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Effect of pre-fledging body condition on juvenile survival in Yellow-legged Gulls *Larus michahellis*

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Abstract. Body condition of nestlings can influence their future survival. Here, we used data obtained from a colour-ringing program of Yellow-legged Gull *Larus michahellis* in two colonies from northern Iberia to quantify the relative importance of pre-fledging body size and mass on post-fledging juvenile survival. Chicks were ringed with colour-rings at their colony in June/July when they were almost ready to fledge, and, thereafter, sighting data of these birds were collected over a period of one year and analysed with Cormack-Jolly-Seber capture-recapture models. The Yellow-legged Gull in the region is resident, so sighting data were mostly collected within an area close to natal colonies, where the field effort was intensive. Monthly survival from August onwards was higher than from ringing date to August (0.59 ± 0.06 SE), reaching model averaged values of 0.91 ± 0.03 and 0.98 ± 0.03 for the two colonies analysed. Moreover, condition of chicks (measured as residual body mass and body size) before fledging had a positive effect on survival from ringing date to August, but not from August onwards, when survival was strongly affected by the colony of origin.

Key words: Cormack-Jolly-Seber models, MARK software, northern Iberia, population dynamics, sighting data, fledglings condition, seabirds, demography

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INTRODUCTION

Survival rate is one of the main parameters determining population dynamics (Newton 1998). Population dynamics of seabirds are sensitive to variation in adult survival rates, consistent with a K-strategy, with annual values normally ranging between 0.75 and > 0.95 (Croxall & Rothery 1991). First year of life, by contrast, is characterized by a high mortality rate (Gaston 2004). Unusually high survival rates during this period (hereafter, juvenile survival), however, can have a severe impact on population dynamics. For instance, high food supply during breeding season allows a high reproductive output in large gulls (Oro et al. 1995; Annett & Pierotti 1999, Rock 2005), and also high post-fledging survival. As a consequence of this, some British gull populations have multiplied their numbers by a factor of more than 10 in a single decade (Rock 2005). Knowing juvenile survival is hence of great importance for proper understanding of population dynamics of long-lived organisms, such as seabirds. Although juvenile and sub-adults survival of seabirds can be assessed using multi-state models (Lebreton et al. 2009), the literature on this particular period of life is still rather scarce.

In seabirds, juvenile survival can be divided into two main periods: nestling survival (from hatching to fledging; in large gulls it covers a period of ca. 35–40 days; Olsen & Larson 2004) and post-fledging survival (once chicks fledge and leave the colony). Furthermore, in some species such as the Yellow-legged Gull *Larus michahellis*, these two stages can be also distinguished during the post-fledging period: the one when juvenile birds only move around the colony and depend on parental care (up to ca. 25 days from fledging date in some large gulls, but see Kralj et al. 2014), and a subsequent one during which juveniles leave the surroundings of the colony and become independent (Cramp & Simmons 1983).

Body condition is one of the main parameters determining survival during the nestling period (e.g., Christie et al. 1998). Chicks in poor condition will also be more likely to experience lower survival rates during the nestling period than chicks in better condition (but see Bolton 1991). Birds in poor condition will have smaller safety margins to overcome a period of presumably lower feeding rates until they reach sufficient experience at foraging once they become independent. Therefore, chicks fledging in poor condition will be also expected to suffer lower survival rates after leaving the colony (Ringsby et al. 1998). Once they survive this period, condition at early stages could also affect future survival. In particular, body condition during the nestling period or just before fledging is reported to have long-term effects and to be negatively correlated with post-fledging survival in several bird species (Magrath 1991, Schmutz 1993, Cam et al. 2003, Braasch et al. 2009).

The generalization in the use of colour-rings and the development of numerous networks of birdwatchers in Europe has noticeably improved the efficacy of ringing projects, since colour-rings have allowed to increase resighting rates (Rock 1999). Here, we used data obtained from a colour-ringing program of Yellow-legged Gull chicks from a resident population in northern Iberia to estimate survival of first-year gulls. We used Cormack-Jolly-Seber (hereafter, CJS) capture-recapture models to quantify the relative importance of chick body condition on both short- and long-term juvenile survival.

The Yellow-legged Gull is one of the most abundant large white-headed gulls in south-west Europe (mainly Iberia, southern Mediterranean France and the western Mediterranean islands), north-western Africa and the Macaronesian region (Olsen & Larson 2004, Molina 2009). Two decades ago, the species has colonized the English Channel and some other areas from central-western Europe (Yésou 1991).

METHODS

Study area and data collection

Yellow-legged Gull chicks were ringed in two of the main colonies from Gipuzkoa province (N Spain): Ulia and Santa Clara (Fig. 1, Table 1). During the breeding seasons of 2007 to 2010, 901 chicks with a sufficiently long tarsus to be ringed were marked with both a metallic and engraved colour ring (Table 1). Body mass and tarsus length were also recorded. Normally, ringing was carried out in a single or a few days at each colony, so the protocol was designed to ring as many chicks as possible during the visits.

