopped regularly flying to feed their young when they were between 40 and 50 days old. Starting at about 55 days, fledglings wandered through the marshes (maximum distance observed from the nest: 5.5 km in Baie de Seine at 78 days).

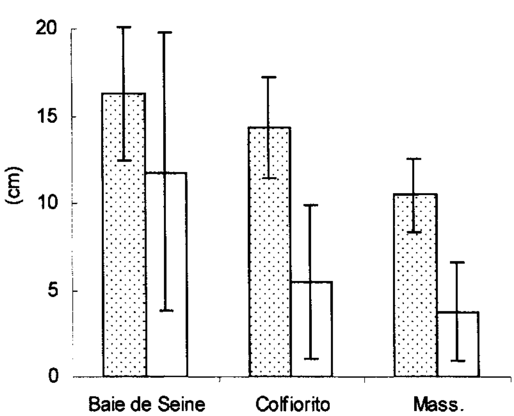

Figure 1. Mean Great Bittern nest thickness (±S.D.; dotted bars) and mean variation (±S.D.; open bars) of the water level around the average in the reproductive season at the three indicated sites (Mass. = Massaciuccoli).

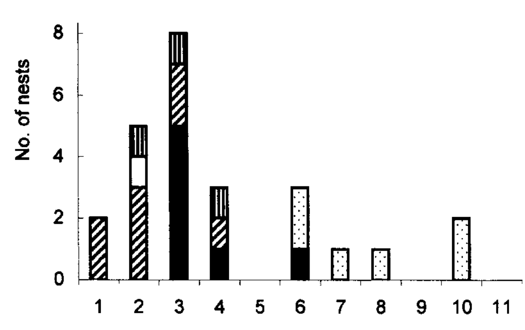

Figure 2. Laying week (week 1 = 1-7 April) for eight nests of Great Bittern at Colfiorito (one in 2000, seven in 2001; hatched bars), one at Massaciuccoli in 1999 (white bar), six in the rice-fields area in 1998-2000 (dotted bars), three in 2001 (vertical striped bars) and seven in 2002 (black bars) in Baie de Seine.

Table 1. Clutch size and nest success during the first breeding phases in Great Bittern for nests with complete data from three sites in Italy and one in France. For each parameter mean ±S.D., success as a percentage of eggs or young reaching the indicated phase, are presented, as well as the results of the ANOVA test with the site as a factor.

	Mean ±S.D.	No. nests	Success (%)	F	d.f.	P
Clutch size	4.1 ± 0.7	14	—	0.13	3, 10	n.s.
Hatched eggs	3.2 ± 1.3	10	76	0.22	2, 7	n.s.
10-14 days old young	3.0 ± 1.5	7	96	0.14	2, 4	n.s.

Eleven out of 19 tagged young bitterns died, nine before independence from the female, and two when 65-75 days old. Mortality was recorded in all four arbitrarily designated age-classes (Fig. 3b) but in particular between 20 and 35 days. Only one chick died before 20 days. At Colfiorito, seven out of eight corpses were found within a few days of death: two had been predated, probably by a rat and a dog, while the other five, including one fully fledged juvenile, had no injuries. The remains of another one were found at Baie de Seine close to a fox burrow, but it was impossible to assess if it was predated or eaten after its death. Another case of predation was observed at a nest in Baie de Seine on an untagged chick, which appeared to have been killed and partially eaten by a Marsh Harrier (*Circus aeruginosus*). Three out of seven untagged chicks were found dead in the nest in Baie de Seine in 2001 with no injuries.

For the surviving young, despite of intensive searches of the study areas for several weeks, the signal from the tags was lost when they were 66-78 days old, and in one case the 69-days old young was observed taking off at dusk, flying in large circles over the marsh of Colfiorito, uttering flight-calls before leaving eastward.

Comparison of Breeding Parameters with other Studies

Table 2 compares data reported in literature with those found in this study. Egg size was comparable for the countries considered, although smaller eggs were reported from an unspecified location in the former U.S.S.R. For areas with detailed data, clutch size differed significantly ($\chi^2_3 = 8.1$, $P < 0.05$), with French, Italian and Polish sites having smaller clutch sizes than Danish and German ones. The laying period was not strictly synchronous through Europe, but in general it appears that clutches were laid in northern countries not later than in southern ones.

