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Estimation of the demographic parameters of Common Reed Warbler *Acrocephalus scirpaceus* breeding in three wetlands of central and northern Italy through data of Capture-Marking-Recapture (CRM)

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Abstract – We used capture-mark-recapture data from three ringing sites in central-northern Italy to estimate adult survival, recruitment and population growth rates of the Common Reed Warbler. We used software MARK to analyze mist-netting data collected according to the Italian Constant Effort Site ringing scheme (named PRISCO). At each site, rate estimates were adjusted for transient birds with respect to sex. Expressed as percentages, survival rates at Palude Brusà (VR) site were 63±6 for both sexes; at Punte Alberete (RA) were 61±4 for males and 48±5 for females; at Emissario Trasimeno (PG) 48±2 for both sexes. Recruitment rates, for both sexes, at Palude Brusà were 46 ± 8, Punte Alberete 50±6 and Emissario Trasimeno 63±6. At Punte Alberete and at Emissario Trasimeno, Common Reed Warbler populations decreased during the study periods; at Palude Brusà the population remained substantially stable. This investigation can not fully prove it, but our experience in these 10 years of study makes us think that populations decline observed above all at Punte Alberete and Emissario Trasimeno, is most likely caused by the incorrect management of the water levels of the reed beds during the reproductive period. At Palude Brusà , although the population remained stable during the period considered, there has been a gradual drainage and burying of the swamp with the consequent loss of the extension and the quality of the reeds. This situation, exacerbated by the small size of the area and its isolation from other wetlands, could cause, also in this site, a decline in the medium term.

Key-words: survival rate, recruitment rate, population growth rate, mist-netting, Constant Effort Site scheme.

INTRODUCTION

The Common Reed Warbler *Acrocephalus scirpaceus* is a polytypical species with a Eurasian distribution breeding in areas with a continental climate at medium latitudes (del Hoyo *et al*. 2006). It is a long-distance migrant, winters mainly in Africa south of the Sahara in a latitudinal range between 4° and 12° N between Guinea and southern Sudan (Zwarts *et al*. 2014). Recaptures of ringed birds carried out in Africa indicate Senegal, Nigeria and Togo among the wintering areas of the Common Reed Warblers nesting in Italy (Spina & Volponi 2009, Volponi pers. obs.). In Italy it nests in the low-altitude wetlands of the peninsula and the major islands rich in reed beds, with a more continuous distribution in the Central-eastern Po Valley. Post-breeding migration occurs between the end of July and October with adults preceding the young birds (Insley & Boswell 1978, Dowsett–Lemarie & Dowsett 1987), while the spring migration begins at the end of March and lasts until the beginning of June (Brichetti & Fracasso 2010). The European populations are basically stable, with an increase in the northern regions and a decline in the southern ones (Brichetti & Fracasso 2010). At the international level and in Italy the Common Reed Warbler is classified as a "least concern" species (L.C.) (Peronace *et al*. 2012, BirdLife International 2016). However, in many areas in Italy, there has been a decline in the population generally attributed to the reduction and fragmentation of wetlands, the burial of marshlands, and the degradation of reed beds (Muzzatti *et al*. 2010, Campedelli *et al.* 2012, Nardelli *et al*. 2015). Recent estimates of the trend of the Italian population of Common Reed Warbler indicate short - and long-term decreases of 15-25% (Nardelli *et al.* 2015). These considerations led us to analyze the data collected through a long-term program of constant effort ringing (PRISCO) to estimate the demographic parameters of this species in three sample locations located respectively in the Central-Eastern Po Plain, on the northern Adriatic coast and in central Italy. Survival, recruitment and population growth rates are considered important indicators of the vitality of populations able to provide useful management indications aimed at protecting the species (Thaxter *et al*. 2006). The aims of our work are:

- to define the short-term trend (ten years) of the three local populations;
- highlight any differences in population dynamics in the three areas;
- highlight the role of the various demographic parameters on the trends observed;
- to evaluate demographic parameters and trends of the populations monitored in relation to the environmental conditions and the management of the wetlands of the study area.

