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ANNUAL SURVIVAL RATES OF A MARSH WARBLER, *ACROCEPHALUS PALUSTRIS*, BREEDING POPULATION IN NORTHERN ITALY

Abstract. — Jolly-Seber open-population models were used to analyse the capture-recapture data of 194 adult Marsh Warblers mist-netted during the breeding season from 1986 to 1990 in a moist waste-land in NW-Italy. Estimates of population parameters and test statistics enabling the choice of the most appropriate model for the data were computed with the computer program JOLLY. The selected model (constant survival and capture probabilities) estimates an annual minimum survival rate of 0.56 (S.E. = 0.07). Estimates of population size yielded by this model were compared to the Lincoln-Petersen two-samples estimates.

Riassunto. — *Tassi di sopravvivenza annuale in una popolazione di Cannaiola verdognola,* Acrocephalus palustris, *dell'Italia nord-occidentale.*

Dati di cattura-ricattura di 194 Cannaiole verdognole adulte inanellate nelle stagioni riproduttive dal 1986 al 1990 in una zona umida sita in provincia di Cuneo sono stati analizzati tramite il modello probabilistico di Jolly-Seber per popolazioni aperte ad incrementi (nascite, immigrazione) o a decrementi (mortalità, emigrazione) ed altri modelli da questo derivati. I calcoli dei parametri di popolazione (tasso di sopravvivenza, probabilità di cattura, dimensioni della popolazione) sono stati effettuati mediante il programma JOLLY, che elabora anche tests statistici fra modelli e tests per la bontà dell'adattamento (goodness-of-fit tests) i quali consentono di scegliere il modello più appropriato per i dati sperimentali. Il modello prescelto (quello che considera costanti nel tempo la sopravvivenza e la probabilità di cattura) fornisce una stima della sopravvivenza minima pari a 0,56 (S.E. = 0,07), valore che appare piuttosto elevato nell'ambito dei piccoli Passeriformi. Lo stesso modello permette di ottenere stime della dimensione della popolazione; queste sono state confrontate con quelle fornite dall'indice di Lincoln-Petersen, valido solamente per polazioni chiuse (ove cioè non si hanno nè perdite nè aumenti), qui applicato ai doppi campionamenti effettuati ogni anno in giugno e luglio.

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Introduction.

Survival rates of some populations of Reed Warbler, *Acrocephalus scirpaceus,* have been investigated in England (LONG 1975, GREEN 1976) and France (TAILLANDIER, 1990). On the contrary, no estimates are known for the congeneric Marsh Warbler, *Acrocephalus palustris.* Here we present data on the survival rate and population sizes, estimated by means of capture-recapture methods, of a population breeding at a site in the western part of the Po Valley (N-Italy). This area lies at the southern boundary of the Marsh Warbler breeding range (VOOUS 1960), but the species there is widespread and reaches, in suitable habitats, high densities (BOANO & CATTANEO 1988, BRICHETTI et al. 1989).

Study area and Methods.

Study area. The study site was located near Sommariva Bosco, 257 m a.s.l. (CN, NW-Italy) (44° 46′ N - 7° 45′ E), on a 4 ha waste-land, and it was surrounded by Poplar (*Populus* sp.) plantations, wet meadows and cereal fields. A thick herbaceous vegetation, prevalently made up of *Urtica dioica, Phragmites australis, Solidago gigantea* and *Filipendula ulmaria,* with shrubs of *Salix cinerea* (*capraea* group), *Cornus sanguinea* and small trees of *Salix alba* or *Alnus glutinosa* covered the central part. Some other belts (about 1 ha) of suitable vegetation were spread out along poplar margins and ditches, near the study site. Other similar patches of good Marsh Warbler habitat were dispersed North and South of the study area.

Field techniques. Observations and mist-netting operations were carried out from May to September of seven consecutive years (1984-1990). In every netting session 6 to 9 mist-nets (12 m long, 4 shelves, 32 mm mesh) were deployed in a central area of about 2.25 ha. Mist-nets were kept in place for two consecutive days; the precise location of some nets shifted irregularly from a session to the next.

327 birds (256 adult and 71 young) were ringed (INBS metal rings), aged according to WILLIAMSON (1976) and SVENSSON (1984) and sexed by inspection of brood patch and cloacal protuberance.