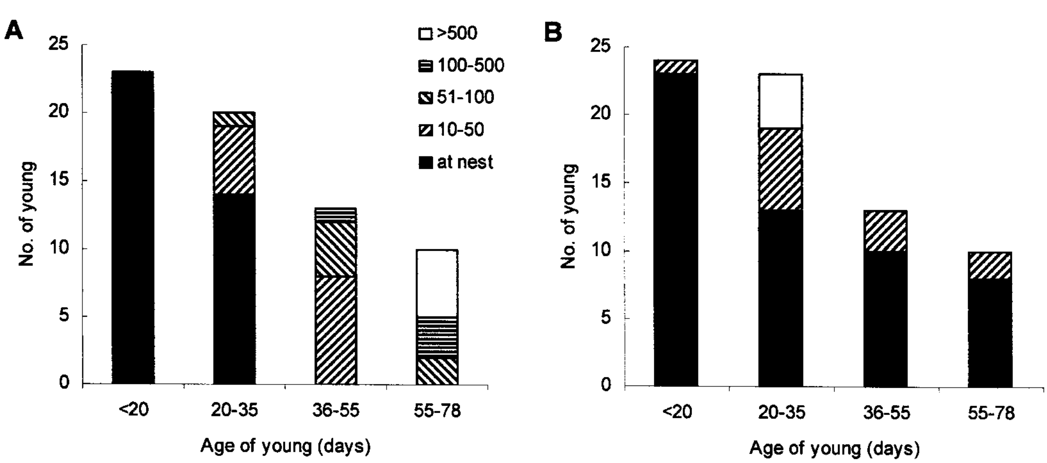

Figure 3. a) Number of young Great Bitterns found at different distances from the nest at the indicated age classes. b) Number of living (black bars) or dead (hatched bars) tagged young Great Bitterns at the indicated age classes. The chicks whose tag signal was lost are indicated by the open bar.

Table 2. Great Bittern breeding parameters in Europe as derived from a literature survey (including the present study. Mean ± S.D. are presented whenever given by Authors.

Egg size							
Country	Length (mm)					Width (mm)	N
Great Britain[1]	52.6					38.5	100
Germany[2]	52.6					38.5	n.a.
Germany[3]	52.7					38.7	54
Former USSR[4]	49.5					37.6	n.a.
France-Italy*	51.7 ± 1.8					38.3 ± 1.3	27
Clutch size	No. of eggs						
Country	3	4	5	6	7	Min-max	N
Denmark[5]	1	3	15	11	1	3-7	31
Germany[6]	1	19	29	11	—	3-6	60
Great Britain[1]						3-7	n.a.
Former USSR[4]						3-7	n.a.
Poland[7]	—	2	1	—	—	4-5	3
France-Italy*	2	10	1	1	—	3-6	14
Laying period							
Country						Peak	N
Denmark[5]	early March-late May					mid April	30
Great Britain[1, 8]	end March-mid June					—	n.a.
Germany[5]	early March-early June					early May	15
Germany[9]	end April-end May					—	13
Former USSR[4]	late April-early June					—	n.a.
France-Italy*	early April-late May					late April	27
Reproductive success							
Country	Mean SD					%	N
	No. eggs hatched						
Germany[9]	3.2 ± 1.2					64	13 nests, 66 eggs
France-Italy*	3.2 ± 1.3					76	10 nests, 42 eggs
	No. 14-d old young						
Germany[9]	2.8 ± 2.3					88	13 nests, 42 chicks
France-Italy*	3.0 ± 1.5					96	8 nests, 25 chicks

[1]Whiterby *et al.* 1939.
[2]Gentz 1965.
[3]Bauer and Glutz von Blotzheim 1966.
[4]Dement'ev and Gladkov 1951.
[5]Hermansen 1972.
[6]Data pooled from Gentz 1965, Gauckler and Kraus 1965, Hermansen 1972.
[7]Piskorski 1999.
[8]Mallord *et al.* 2000.
[9]Gauckler and Kraus 1965.
*This study; n.a.: not available.

Hatching success and "fledging" success (chicks that reached 14 days) reported from a single location in Germany and those found in this study did not differ significantly (Mann-Witney U-test: U = 60.5, n.s., and U = 30.5, n.s., respectively).