MATERIALS AND METHODS

The survey was conducted in three wetlands located in central-northern Italy:

1. Palude Brusà (PB) (45°10'N, 11°13'E) is a 70-hectare freshwater wetland located in northeastern Italy in the municipality of Cerea (Verona) at an altitude of 13 m a.s.l. The area is bound as a nature reserve and Ramsar area and is included in the Natura 2000 network as a SIC and a ZPS area. The capture site, covering about 6 ha, mainly included areas of marsh reed bed (*Phragmites australis*) interpenetrated by sedges (*Carex* sp. pl.) and mixed shrubs (*Salix cinerea, Salix fragilis, Sambucus nigra, Sambucus ebulus, Cornus sanguinea*) arranged around a pond about 1.5 ha wide and on average 50 cm deep. The average height of the vegetation in which the mist-nets were located was 3.25 m.
2. Punte Alberete (PA) (44°30'N, 12°15'E) is a freshwater wetland located near the Adriatic coast 10 km north of the city of Ravenna. Situated at an average altitude of 4 m a.s.l., it is subject to various protection restrictions and it is included in the Po Delta Regional Park and in the Natura 2000 network. Together with the adjacent Valle Mandriole, it forms the residue of the marshes present until the 1960s in the terminal stretch of the river Lamone and gradually dammed and reclaimed from the first half of the nineteenth century. Extended to around 150 ha, the area is actively managed by water levels and is largely flooded (10-90% depending on the season). In the most notable areas corresponding to ancient dune cordons, 30-50% of the surface predominate shrub and tall tree species (*Populus alba, Fraxinus angustifolia, Salix alba, Ulmus minor)* typical of the hygrophilous Po Valley woods. These alternate with vast meadows of *helophytes* in the temporarily flooded lowlands, canals and open bodies of water in the deepest and permanently flooded areas. The surface sampled with nets, coinciding with the reed bed, had an extension of about 11 ha. The average height of the vegetation in which the mist-nets were located was 3.04 m.
3. The Emissario Trasimeno (ET) capture area (43°06'N, 12°11'E) is located on the southeastern shore of Lake Trasimeno, in the territory of the municipality of Magione (Perugia) at an altitude of 257 m a.s.l. "Oasis of Protection" since 1989, the area is now included in the Trasimeno Regional Park. The Trasimeno is a laminar lake characterized by an area of 122 km^2 with relatively low water levels: the maximum depth is just over 6 m while the average depth of about 4.5 m. In the deepest areas of the lake there are hydrophytic formations belonging to the classes *Charetea, Lemnetea, Potametea*, while in the bank area one finds semi-submerged helophytic communities (in particular the association *Phragmitetum vulgaris*) and riparian scrublands, whose dominant species are *Salix alba, Salix purpurea, Populus nigra* and *Populus canescens* (Venanzoni & Gigante 2000, Venanzoni *et al*. 2006, Landucci *et al*. 2011, 2013). The structure of the vegetation is constantly evolving (Venanzoni & Rampiconi 2001, Lazzerini 2011), also due to the considerable interannual level excursions. The environment suitable for the reproduction of the Common Reed Warbler (reed bed) covered an extension of 348 hectares in the early 2000s (Cecchetti *et al*. 2005), but during the period of the survey it rapidly decreased, continuing a downward trend in progress already in action for some decades (Gigante *et al*. 2011). The average height of the vegetation detected along the transects of the mist-nets was 3.95 m.

The survey was conducted using the technique of capturing, marking and recapturing birds in flight of all ages and sexes. The data analysis concerned only the adult subjects for their greater fidelity to the reproductive site and to the high recapture probability (Borowiec 1983). Birds were caught by means of standard mesh mist-nets with 4 bags and a mesh of 16 mm, with a length of 12 m and a height of 2.80 m. The standard protocol for constant effort capture of the PRISCO project was used (Volponi & Licheri 2002). This protocol follows that of the Constant

Effort Sites scheme (Peach *et al*. 1996) and includes 12 capture sessions, one per decade in the May-August period, with opening of the mist-nets for six consecutive hours from 6 am to 12 pm.

