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APPARENT SURVIVAL RATE IN A BLUETHROAT *LUSCINIA SVECICA AZURICOLLIS* POPULATION IN SPAIN

TASA DE SUPERVIVENCIA APARENTE EN EL PECHIAZUL *LUSCINIA SVECICA AZURICOLLIS* EN ESPAÑA

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Summary.—Survival estimation is fundamental to understanding population dynamics and has great value from a conservation standpoint. We calculated the apparent survival rate and its variation between age classes and years for a bluethroat *Luscinia svecica azuricollis* breeding population in Spain. Cormack-Jolly-Seber models were used on capture-recapture data obtained during the breeding season from 1998 to 2005. Bluethroats first captured as adults exhibited higher apparent annual survival (0.52) than those first captured as first-year birds (0.31). We discuss these results within a larger geographic context and compare them with other similar species.

Resumen.—La estimación de la supervivencia es fundamental para comprender diferentes aspectos de la dinámica de poblaciones y tiene un valor importante desde el punto de vista de la conservación. Calculamos en este artículo la supervivencia aparente y su variabilidad en función de la edad y el año de estudio para una población de pechiazules *Luscinia svecica azuricollis* en España. Se utilizaron para ello modelos de Cormack-Jolly-Seber a partir de datos de captura-recaptura obtenidos durante el periodo 1998-2005. La supervivencia aparente en aves capturadas por primera vez como adultos (0,52) fue mayor que en aves capturadas por primera vez como juveniles (0,31). Todo ello se discute y analiza dentro de un contexto geográfico más amplio así como en relación con los valores que se disponen para especies similares.

Survival and productivity are the two parameters determining population size, so annual survival estimation is fundamental to understanding animal population dynamics. Understanding patterns of annual survival has high priority from a conservation standpoint (Siriwardena *et al*., 1998; Desante *et al*., 2001). Unfortunately, survival data are simply non-existent for many species and/or are available only locally, where trends may

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often not enable extrapolation to wider areas owing to population-specific dynamics (Peterjohn *et al*., 1995; Sokolov *et al*., 2001).

The bluethroat *Luscinia svecica* is a polytypic migrant passerine occurring across the Palaearctic and reaching the northwest Nearctic (Cramp, 1988). Populations breeding in Spain belong to *L. s. azuricollis*, a subspecies well differentiated from *L. s. cyanecula* (breeding from western to eastern Europe) as shown by recent genetic studies (Johnsen *et al*., 2006).

Although some West-European bluethroat populations have recently increased considerably, e.g., in France (Constant and Eybert, 1995, Zucca and Jiguet, 2002) and northern Europe (BirdLife, 2004), others, like *L. s. azuricollis* or even some *L. s. namnetum*, may remain at high risk of extinction (Huntley *et al*., 2007). Although Huntley *et al*. (2007) only refer to effects of climate change on population trends, there are several other factors that may impact bluethroat population trends. For instance, *L. s. azuricollis* may be strongly affected by loss of breeding habitat (Arizaga *et al*., 2011). Survival estimation is therefore a priority to identify the possible conservation problems faced by this subspecies of bluethroat.

Here, we explored for the first time variation in survival rates of a bluethroat population in Spain. Data were obtained in one of the chief breeding areas for bluethroats in Spain, in a forest of holm oaks *Quercus rotundifolia* situated in Palacios de la Valduerna (42º 20' N, 05º 58' W), province of León, northwestern Spain (for further details see García *et al*., 2000). Bluethroats were caught with mist nets (16 mm mesh; 2.5 m high; 5 shelves) during March/April to September 1998-2005. Net length used each year ranged between 72-96 m. The mean number of visits per year was 14.1 (SD: 9.5; range: 3, in 2005; 31, in 2003), and mist nets remained opened daily for five hours from dawn. We also used spring traps in order to increase the sample size. Once captured, bluethroats were marked with metal ring and aged (Jenni and Winkler, 1994), either as first-year birds when birds were in their first calendar year (EURING code: 3), or as adults, when birds were older (EURING code: 4).

Bluethroats captured at our site were considered local, since transients were thought to be rare or absent as bluethroats from other parts from Europe occupy reedbeds and wetlands when moving through Iberia (Peiró, 1997; Bermejo and de la Puente, 2004; Arizaga *et al.,* 2006, 2010). During the long-term survey carried out at our site we did not obtain recoveries from abroad, and all bluethroats captured in late summer were seemingly local birds, i.e. moulting adults or first-year birds and birds recaptured in multiple years at that site; JG, pers. obs.). In contrast, recoveries of bluethroats from abroad are common at nearby wetlands in León.

We used Cormack-Jolly-Seber (CJS) models to estimate apparent survival. Such models separately estimate survival (ϕ, probability that a bird captured at time t is still alive at $t+1$) and recapture probability (p, probability that a bird captured at t and still alive at $t+1$ is recaptured at $t+1$).

Before starting to select models, we checked whether the data were in agreement with CJS assumptions using a goodness-of-fit (GOF) test. We used U-CARE software (Choquet *et al*., 2001) to undertake a GOF test on a CJS model where both ϕ and p varied from year (y) to year [ϕ(y) p(y)]. A global GOF test showed that the data set fitted the CJS assumptions ($P = 0.996$). Specific Test 3SR to detect transience (when p of a bird captured at t is present at the sampling site at $t+1$ is zero) was non-significant ($P = 0.710$).