DISCUSSION

Nesting Habitat and Nest Characteristics

Several nests were found very close to each other. Extreme closeness (15-20 m) of neighboring nests has also been reported by Zarudnyi (1888 in Dement'ev and Gladkov 1951), Gauckler and Kraus (1965) and Gentz (1965). Bittern nests were found in several different vegetation types, and even in some sites, no nests were found within reed beds despite their wide availability (e.g., Colfiorito: Adamo *et al.* 2004): they are also reported to nest in *Cladium, Typha, Scirpus* (Gauckler and Kraus 1965; Gentz 1965; Bauer and Glutz von Blotzheim 1966; Bibby and Lunn 1982; Hancock and Kushlan 1984), and even among dense *Salix* growth (Dement'ev & Gladkov 1951). In five cases, the vegetation cover was re-growing (after harvesting or fire) when females started nest building, and vegetation height was very low. Bitterns are also generally reported to nest on wet vegetation stands (Cramp and Simmons 1977; Voisin 1991; Tyler *et al.* 1998). Water depth (5-60 cm) provided by Gauckler and Kraus (1965) is comparable to those obtained in this study (0-80 cm). The single nest found within dry vegetation was in an area that suffered from a marked rise in ground level over the last years (P. Sabine, pers. comm.). Nest's platform dimensions varied between sites: its size was larger on deeper water, while its thickness was apparently influenced by the extent and rapidity of water level variations. Overall, bitterns appear to be eclectic with regard to habitat choice, and can tolerate a wide variation with regard to water depth below the nest, nest shape and size, that at least partially vary with local habitat features.

Breeding Parameters

Egg sizes are comparable through the breeding range of the bittern. Conversely, clutch sizes were smaller in France and Italy (and perhaps Poland) compared to Denmark and Germany. Laying dates at Colfiorito, Baie de Seine, and Massaciuccoli were similar, while in the rice-field area, laying was delayed by more than three weeks. At this latter site, favorable nesting conditions are absent until early May when artificially flooded fields with growing rice become available as feeding areas. In western Europe laying dates appear to be on the whole comparable and slightly later than those from former USSR. However, the general pattern appears to be quite homogenous. Mallord *et al.* (2000) documented a case of double brooding, subsequent to a very early first brooding, apparently due to favorable flooding condition at the study site. It seems likely that bitterns modulate the timing of the breeding season according to environmental conditions, and in particular to flooding conditions and food availability, both factors being linked to some extent. Other factors, such as the presence of a particular cover or climatic factors (at least within the gradient examined), as supposed by Hermansen (1972), are possibly secondary. Hatching and reproductive success (until young are 14 days) were similar between our study and the only other published study.

Post-fledging Behavior and Survival

Radio-tagged fledglings left the nest moving at increasing distances with age (see also Mallord *et al.* 2000 for monitoring of a single brood). The ability of young to move far from the nest may allow females to reduce foraging movements between feeding areas and nest, which may improve breeding success in a species with uniparental care (such as the bittern). Fledglings foraged independently when about 55 days old, as previously reported by Heinroth (1926 in Witherby *et al.* 1939; eight weeks) or Mallord *et al.* (2000; 53-58 days). No longer than two weeks after independence, all the surviving young left the area for dispersal. In one documented case, the young left the marsh with a behavior very similar to that of bitterns leaving stop-over or wintering sites during spring migration (Puglisi and Baldaccini 2000).

A high proportion of tagged young bitterns died during our study, mainly before 35 days, and it could even be higher as we cannot exclude that the signals from the four tags lost when the chicks died and transmitters sank. Causes of death are difficult to establish, even when using radio-tagged chicks, and moreover, it has to be established that tagging (or even capture) does not lead to excessive mortality (Bro *et al.* 1999). Of eleven chicks found dead (8 with transmitters, 3 without), three were killed by predators. All the others were found with intact corpses. We believe that the main cause of mortality was starvation because i) mortality of chicks was not evenly distributed across years, year 2001 providing alone 12 out of 14 dead chicks (an indirect impact of the study should have provided more or less constant mortality rates); ii) all chicks that eventually died did not regurgitate food while being tagged conversely to all others (pers. obs.); iii) video-recording documented a low provisioning rate for four chicks that subsequently died at two nests, while feeding rate was higher in a third nest with three chicks that subsequently fledged (Adamo 2002); iv) mortality was most pronounced at 20-35 days, presumably at maximum growth rate and when food demands are highest; and v) all corpses showed no injuries to the leg fitted with the tag (a fledging tagged during this study was however found dead about 15 months later with its leg inflamed around the tag, G. Gilbert pers. comm.). Although some effect of radio-tagging chicks cannot be excluded, the evidence is that these effects, if any, did not led to significant mortality.

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