The captures are passive not being allowed the aid of bird callers or other luring elements. As per protocol, the position of the mist-nets has been kept almost unchanged throughout the study period and the vegetation near the mist-nets has been kept constant where necessary, to avoid environmental changes in the capture site. All captured individuals were marked with metal rings provided by ISPRA. During each capture the morphological and morphometric measurements were carried out as indicated by the Italian ringing scheme. For the determination of sex and age, reference was made to Karlsson *et al*. (1988), Svensson (1992) and Jenni & Winkler (1994). In the Palude Brusà station nine mist-nets were arranged to form three transects for a total length of 108 m. The capture histories of 430 adult Common Reed Warblers (255 males and 175 females) ringed in the period 2002-2011 were analyzed. At Punte Alberete, 19 mist-nets were placed in 6 transects with a length between 12 and 60 m for a total of 228 m. The capture histories of 793 subjects (402 males and 391 females) ringed in the period 2002-2010 were analyzed. At the Emissario Trasimeno 10 mist-nets were positioned in a single 120 m transect, oriented perpendicular to the coastline. The capture histories of 1516 individuals ringed in the period 2002-2012 were analyzed (770 males and 746 females). Survival, recruitment and population growth rates were estimated using the MARK v. software. 8.0 (White & Burnham 1999) which uses the "maximum likelihood" theory applied to the histories of capturing marked subjects. The probability of survival F is defined as the probability that an animal of age *v*, alive at time i, survives until time (i +1) (*v* = 0,1,2 ... n; i = 1 ... k- 1) with K equal to the number of capture occasions (Pollock *et al*. 1990). The complement of the survival rate (1 - F) estimated by the capture-recapture models, includes both death and permanent emigration from the original population (an emigrant individual is equivalent to a dead one), so that the survival obtained must be considered a "minimal survival". To verify the basic assumptions of the capture-recapture models (Cormack 1964, Jolly 1965, Seber 1965) (CJS models) the program "RELEASE" and its Goodness of Fit (GOF) or "goodness of fit" tests (test 2 and test 3 in Burnham *et al.* 1987) was used, integrated into the U-Care software v. 2.2 (Choquet *et al*. 2005). The latter were first run on a generic model that allowed the survival probability (F) and the capture probability (p) to vary with sex (s) and years (t) (Fs*t, ps*t in the notation of Lebreton *et al*. 1992). Then, based on the results of tests 2 and 3 that highlighted the presence or absence of any transient subjects (passing birds that do not belong to the study population and emigrate permanently after the marking), it was decided whether to continue with CJS models or with "Time Since Marking" models (TSM) (Pradel *et al*. 1997) that took account of transients, by selecting those that were progressively more restrictive. A recurring problem in the analysis of capture-recapture data, is to consider, together the resident birds (residents) which have nested in the area, also the transient birds (transients) whose inclusion leads to underestimate local survival (Peach *et al*. 1990, 1991, Peach 1993, Cooch & White 2005). With the TSM models two different estimates of survival are elaborated: one for the resident subjects mixed with migrants, and the other for residents only. This second value was considered as an acceptable estimate of local survival. For the notation of the TSM models the bar (/) was used to separate the parameters of the transient+resident subjects (to the left of the bar) from the resident ones (to the right of the bar). For example the F[2t /.] notation means that survival rates of resident females mixed with transient ones varies over time, while resident females have a constant survival rate. Estimates of survival and capture probability were calculated using the best performing models according to the Akaike Information Criterion AICc (Akaike 1973) approximated for small samples (White & Burnham 1999), the value of its weight AICcw (Burnham & Anderson 2004) and following the "principle of parsimony" (Lebreton *et al*. 1992). Buckland & Baillie (1987) found no evidence that the survival rates of adult Common Reed Warblers varies with age, hence age-dependent models are not considered in this paper. The recruitment rate f represents "the number of new subjects entering the population between two capture occasions" (Pradel 1996). For the estimation of recruitment rates not being possible to use the TSM models, the Pradel models (1996) contained in the MARK program were used, associated with capture histories in which the first observations of each individual were eliminated to remove transient subjects, according to the indications of Paradis *et al*. (1993) and Pradel *et al*. (1997). The best fitting model was chosen among those with different recruitment between males and females and those with the same recruitment. The population growth rate l indicates whether a population is growing (l > 1), declining (l < 1) or stable (l = 1). The population growth rate l, divided by sex, were estimated by analyzing capture histories in which the first observations of each individual were eliminated according to the indications of Paradis *et al*. (1993) and Pradel *et al*. (1997) with the use of the Pradel models (1996) integrated into MARK. The average life expectancy was calculated using the formula: -1 / (Log F) proposed by Seber (1982).