Data analysis. Demographic parameters were estimated from the capture-recapture history using Jolly-Seber and related models (JOLLY, 1965; SEBER, 1965; NICHOLS et al. 1981, POLLOCK et al . 1990). The basic Jolly-Seber model is based on the following assumptions: 1) every bird

present in the population at the time of sampling has the same probability of capture; 2) every marked bird present in the population after sampling has the same probability of surviving until the next sample; 3) marks are not lost or overlooked; 4) all emigration is permanent; 5) all samples are instantaneous (i.e. sampling time is negligible relative to the intersample period).

To minimize violations of assumptions we restrict here the analysis to the capture-histories of 194 adults ringed in the ten ringing sessions (twice a year) held in June-July from 1986 to 1990, pooling the data of each year; thus we exclude birds ringed during the main migration times, previous small samples and the young, the low philopatry of which allowed only one recapture in the five years.

Demographic estimates were obtained using the computer program JOLLY (POLLOCK et al. 1990). This program provides parameter estimates under the basic Jolly-Seber model (Model A) and other related models which either generalize or further restrict assumptions about capture and survival probabilities (assumptions 1 and 2) (Table I).

TABLE I. — Specific assumptions of the JOLLY models.

A	Time specific survival and capture probability
B	Constant survival, time specific capture probability
D	Constant survival and capture probability

We based decisions about model appropriateness on goodness-of-fit tests and tests between models (POLLOCK et al. 1985; BROWNIE et al. 1986).

For comparison, population estimates were also calculated with the Lincoln-Petersen two-sample method, as modified by Chapman (1951, in SEBER 1982), the June and July sessions of each year being the two involved samples. The method assumes that: 1) the population is closed to additions and deletions; 2) all animals are equally likely to be captured in each sample; 3) marks are not lost and are not overlooked by the observer.

Results.

Arrival and Departure date, Sex ratio. First arrivals were observed from early May (the earliest being May 1) and most of the population settled down by the second decade of May. Nest-building started imme-

diately (a completely built nest being found 21 May); the first eggs were laid from the end of May (30 May). The first fledged young were captured from 30 June. The majority of the Marsh Warblers left the area in mid-August, and only in 1986 did we capture an emancipated young as late as 19 September. This was the only young subsequently retrapped, as an adult female, in 1987.

A total of 165 individuals were sexed: 81 were males and 84 females (a ratio of 0.49).

Survival and Population estimates. Table II shows the data set utilized to calculate demographic parameters with the Jolly-Seber open-population models.

TABLE II. — Captures and recaptures of Marsh Warbler from 1986 to 1990 summarized in « B-Table » format (according to LESLIE et al., 1953).

Last captured in year	Year of recapture				
	1986	1987	1988	1989	1990
1986	—	2	2	1	1
1987		—	12	4	1
1988			—	7	1
1989				—	5
1990					—
Marked	0	2	14	12	8
Unmarked	35	55	36	28	40
Caught	35	57	50	40	48
Released	35	57	49	40	48

Survival rate, capture probability and related standard errors, as calculated with Model D (constant survival rate, constant capture probabilities), are shown in Table III.

TABLE III. — Survival rate (PHI), capture probabilities (P), and associated Standard Errors, according to the Model D.

PHI	0.56	S.E. (PHI)	0.07
P	0.25	S.E. (P)	0.05

Model D is not rejected by the test versus Model A ($\chi^2 = 5.61$; d.f. $= 5$; $p = 0.35$), nor by that vs. Model B ($\chi^2 = 1.43$; d.f. $= 2$; $p = 0.49$). The results of the tests between models and the goodness-of-fit tests (Table IV) allow us to retain the Model D, because of the greater

TABLE IV. — Goodness-of fit tests of the three JOLLY models.

Model	Chi-square	DF	Probability
A	0.06	1	0.81
B	1.19	2	0.55
D	5.67	6	0.46

precision of the estimates. Table V shows the data set used for the Lincoln-Petersen estimates. Mean population sizes, as calculated with Jolly-Seber model D and Lincoln-Petersen method are shown in Table VI.

TABLE V. — Data set for the Lincoln-Petersen estimates.

Year	n(1) (June)	n(2) (July)	m(2) (July)
1986	21	18	3
1987	19	48	6
1988	40	15	5
1989	24	9	1
1990	28	28	5

n (1) - birds caught, hence marked, in the first sample;
n (2) - total birds caught in the second sample;
m(2) - marked birds caught in the second sample.

TABLE VI. — Population estimates.

Year	Model D		Lincoln-Petersen	
	N	S.E.	N	S.E.
1986	—	—	104	38
1987	239	56	139	37
1988	200	45	108	30
1989	157	38	124	62
1990	196	49	139	42

Discussion.

