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Detection probability of nests of Squacco Herons in southern France

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ABSTRACT. The double observer approach with marked nests was used in southern France for estimating the detection probability of nests of the Squacco Heron (*Ardeola ralloides*), a cryptic species in its breeding behavior. Results indicate that the detection probability varied from 0.518 to 0.700 between observers. The overall detection probability, i.e., the probability that a nest was detected by at least one observer, was 0.856. Given a total of 66 nests found by both observers during the surveys, the breeding population was estimated at 77 nests. Since previous estimates of the Squacco Heron breeding population size did not take into account detection probability, we suggest that the breeding population is larger than previously thought in the Camargue and in other European breeding localities.

SINOPSIS. **Probabilidad de detectar nidos de *Ardeola ralloides* en el sur de Francia**
El acercamiento (approach) de doble observador fue utilizado para determinar la probabilidad de detectar nidos marcados de *Ardeola ralloides* (especie críptica) en el sur de Francia. Los resultados indican que la probabilidad de detección varía de 0.518 a 0.700, entre observadores. La probabilidad en general de detectar un nido (ej. la probabilidad de ser detectado al menos por uno de los observadores) fue de 0.856. Dado el caso de que ambos observadores detectaron 66 nidos, se estima que hay en la localidad 77 nidos. Dado el caso de que los estimados previos de este tipo de garza no tomaron en consideración la probabilidad de detección, sugerimos que la población reproductiva es más grande que la previamente informada para Camargue y otras localidades de Europa.

Key words: Camargue, double observer, nest detection, Squacco Heron

Accurate estimates of population size from animal surveys are an important tool for understanding population dynamics and for setting conservation priorities (Carter et al. 2000; Thompson 2002). Unbiased population size estimates may be obtained only if surveys take into account the detection probability (or detectability) of their target species, i.e., the probability of missing an individual given it is present in the sampling area (Rosenstock et al. 2002). Not taking into account the proportion of individuals missed during surveys may lead to serious biases in estimates of abundance (Nichols et al. 2000).

The Squacco Heron (*Ardeola ralloides*) is a small migratory heron breeding in Europe and Africa. Because of its relatively low numbers in Western Europe, the species is classified as Vulnerable by Hafner (1994) and is thus of strong conservation concern. In addition, apart from some estimates of nesting success (Delord et al. 2003), the demography of this species in poorly known. The Camargue (southern France) breeding population (ca. 100 pairs) holds most (ca. 99%) of the total breeding population in France and has been monitored over the long term (but with survey protocols not taking into account detectability; Hafner et al. 2001). Because Squacco Herons build small nests in dense vegetation, such as woods of *Tamarix* spp. trees, their nests may remain undetected during nest surveys, which are generally conducted for relatively short time intervals in order to minimize disturbance (Hafner 1977).

Here we estimate detectability of nests of the Squacco Heron in the Camargue using a double observer approach (Nichols et al. 2000), and produce estimates of population size taking into account detection probabilities.

METHODS

Squacco Herons have been studied in the Camargue for more than 30 yr (Hafner 1977;

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Table 1. Estimates of Squacco Heron nest detection probabilities for two observers in southern France using the double observer approach.

	Observer A		Observer B	
Model	Mean (SE)	95% CI	Mean (SE)	95% CI
p(i)	0.518 (0.111)	0.300–0.736	0.700 (0.118)	0.468–0.932
p(.)	0.596 (0.110)	0.380–0.811	0.596 (0.110)	0.380–0.811

Hafner and Didner 1997; Hafner et al. 2001). In the Camargue, the Squacco Heron nests in mixed-species colonies with Little Egrets (*Egretta garzetta*), Cattle Egrets (*Bubulcus ibis*), Black-crowned Night Herons (*Nycticorax nycticorax*), and Grey Herons (*Ardea cinerea*). Nests are situated in woods of tamarisk trees (*Tamarix gallica*), elm trees (*Ulmus campestris*), and ash trees (*Fraxinus* sp.) often surrounded by water.

Surveys were conducted in June 2002 on three mixed colonies of herons. During surveys, a double observer approach (Nichols et al. 2000) was used to estimate nest detection probability. Two observers entered the colonies and searched for Squacco Heron nests along transects. A designated "primary" observer marked each transect with colored plastic tape, and searched for nests on and on each side of the transect line. Each nest found was marked with a numbered colored tag. Squacco Heron nests are smaller than the other sympatric herons' nests and can be easily distinguished. In addition, nest contents were checked, permitting us to identify with certainty the ownership of each nest based on egg or chick characteristics (Cramp 1977; Hafner and Didner 1997). The other ("secondary") observer followed the plastic tape and recorded all the nests marked by the primary observer as well as any nest not detected by the primary observer. Observers alternated primary and secondary roles for a total of six transect-counts. Computation of detection probability was made with program DOBSERV (Hines 2000). Because our sample size (number of transects) was relatively small, we could not test whether nest detection probability differed between colony sites. However, we could test for differences between observers. Two models where compared, one where nest detection probability varied between observers [model p(i)], and one where detection probability was constant [model p(.)]. Models were compared using the Akaïke Information Criterion with small-sample bias adjustment (AICc) computed by program DOBSERV. The model with the lowest AICc was the one selected.