RESULTS

The results obtained from the three study areas are shown below. Tab. 1 summarizes the data of the subjects ringed, recaptured and released annually in the three areas.

Palude Brusà

Capture and survival probability in the various years of study were evaluated using nine models. (Tab. 2). The GOF test of the most generic CJS model (Fs*t, ps*t) $\chi^2 = 30.5$; $df = 26$; $P = 0.25$ indicates that the general assumptions of the CJS model are respected. However the 3.SR component (males: $\chi^2 = 20.1$, $df = 7$, $P = 0.01$, females: $\chi^2 = 11.9$, $df = 6$ $P = 0.06$), highlights the presence of transient subjects, to a greater extent among males. The subsequent analysis was then conducted using the TSM models. The best fitting model provides equal and constant survival rates for residents in both sexes. The capture probability was variable over the years for males and constant in females (F1,F2[t / .] p1[t] p2[.]). Estimated survival probability for both sexes was 0.63 ± 0.06 SE. The capture probability in males was variable between 0.10 ± 0.07 SE and 0.75 ± 0.19 SE, while in females it was 0.35 ± 0.08 SE. The estimate of the recruitment rate, obtained with the model F1,F2[.] p1[t] p2[.] f1,f2 [.] (Tab. 3) was 0.46 ± 0.08 SE in both sexes. The estimate of the population growth rate l, obtained with the model F1,F2[t] p1[t] p2 [.] l1[.] l2[.] was 1.04 ± 0.07 SE for males and 1.03 ± 0.03 SE for females. The average life expectancy was 2.2 years. The maximum longevity was achieved by an adult male (ringed with EURING age code 4) recaptured after 3614 days.

Punte Alberete

The GOF test of the most generic CJS model ($\chi^2 = 47.7$; $df = 46$; $P = 0.40$) and all of its components indicate that the general assumptions of the CJS model are respected. The 3.SR test (males $\chi^2 = 10.6$; $df = 7$; $P = 0.16$; females $\chi^2 = 6.01$; $df = 7$; $P = 0.54$) shows a presence, even if not significant, of transient subjects among males and therefore also in this case TSM models were used. The best fitting model provide constant survival rates in the two sexes and capture probability variables over the years in males and constant in females (F1[t /.] F2[. /.] p1[. / t] p2[.]) (Tab. 4). Survival thus estimated was 0.61 ± 0.04 SE in males and 0.48 ± 0.05 SE in females. Capture probability in males was variable between 0.12 ± 0.06 SE and 0.54 ± 0.09 SE; in females it was 0.34 ± 0.06 SE. The estimate of the recruitment rate, obtained with the model F1[.] F2 [.] p1[t] p2 [.] f1,f2[.] (Tab. 5) was 0.50 ± 0.06 SE for both the sexes. The estimate of the population growth rate l, obtained with the model F1[t] F2[.] p1[t] p2[.] l1[.] l2[.] was 0.89 ± 0.05 SE. for males and 0.96 ± 0.02 SE for females. The average life expectancy was 2 years for males and 1.4 years for females. The maximum longevity was reached by an adult male ringed with EURING age code 4, recaptured after 3647 days.

Emissario Trasimeno

The GOF test of the most generic model ($\chi^2 = 54.7$; $df = 44$; $P = 0.13$). informs that the general assumptions of the CJS model are not respected due to the 3.SR component (males $\chi^2 = 23.2$; $df = 9$; $P = 0.006$; females $\chi^2 = 14.3$; $df = 9$; $P = 0.11$) which shows a significant presence of transients in males. The analysis was therefore carried out using the

Table 1. Adult Common Reed Warbler marked, recaptured and released (birds marked during the year + birds recaptured in previous years) in the three areas of study. m. = males; f. = females; r.= ringed; rec. = recaptured; rel.= released.