Population size. The estimates of the population size look nearly constant in the study periods, with both open and closed models. The estimates of the retained Model D are larger than those yielded by the Lincoln-Petersen method.

Biased estimates may result by heterogeneous capture probabilities with both the models (POLLOCK et al. 1990); for example, birds holding territory near nets may have greater capture probabilities and this results in a negatively biased estimate (a case likely affecting our Lincoln-Petersen estimate); on the contrary, trap-shyness or temporary emigration leads to overestimation of population size with the open-population models.

Trap-shyness seems not to be important in our study, particularly in the case of the open population models, with an intersample period of about one year. Nevertheless a lower capture probability for some individuals could be due to a certain shift of the territories between years, but we are also aware that temporary emigration has been recorded in an intensively studied Marsh Warbler population, where two males reappeared in their previous territories after an absence of two years (DOWSETT-LEMAIRE 1978).

In summary the translation of our population estimates into estimates of density without supplementary information, in spite to the relative isolation of the study site from other Marsh Warbler habitat patches, is necessarily subject to caution.

Density appears very high even if related to the whole surface (5 ha) covered with suitable vegetation (reaching respectively 24.6 or 39.6 birds/ha if the means of the population sizes yielded by the two different methods are taken into account). Yet we can compute even higher values (33 and 41 birds/ha) from the DOWSETT-LEMAIRE (1981: 445) data, if we consider the breeding *plus* the « floating » birds settled in the study area. On the other hand, Kelsey (pers. comm.) found in Worcestershire, England, a mean territory area of about 480 sq. metres (which theoretically allows a density of about 40 birds/ha), but the actual highest density was 6.9 territories/ha for any given breeding site.

In our view, the high values obtained support the caveat about standard mapping techniques used to estimate the densities of marshland passerines: underestimates are certainly a common case (BELL et al. 1968, 1973, DOWSETT-LEMAIRE 1981), but overestimates could also occur because of the brief initial period of unsettled behaviour after return

and the polyterritoriality of some males (KELSEY 1989 and pers. comm.). So, intensive territory mapping of colour-ringed populations is necessary if it is hoped to obtain a good measure of density.

Our data are however sufficient to underline the suitability of the site for Marsh Warblers and to show the relative stability of the population during the study period.

Survival. Unlike population size estimates, Jolly-Seber survival estimates are robust to assumption violations like those discussed above (CAROTHERS 1973, POLLOCK et al. 1990, SPENDELOW & NICHOLS 1989), but the complement of survival rate (1 - PHI), as estimated by the capture-recapture models, does includes both death and permanent emigration, so PHI should be considered a minimal survival rate.

We do not know of any other explicit mortality estimates for the Marsh Warbler: DOWSETT-LEMAIRE (1978) reports a low adult return rate (males = 26.0%, female = 17.4%, mean = 22.5%), and argues that the species shows a high level of breeding dispersal (e.g.: many individuals did not return in the previous breeding area, moving to different breeding sites). KELSEY (1989) in a isolated and declining population in Worcestershire, England, found a return rate of 57% in 1985 and a lower one of 27% in the next year (1).

Estimates of survival rates are known for some populations of Reed Warbler, *Acrocephalus scirpaceus*, both in Great Britain (LONG 1975, GREEN 1976) and in France (TAILLANDIER 1990) and all agreed with our estimate, being respectively of 0.56, 0.51 and 0.54. These estimates, like ours, are based on the recapture or resighting of individually recognizable birds in a restricted study area, so they are concerned with the same problem of discrimination between permanent emigration and mortality.

A method to gain inference about the magnitude of the permanent emigration is the comparison between the survival rates provided by local capture-recapture experiments and those based on ringing recoveries drawn from a large geographic area (wich could cover the whole range of the species). We therefore examined the survival rates of 14 other European small passerines based on ringing recoveries and computed with the Haldane method (AA.VV. in SAETHER 1989): they range

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(1) While this work was in print we could learn from GLUTZ VON BLOTZHEIM U.N. (ed.), 1991 (Handbuch der Vögel Mitteleuropas, Vol. 12/I, Sylviidae, *Aula Verlag*, pag. 421), that in West Germany G. Rheinwald (unpubl.) found an adult survival rate higher than 0.47 and Stein (1986) found it ranging between 0.46 and 0.57 for the adult males of two populations near Magdeburg, (n = 280 captures and 80 recaptures).

between 0.35 and 0.57, averaging 0.47 (S.E. = 0.02), and thus the above estimates on Reed and Marsh Warbler score high.