All chicks were ringed during late June and the beginning of July, only under good weather to prevent possible handling effects on nestling survival. Body mass (20 g accuracy) of each bird was measured with a hand-held 2,000 g balance and the tarsus length measured with a digital calliper (0.01 mm accuracy). The sampling colonies are situated 3.5 km from each other and had a similar nest density (Table 1) and topography (for details see Arizaga et al. 2009).

Dataset consisted of sighting data of gulls seen alive, reported by birdwatchers, compiled from August of 2007 to June of 2011. Although some dead gulls were also found, these comprised

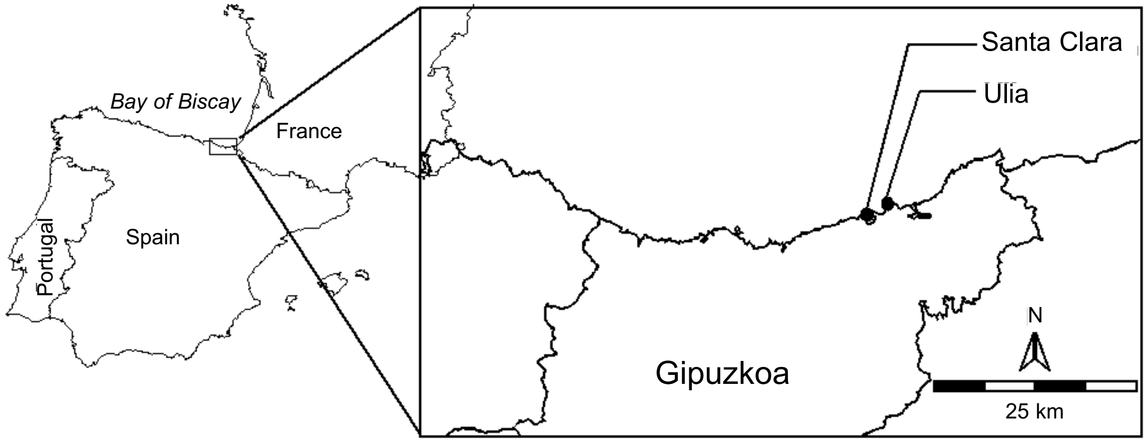

Fig. 1. Location of the two Yellow-legged Gulls colonies where the study was carried out in the province of Gipuzkoa, in the southeastern Bay of Biscay.

Table 1. Colony characteristics and the numbers of chicks ringed each year. Nest density is given as the mean ± SD and the colony size with an accuracy to 25 pairs (both values for 2007), the annual numbers of chicks ringed, and the means (± SD) of tarsus length and body mass.

	Colony	
	Ulia	Santa Clara
Colony features		
Nest density (nest/9 m^2)	0.28 ± 0.06	0.26 ± 0.12
Population size (pairs)	325	100
Chicks ringed		
2007	202	85
2008	199	51
2009	178	50
2010	136	0
Chicks condition		
Tarsus length (mm)	58.4 ± 5.6	59.0 ± 5.0
Body mass (g)	590 ± 140	630 ± 146

< 2% of the sightings and, therefore, we decided to remove them from the analyses. All sighting data were obtained from places outside the colonies (i.e., once chicks had fledged), along the coast or inland, in harbours, rivers, intertidal flats and dumps, etc. (Arizaga et al. 2010). Once they fledge, our population's Yellow-legged Gull first-year birds do not go back to colonies during this period (J. Arizaga, pers. obs.), so the colonies were not surveyed to localize colour-ringed first-year birds. First-year gulls in the area are resident, and most move within the 50 km radius (median distance: 30.9 km) from their natal colonies (Arizaga et al. 2010), so apparent survival calculated with CJS models represents a reliable estimate of true survival in this case, since the emigration component is likely to be negligible. Sightings mostly came from within the region around the study colonies shown in Fig. 1.

Data analyses

We used CJS models to estimate juvenile survival. These models allow to separate survival (φ — probability that a bird survives from t to $t + 1$) from resighting probability (p — probability that a bird sighted at t and still alive in $t + 1$ is sighted at $t + 1$) (Lebreton et al. 1992).

Due to the ringing protocol carried out in the colonies, we cannot assume that all chicks had the same age when they were ringed. We selected for the analyses only chicks with a tarsus length > 58 mm at ringing ($n = 515$), equivalent to an age of > 25 days, i.e. chicks with a tarsus length over the mean (Table 1), thus considered only those chicks which were closer to fledge. Since we aimed to estimate survival from fledging onwards, we intended to remove as much of pre-fledging mortality as possible.