	Palude Brusà				Punte Alberete				Emissario Trasimeno			
	m.r.	f.r.	rec.	rel.	m.r.	f.r.	rec.	rel.	m.r.	f.r.	rec.	rel.
2002	32	17	-	49	66	59	-	125	79	59	-	138
2003	30	17	9	56	66	47	36	149	92	75	17	184
2004	22	17	2	41	53	42	22	117	65	75	18	158
2005	8	10	6	24	47	42	37	126	68	67	18	153
2006	3	2	4	9	36	45	26	107	110	119	22	251
2007	30	17	8	55	33	59	33	125	55	78	16	149
2008	36	43	8	87	21	28	32	81	67	48	13	128
2009	40	24	5	69	45	36	18	99	47	56	16	119
2010	31	13	7	51	35	33	17	85	58	70	22	150
2011	23	15	11	49					92	68	18	178
2012									37	31	12	80

Table 2. Model selection results for the estimation of survival and capture probability at the Palude Brusà. The best fitting model according to AICc and AICcw values is marked with an asterisk. M2- = TSM model with 2M- classes (transients + residents / residents); *N* Par. = number of parameters; F = survival probability; p = capture probability; t = time interaction; 1= males; 2 = females; [.] = constant parameter.

M2-models	AICc	AICcw	*N*. Par.	Deviance
{F1,F2 [t /.] p1[t] p2[.]}	429.776*	0.99251	20	90.2807
{F1[.] F2[. /.] p1[t] p2[.]}	439.7095	0.00692	13	115.3612
{F1[.] F2[t /.] p1[t] p2[.]}	443.8776	0.00086	21	102.1765
{F1[.] F2[t /.] p1[t] p2[. / t]}	447.3628	0.00015	29	87.6335
{F1[.] F2[. /.] p1[.] p2[.]}	451.2700	0.00003	5	143.640
{F1[t] F2[t /.] p1[t] p2[.]}	452.1404	0.00001	29	92.4111
{F1[.] F2[t /.] p1[.] p2[.]}	454.7988	0	13	130.4506
{F1[.] F2[t / t] p1[t] p2[.]}	458.4319	0	28	100.9944
{F s*t p s*t}	466.822	0	36	90.7322

Table 3. Results of the selection of the best models for the estimate of the recruitment rate at the Palude Brusà. The best fitting model according to AICc and AICcw values is marked with an asterisk. *N* Par. = number of parameters; f = recruitment rate; F = survival probability; p = capture probability; t = time interaction; 1= males; 2 = females; [.] = constant parameter.

Pradel models	AICc	AICcw	*N*. Par.	Deviance
{F1,F2[.] p1[t] p2[.] f1,f2[.]}	290.9249*	0.77166	13	71.0620
{F1,F2[.] p1[t] p2[.] f1[.] f2[.]}	293.3603	0.22834	14	70.0771

Table 4. Model selection results for the estimation of survival and capture probability at Punte Alberete. The best fitting model according to AICc and AICcw values is marked with an asterisk. M2- = TSM model with 2M- classes (transients + residents / residents); *N* Par. = number of parameters; F = survival probability; p = capture probability; t = time interaction; 1= males; 2 = females; [.] = constant parameter.

M2-models	AICc	AICcw	*N*. Par.	Deviance
{F1[t /.] F2[. /.] p1[. / t] p2[.]}	1329.0031*	0.80563	20	167.9535
{F1[t /.] F2[. / .] p1[t / t] p2[.]}	1332.7551	0.12342	27	156.9524
{F1[t /.] F2[. / .] p1[t] p2[.]}	1335.9821	0.02458	20	174.9324
{F1[t /.] F2[.] p1[t] p2[.]}	1336.0187	0.02414	19	177.0581
{F1[.] F2[.] p1[t] p2[.]}	1336.7971	0.01636	11	194.3847
{F1[t/.] F2[. /.] p1,p2[.]}	1339.8011	0.00364	12	195.336
{F1[t /.] F2[. /.] p1[.] p2[.]}	1340.7857	0.00223	13	194.2633
{F s*t, p s*t}	1353.470	0.0001	30	171.270

Table 5. Results of the selection of the best models for the estimation of recruitment rate at Punte Alberete. The best fitting model according to AICc and AICcw values is marked with an asterisk. *N*. Par. = number of parameters; f = recruitment rate; F = survival probability; p = capture probability; t = time interaction; 1= males; 2 = females; [.] = constant parameter.