Apart from a possible year-effect on apparent survival [ϕ(y)], we also considered an additional model in which survival of first-year birds from year i (first capture event) to year $i+1$ differed from survival in subsequent years, since survival of birds in their first year of life shows lower rates than in older birds (Newton, 1998). In contrast, survival of adults was considered to be constant. Therefore, we worked with two separate age groups, first-year birds that we considered age-dependent, and adults (second-year or older birds). We named this model ϕ(a). Thus, overall, $\phi(\mathrm{y}\times\mathrm{a})$ $p(\mathrm{y}\times\mathrm{a})$ was the most complex model from which to start model selection. Corrected Akaike values (AICc) were used to rank GOF of models to data (Burnham and Anderson, 1998). Models with an AICc difference >2 were considered to be significantly different. CJS models were run using MARK 5.1 (White and Burnham, 1999).

Overall, we obtained a matrix of 296 rows (individuals) by eight years. Of these, 182 birds were first captured as first-year birds and 114 birds were first captured as adults. Most bluethroats were captured only once (first-year birds: 84.1%; adults: 68.4%), but a higher percentage of adults was recaptured one or more years after the first capture event compared with first-year birds $(\chi^2_1 = 27.099, P < 0.001)$.

The model that best fitted the data was that assuming different survival rates between age classes (table 1); in particular we obtained an apparent survival estimate (±SE) of 0.31 ± 0.06 for first-year birds between their first and second year of life, and an apparent survival estimation of 0.52 ± 0.05 for older birds, whether these were first captured as first-year birds or as adults. Models assuming year-to-year survival variations were not supported by our data set. Recapture probabilities varied yearly, ranging between 0.10 ± 0.10 and 0.63 ± 0.12.

The estimate obtained for adults was slightly lower than the mean value obtained in a previous study based on recovery data analyses of bluethroats ringed in breeding quarters over a wide geographic area in

TABLE 1

Results of Cormack-Jolly-Seber models used to estimate apparent survival (ϕ) and recapture probability (p) (from 14 models run, only the best four models and the last one are shown). Corrected Akaike values (AICc); difference in AICc values in relation to the first model; AICc weights, number of parameters and deviance are given. Abbreviations: y, year; a, age.

[Resultados de los modelos Cormack-Jolly-Seber (se muestran los mejores cuatro modelos así como el último modelo) utilizados para calcular la supervivencia aparente (ϕ) y la probabilidad de recaptura (p). Se muestran el valor de Akaike corregido para muestras pequeñas (AICc); la diferencia de AICc de cada modelo respecto al primer modelo; el peso relativo de cada modelo; el número de parámetros estimado en cada modelo y su desviación. Abreviaciones: y, año; a, edad.]

Models	AICc	ΔAICc	AICc Weight	No. Parameters	Deviance
1. ϕ(a), p(y)	452.12	0.00	0.94	9	56.32
2. ϕ, p(y)	457.72	5.60	0.06	8	64.02
3. ϕ, $p(\mathrm{a}\times\mathrm{y})$	465.30	13.18	0.00	15	56.65
4. $\phi(\mathrm{a}\times\mathrm{y})$, p	466.22	14.11	0.00	15	57.57
Last: ϕ, p	498.14	46.03	0.00	2	116.81

Europe, i.e. 0.66 (Møller, 2006). Considering survival rates provided by Møller (2006) of 69 passerines (median = 0.49, 25% and 75% percentiles, 0.43 and 0.59, respectively), mean survival values for adults in Spain did not exceed the 75% percentile, although they were sufficiently high to maintain a stable or even an increasing population size (Gómez-Manzaneque, 2003; Joyeux *et al*., 2010).

First-year bluethroats showed an apparent survival rate (0.31) no lower than that found in other European passerine birds in their first year of life (range: 0.25-0.45; Saether, 1989). It is worth noting that our survival estimate could be underestimated if there were non-local first-year bluethroats within our sample (e.g. on post-fledging dispersal). Therefore, the decrease in the population may be associated with either low productivity and/or habitat loss. However, the role of survival in a given population is dependent on the specific life history characteristics and the nature of other parameters that shape population growth, particularly productivity. Thus, to determine whether survival of first-year bluethroats in Spain is low or high, additional research on simultaneous productivity within this population is needed.

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APPENDIX I

Life encounters (m-array table) of bluethroats captured at a breeding site in Spain (*R*, number of bluethroats released at year *i*).
[Tabla de vida de los pechiazules capturadas en el área de muestreo en España (R, número de ejemplares liberados en i).]

Year	*R(i)*	1999	2000	2001	2002	2003	2004	2005	Total
First-year									
1998	24	1	0	2	0	0	0	0	3
1999	5		1	1	0	0	0	0	2
2000	32			3	1	0	0	0	4
2001	26				5	0	1	0	6
2002	43					6	1	0	7
2003	39						10	0	10
2004	36							0	0
Adults									
1998	5	0	0	0	0	0	0	0	0
1999	14		1	1	1	1	0	0	4
2000	25			8	3	0	0	0	11
2001	23				8	2	0	0	10
2002	37					14	2	0	16
2003	38						11	0	11
2004	23							0	0