We believe that the complement of our survival estimate is therefore close to the true mortality, and that this Marsh Warbler population shows a strong breeding philopatry.

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REFERENCES

BELL B. D., CATCHPOLE C. F. & CORBETT K. J., 1968 - Problems of censusing Reed Buntings, Sedge Warblers and Reed Warblers - *Bird Study*, 15: 16-21.

BELL B. D., CATCHPOLE C. K., CORBETT K. J. & HORNBY R. J., 1973 - The relationship between census results and breeding populations of some marshland passerines - *Bird Study*, 20: 127-140.

BOANO G. & CATTANEO G., 1988 - *Acrocephalus palustris* - In MINGOZZI T., BOANO G., PULCHER C. & coll. - Atlante degli uccelli nidificanti in Piemonte e Valle d'Aosta - *Monogr. Mus. reg. Sc. nat. Torino*, 8.

BRICHETTI P., GARGIONI A. & GELLINI S., 1989 - Selezione dell'habitat in una popolazione di Cannaiola verdognola, *Acrocephalus palustris*, nella pianura lombarda - *Riv. ital. Orn.*, 59: 205-217.

BROWNIE C., HINES J. E. & NICHOLS J. D., 1986 - Constant-parameter capture-recapture models - *Biometrics*, 42: 561-574.

CAROTHERS A. D., 1973 - The effects of unequal catchability on Jolly-Seber estimates - *Biometrics*, 29: 79-100.

DOWSETT-LEMAIRE F., 1978 - Annual turnover in a Belgian population of Marsh Warblers, *Acrocephalus palustris* - *Gerfaut*, 68: 519-532.

DOWSETT-LEMAIRE F., 1981 - Eco-ethological aspects of breeding in the Marsh Warbler, *Acrocephalus palustris* - *Rev. Ecol. (Terre et Vie)*, 35: 437-491.

GREEN R. E., 1976 - Adult survival rates for Reed and Sedge Warbler - *Wicken Fen Group Report*, 8: 23-26.

KELSEY M. G., 1989 - A comparison of the song and territorial behaviour of a long distance migrant, the Marsh Warbler *Acrocephalus palustris*, in summer and winter - *Ibis*, 131: 403-414.

JOLLY G. M., 1965 - Explicit estimates from capture-recapture data with both death and immigration-stochastic model - *Biometrika*, 52: 225-247.

LESLIE P. H., CHITTY D. & CHITTY H., 1953 - The estimation of population parameters from data obtained by means of the capture-recapture method: III. An example of the practical applications of the method - *Biometrika*, 40: 137-169.

LONG R., 1975 - Mortality of Reed Warblers in Jersey - *Ringing and Migration*, 1: 28-32.

NICHOLS J. D., NOON B. R., STOKES S. L. & HINES J. E., 1981 - Remarks on the use of mark-recapture methodology in estimating avian population size. In: Estimating numbers of terrestrial birds - *Stud. Avian Biol.*, 6: 121-136.

POLLOCK K. H., HINES J. E. & NICHOLS J. D., 1985 - Goodness-of-fit tests for open capture-recapture models - *Biometrics*, 41: 399-410.

POLLOCK K. H., NICHOLS J. D., BROWNIE C. & HINES J. E., 1990 - Statistical inference for capture-recapture experiments - *Wildl. Monogr.*, 107: 1-97.

SAETHER B.-E., 1989 - Survival rates in relation to body weight in European birds - *Ornis Scandinavica*, 20: 13-21.

SEBER G. A. F., 1965 - A note on the multiple-recapture census - *Biometrika*, 52: 249-259.

SEBER G. A. F., 1982 - The estimation of animal abundance - 2nd ed., *Griffin*, London.

SPENDELOW J. A. & NICHOLS J. D., 1989 - Annual survival rates of breeding adult Roseate Terns - *Auk*, 106: 367-374.

SVENSSON L., 1984 - Identification guide to European Passerines - 3ª ed., Stockholm.

TAILLANDIER J., 1990 - Premières données sur la dynamique d'une population de Rousserolle effarvatte (*Acrocephalus scirpaceus*) en marais salant de Guérande (Loire-Atlantique) - *Alauda*, 58: 21-28.

VOOUS K. H., 1960 - Atlas of European Birds - *Nelson*, London.

WILLIAMSON K., 1976 - Identification for Ringers 1. The Genera *Cettia, Locustella, Acrocephalus* and *Hippolais* - BTO Guide n. 7, Oxford.