Pradel models	AICc	AICcw	*N*. Par.	Deviance
{F1[.] F2[.] p1[t] p2[.] f1,f2[.]}	1022.2140*	0.67674	13	107.7694
{F1[.] F2[.] p1[t] p2[.] f1[.] f2[.]}	1023.6917	0.32326	14	106.9682

TSM models. The best fitting model foresees a constant survival probability in the two sexes and a capture probability variable in the years for the males and constant in females (F1[. /.] F2[. /.] p1[. / t] p2[. /.]) (Tab. 6). The estimated survival is 0.48 ± 0.02 SE in both sexes. The capture probability in males varies between 0.11 ± 0.09 SE and 0.78 ± 0.06 SE, while in females it is 0.26 ± 0.08 SE. The estimate of the recruitment rate obtained with the model F1, F2[.] p1[t] p2[.] f1,f2[.]) (Tab. 7) was 0.63 ± 0.06 SE for both sexes. The estimate of the population growth rate l, obtained with the model F1[.]F2[.] p1[.] p2[.] l1[.] l2[.] is 0.97 ± 0.01 SE for both sexes. The average life expectancy was in both sexes of 1.4 years. The maximum longevity was achieved by an adult male with the EURING age code 4, recaptured after 3238 days.

DISCUSSION

The inter-annual survival rate in the Palude Brusà (63%) was higher than those recorded at Punte Alberete (males 61%, females 48%) and Emissario Trasimeno (48%). Thaxter *et al*. (2006) by comparing the demographic parameters of two British populations of Common Reed Warbler, found that high survival rates accompanied by low recruitment rates characterize the smallest and most isolated population living in an area of relative minor extent and, vice versa, survival low and high recruitment in the population in the area with opposite characteristics. These authors state that in the larger and less isolated areas there can be greater reproductive dispersion and therefore a greater turnover of breeding subjects. In the case of the Palude Brusà, the nearest wetland of a certain extent that can act as a "source area" is the Busatello Marsh, which is about 8 km away. The interchange of subjects between these two areas is confirmed by the recapture of four Common Reed Warblers nesting in the study area. Punte Alberete form part of the Po Delta and lies close and in ecological continuity with wetlands (Valle Mandriole, Bardello, Ortazzo, Valleys of Argenta) in which a high concentration of breeding pairs have been detected (Costa *et al*. 2009). As far as Emissario Trasimeno is concerned, the source areas are very close to the study area and primarily involve the strip of reedbed located on the shores of Lake Trasimeno and in particular the

Table 6. Model selection results for the estimation of survival and capture probability at Emissario Trasimeno. The best fitting model according to AICc and AICcw values is marked with an asterisk. M2- = TSM model with 2M- classes (transients + residents / residents); *N*. Par. = number of parameters; F= survival probability; p = capture probability; t = time interaction; 1= males; 2 = females.; [.] = constant parameter.

M2-models	AICc	AICcw	*N*. Par.	Deviance
{F1[. /.] F2[. /.] p1[. / t] p2[. /.]}	1300.227*	0.34799	16	170.8623
{F1[. /.] F2[. /.] p1[. / t] p2[.]}	1300.5461	0.29665	15	173.2219
{F1[. /.] F2[. /.] p1[.] p2[.]}	1302.5922	0.10665	6	193.517
{F1[. /.] F2[. /.] p1[. /.] p2[. /.]}	1303.2698	0.07600	8	190.157
{F1[t /.] F2[. /.] p1[. /.] p2[. /.]}	1305.6998	0.02255	17	174.2922
{F1[. / t] F2[. /.] p1[t] p2[.]}	1308.7789	0.00484	22	167.117
{F1[. /.] F2[. /.] p1[t] p2[t]}	1311.3762	0.00132	24	165.5954
{F1[t /.] F2[t /.] p1[t] p2[.]}	1311.4453	0.00128	33	146.997
{F1[.] F2[.] p1[. / t] p2[. /.]}	1317.524	0.00006	14	192.2376
{F s*t, p s*t}	1323.64	0.00002	38	148.730

Table 7. Results of the selection of the best models for the estimation of recruitment rate at Emissario Trasimeno. The best fitting model according to AICc and AICcw values is marked with an asterisk. *N*. Par. = number of parameters; f = recruitment rate; F = survival probability; p = capture probability; t = time interaction; 1= males; 2 = females; [.] = constant parameter.