RESULTS

Both models fit the data (goodness-of-fit tests: model p(i), G = 0.0, df = 0, $P = 1.0$; model p(.), G = 3.687, df = 3, $P = 0.297$). Based on AICc values, model p(i) (AICc = 11.57) was preferred to model p(.) (AICc = 13.13). Estimates of detection probabilities for each of the two observers for both models are shown in Table 1. The overall detection probabilities, i.e., the probability that a nest was detected by at least one observer, were 0.856 (SE = 0.083) and 0.837 (SE = 0.089) for model p(i) and p(.), respectively. Such estimates permit direct estimation of the number of nests in the colonies surveyed during this study which, given a total number of 66 nests found by both observers during the surveys, is estimated at 77 (66/0.856) nests (SE = 8.31; 95% confidence interval, 69–107 nests) by model p(i).

DISCUSSION

Breeding bird population size estimates based on nests counts are often based on a limited number of surveys (typically one or two). Results from this study clearly indicate that, for some species, the nest detection probability may be smaller than one, and that consequently the breeding population size can be underestimated. Another factor leading to underestimation of population sizes of nesting birds is the effect of asynchronous nesting and nest failure. The accuracy of repeated counts of unmarked nests for estimating numbers of nest starts may be strongly affected by nests missed whenever there nests start and fail prior to or after surveys or during the inter-visit interval (P. C. Frederick et al., pers. comm.). Furthermore, this bias cannot be corrected by increasing the number of surveys during the breeding season, because the bias comes from the fact that nests are not individually identified (P. C. Frederick et al., pers. comm.). Nesting asynchrony may also affect nest detection probability and consequently bias estimates, because nests with chicks may be more easily detected than nests with eggs. For highly asynchronous species, it should be easy to account for this potential source of variability by classifying nests into stages (e.g., egg, chick) and by testing for a nesting-stage effect on detection probabilities during the modeling process.

The approach described here was primarily designed for estimating nest detection probabilities. We believe that this approach can also be used when the goal is to estimate the size of an entire population of a colonial species over a large area. At a larger scale than the colony, the double observer approach could be used to estimate a colony detection probability, with two observers (a primary and a secondary) surveying the study area by airplane (e.g., Pollock and Kendall 1987).

To minimize costs associated with surveys within colonies, one could use a double sampling method (Bart and Earnst 2002) by employing the double observer approach on some transects within each colony to estimate p, the rest of the colony being surveyed by a single observer. Unbiased estimates of nest abundance over the entire study area can be obtained from both the colony detection probability (estimation of the number of colonies) and the nest detection probability (estimation of the number of nests per colony).

The probability of detecting a nest is below one for Squacco Herons breeding in southern France. Our results suggest that if only one observer estimates breeding pairs without taking into account the detection probability, from half to about one third of the nests will be missed, depending on the observer. One observer in each colony conducted previous surveys of the breeding population of Squacco Herons in the Camargue (Hafner et al. 2001). Although several surveys per colony were conducted each year (mean, 6.1; H. Hafner, unpubl. data), nests were not individually marked during these surveys, suggesting that the population size may have been underestimated due to the low nest detection probability for this species and the effect of asynchronous nesting and nest failure (P. C. Frederick et al., pers. comm.). Nesting is relatively asynchronous in Squacco Herons in the Camargue, since nests are initiated over two months (Hafner 1977; Delord et al. 2003). This is in line with the sudden increase of the population observed since 2000 (from 90 breeding pairs during 1970–1999 to 317 during 2000–2002; H. Hafner et al., unpubl. data). The increase may correspond to the initiation of a mark recapture study on Squacco Herons in 2000 and to more intensive nest searches and systematic nest marking, taking into account nest detection probability and the effects of asynchronous nesting. However, part of the increase in population may be real, as the number of colonies of Squacco Herons in the Camargue has doubled during the last 10 yr (Tourenq et al. 2000).

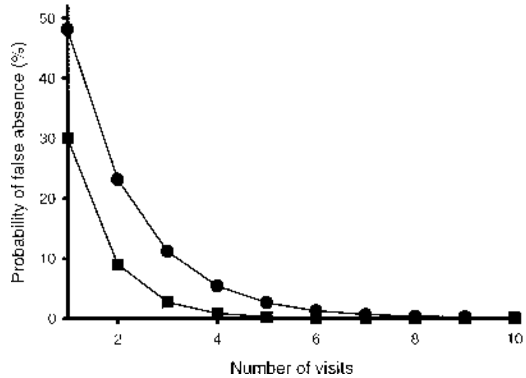

Fig. 1. Probability of false absence for Squacco Herons nests in southern France estimated using nest detection probabilities from model p(i). Circles and squares indicate the two different observers.

A potential bias for population size estimates and studies of species occurrence is false absence, i.e., the probability of not detecting a species on a given site given it is present. The probability of false absence of a species can be estimated as $\alpha = (1 - p)^N$, where N is the number of visits to the site and p is the probability of detecting the species' presence (Kéry 2002). Using our estimates of detection probability from model p(i), one can estimate that four to seven visits (Fig. 1) are necessary to decrease the probability of false absence below 1% when only one observer is conducting visits. Based on our results, we suggest that estimates of the breeding population of Squacco Herons in southern France and at other localities should take into account nest detection probability and nesting asynchrony.

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