Pradel models	AICc	AICcw	*N*. Par.	Deviance
{F1,F2[.] p1[t] p2[.] f1, f2[.]}	865.4716*	0.61757	14	100.0633
{F1[.] F2[.] p1[t] p2[.] f1,f2[.]}	867.1881	0.26179	15	99.3781
{F1[.] F2[.] p1[t] p2[.] f1[.] f2[.]}	868.7376	0.12064	16	98.4948

south-eastern side where numerous and frequent recaptures have been detected. As in the English study, we found higher survival and lower-average recruitment rates (46%) in the less extensive area and with smaller and isolated population (Palude Brusà), while vice versa relatively lower survival rates and more high recruitment rates (63%) in the larger area with a larger and less isolated population (Emissario Trasimeno). The population of Punte Alberete has shown average survival rates (55%) and intermediate recruitment (50%). In the sample of Punte Alberete, survival was greater in males than in females (61% against 48%) while in the stations of Palude Brusà and Emissario Trasimeno there is no statistical support for a difference in survival between sexes. Estimates of the survival rates of adults obtained in the three areas of study are similar or slightly higher (Palude Brusà) than those calculated for populations of French Common Reed Warblers (Taillandier 1990: 54%) and Great Britain (Thaxter *et al*. 2006: 43-58%, Peach 1990: 44-64%, Redfern & Davidson 2003: 54.5%). Survival estimates of 43-57% reported by Bibby (1971), Green (1975, 1976), Long (1975) and Redfern (1978) are not comparable as calculated with models that could include transient subjects. The average capture probability was higher at the Palude Brusà (39%) and lower at the Emissario Trasimeno (average 32%) with values intermediates in Punte Alberete (34%). As in Thaxter *et al*. (2006), the capture probability was always higher in males than in females: Punte Alberete 35% vs 34%, Emissario Trasimeno: 38% vs 26%, Palude Brusà: 43% vs. 35%. The oldest individual during the course of our research, was an adult male (ringed with EURING age code 4) recaptured in Punte Alberete almost 10 years after ringing (3647 days). The minimum age of this Common Reed Warbler is therefore at least 11 years, a value close to the record of longevity of 12 years and 1 month recorded in Sweden, but lower than the absolute record of at least 14 years known for the species (Staav 1998, Fransson *et al*. 2010). The average life expectancy, calculated according to the formula of Seber (1982) was higher in the Brusà (2.2 years) and lower at Emissario Trasimeno (1.4 years). The population trend, calculated with the Pradel models (1996), showed substantial stability for the population of the Palude Brusà. Although the rather high survival rate may explain the slightly positive trend observed in the study period, the analysis shows, however, a poor replacement of breeding subject. This appears in agreement with the hypothesis that the Palude Brusà represents a "small island" of available habitat suitable for reproduction that offers limited possibilities for the immigration of subjects from other areas. The high degree of insularity in the medium to long term could negatively affect the stability of this small population. Another negative factor is the progressive burying of the swamp with a consequent decrease in reed beds as a result of the abandonment of the traditional activity of the winter cut of the reed bed (Pollo *et al*. 2007). In Punte Alberete demographic data confirms the significant decline in the breeding population as seen by the trend in captures, which was negative even beyond the period of this study. After an initial phase of stability, the population showed a numerical decline probably related to the degradation of the aquatic environment and of the reed bed, due to eutrophication and saline wedge ingression coupled with the effects of inappropriate management of summer water levels (with dry setting of the reed bed since the beginning of summer) aimed at the early cut of the reed bed (from the beginning of August) with active nesting and presence of young birds not perfectly flying still on-going (Volponi 2005, 2006). This trend confirms the results of a previous analysis of PRISCO data obtained in the same area in the period 1996-1999, in which lower recruitment rates were estimated and a greater decrease compared to the present survey (Volponi and Pollo, pers. obs.) interpretable with the loss of large areas of reed bed and simplification of the community of *helophytes* due to salinization of surface waters. The high recruitment rate of birds that emigrate from not very distant source areas, together with the consistency of this population that shows relatively high survival rates, are factors that could keep vital the population of Punte Alberete if the management of the marsh vegetation was changed and water conditions were improved. Even for the Emissario Trasimeno in the long term, a moderate decrease in population has been recorded. The estimates of the average population growth rate are however conditioned by the drastic decline in the population during the last year of research (2012 vs 2011: -55%) due to the sudden increase in the lake water level which caused a strong rarefaction of the reed bed in the whole study area. The negative trend is confirmed by the results of a survey carried out in the period 2004-2014 in which the entire perimeter of the lake was sampled using the Listening Point Method, obtaining an estimate of the decrease equal to -2.1% using the TRIM software, which seems to be linked to the decline of the reed bed (Velatta *et al*. 2014). Under these conditions, the high recruitment found may be insufficient to re-establish the population as the nearest "source areas" are themselves declining (Velatta, pers. comm). The general situation thus outlined is quite consistent with surveys conducted at the national level, where a negative trend has been observed for the Common Reed Warbler both in the short (2002-2012) and long term (1990-2012) (Nardelli *et al*. 2015) with an average annual variation of -2.8% and a 23% decrease in the number of pairs contacted in the period 2000-2011 (Campedelli *et al*. 2012, Rete Rurale Nazionale & LIPU 2012). To explain the decline in the Italian populations of Common Reed Warbler, three main factors have been mentioned: 1) loss and/or fragmentation of habitats; 2) management methods in the reproduction areas; 3) climatic factors. Regarding this last factor, the data concerning the wintering areas are controversial. Most of the surveys have not shown the existence of a correlation between precipitation in the African Sahel and the trend of the populations in the reproduction areas (Osterlof & Stolt 1982, Nef *et al.* 1988, Berthold & Fiedler 2005, Weggler 2005, Zang *et al.* 2005, Reif *et al*. 2006, Thaxter *et al.* 2006) with the sole exception of the study conducted at Rostherne Mere (Calvert 2005). Unlike other endangered species (e.g. Sedge Warbler *Acrocephalus schoenobaenus*), the Common Reed Warbler does not electively winter in the wetlands of the Sahel, which are more prone to severe periods of drought, but prefers the arid zones located further south, or the mangrove forests of Guinea Bissau (Altenburg & van Spanje 1989). Even during the spring migration, apart from a few birds which stop at the wetlands in Dyoudy (Senegal) (Bayly *et al*. 2012) and Lake Chad (Ottosson *et al*. 2002), the Common Reed Warblers avoid using the Sahel as a stop-over area. The effects of climatic variations on European breeding populations have not been much studied; however in a research conducted in Poland between 1970 and 2006 it was observed that the increase in temperatures favoured productivity, expanding the egg laying period and the second broods (Halupka *et al*. 2008). More than the global warming that acts on a large scale, we believe that factors that act on a local scale are responsible for changes in the demographic parameters and the decrease in the populations studied. In particular, the observations collected as a corollary of ringing activities show how the transformation, fragmentation and loss of marsh habitats and reed beds due to anthropogenic factors and inappropriate management, are decisive in determining the presence and abundance of *Passeriformes* linked to reed beds. In all three stations there has been a progressive reduction of the areas or the quality of the reed beds during the survey period. According to the results of a monitoring study carried out in the south of France from a dozen wetlands subject to different management of water levels, the period and duration of the maintenance of flooding reed bed conditions and the height of water levels, are key factors in determining the presence and development of the abundant populations of aquatic invertebrates that form the *pabulum* of small *Passeriformes* during the reproductive and migratory period (Poulin *et al*. 2002). As for the cutting of marsh vegetation, often conducted to counteract the natural evolution towards shrub formations, an ideal management plan should include cutting in the winter months and a rotation cut of the old reed beds. Combined with the removal of plant biomass, this allows the re-growth of a more luxuriant reed-bed, a greater possibility of supplying prey items and the production of more robust reeds suitable for nesting (Poulin *et al*. 2002, Thaxter *et al*. 2006). The use of incecticides in the close proximity of wetlands , has to be assessed at a national as well as on the local levels. A recent study carried out in the Netherlands has shown that the decline in the local populations of insectivorous birds, including the Common Reed Warbler, is associated with the use of neonicotinoid insecticides in agriculture. In surface waters, concentrations of Imicloropid higher than 20 ng/l determine an average annual decline of 3.5% (Hallmann *et al*. 2014). The results of the present survey reveal an overall unfavourable trend for the Common Reed Warbler in the three wetlands located in different areas of our country and continues to confirm what has already been found at national level. Our study aims to be a stimulus to monitor the Italian populations of this apparently non-threatened species and to implement a prudent and adaptive management of the wetlands in order to guarantee the conservation and survival of the breeding populations.

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