Covariates included into the CJS models were (1) tarsus length and (2) body mass relative to tarsus length. The relationship of body mass on tarsus length fitted a linear function ($r = 0.63$, $F_{1,513} = 328.619$, $p < 0.001$; Standardized B parameters: +0.625, $t = 18.128$, $p < 0.001$; Fig. 2), and was not improved when considering possible alternative models (2nd-degree polynomic: $r = 0.63$, $F_{2,512} = 165.757$, $p < 0.001$; 3rd-degree polynomic: $r = 0.63$, $F_{2,512} = 165.757$, $p < 0.001$; log-log linear relationship: $r = 0.62$, $F_{1,513} = 311.453$, $p < 0.001$). Accordingly, we used residual body mass on tarsus length as an index of condition (Schulte-Hostedde et al. 2005). Apart from these covariates, we tested for the effect of the colony of origin [in this case as a binary (dummy) variable] and the time (month) since the birds were ringed (months 1 to 11). We did not test for the (possible) effect of year and year × colony interactions due to a sample size limitation (e.g., for the colony of Santa Clara no chicks were ringed in 2010; Table 1).

As we wanted to estimate monthly survival, we selected from the data set only sightings collected during the first ten days of each month, hence "capture" events were 1/3 of the time interval for which we wanted to estimate survival. Years were pooled to increase sample size. Time unit here was month and, therefore, ϕ represents survival probability from a given month to the next one.

The data formed a matrix of 12 columns (12 months, from June/July of a ringing year to June of the next one) × 515 rows (individuals) (Appendix 1). The months of June and July were lumped since chicks were ringed mostly at the

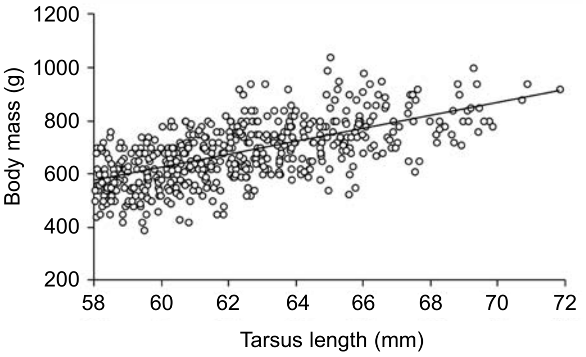

Fig. 2. Relationship of chicks' body mass and tarsus length at the age of ringing. Only chicks with a tarsus length > 58 mm have been considered.

end of June and the number of sighting data obtained in July is very low due to the fact that in this month chicks still remain in or very close to their colonies. CJS models using a logit-link function were run in MARK 6.1 (White & Burnham 1999). Before the analysis we explored the fit of data to CJS assumptions. We used a goodness-of-fit (GOF) test on a starting CJS model where both φ and p varied with time [φ(t) p(t)], performed with the U-CARE software (Choquet et al. 2001, Choquet et al. 2009). The global GOF test for the data set was not significant ($\chi^2_{21} = 32.38$, p = 0.60), although we detected a slight, marginal and negative trap-dependence effect (Z = -2.08, p = 0.04).

Thus, [φ(t) p(t)] was the starting model from which to start to select other models. Corrected Akaike values (AICc) were used to rank models fitted to data (Burnham & Anderson 1998). Models with a ΔAICc < 2 were considered to fit the data similarly, and those for which the difference was > 2 were considered to fit to the data less well. Because models with additional unsupported parameters will be likely to be within 2 AICc units and these models were non-competitive unless the extra parameter leads to a reduction in AICc (Arnold 2010), we analysed in detail the Β-parameters from all models having an ΔAICc < 2 from the best-supported one in order to see if the parameters affected φ. Parameters with a 95% CI including zero showed a non-significant effect of the factor/covariate (Taylor et al. 2004). Finally, we calculated model-averaged parameters using the subset of models with an ΔAICc < 2 in relation to the top one (Burnham & Anderson 1998).

First, we ran all possible models with various patterns in φ and p [constant or affected by time (t)]. From them, φ p(t) was the best model with a ΔAICc = 6.63 in relation to the second one [φ (t) p(t)]. Therefore, and for the subsequent models, we considered p to be affected by time. We expected survival during the first days after the fledging date (June/July) to be lower than later, when gulls are older and have survived a critical period after fledging. Thus, we constructed a new model with two time-categories, t_1 (survival from fledging in June/July up to 31 July), and t_2 (monthly survival between August and June next year), nested within [φ(t) p(t)] as it can be created by setting t_2 parameters equal. This model was found to be better than φ p(t) (ΔAICc = 8.13). Accordingly, we used [φ_{t1}, φ_{t2}, p(t)] as a basic model from which to start to build additive models with covariates/factors (for details see Table 2). Median overdispersion $\hat{c}$ was 1.0 (with a sampling SE = 0.4) and, therefore, the estimates were not adjusted for $\hat{c}$. The survival rate over the first year S_y is a product of all subsequent monthly survival rates [$S_y = t_1 \times (t_2)^{10}$].

RESULTS

The tarsus length of chicks included in the analysis ranged from 58.0 to 71.8 mm, and body mass from 380 to 1040 g. Of 515 chicks, 195 (37.9%) were seen alive at least once after being ringed.

Models with the time effect being lumped into t_1 (survival from nestling to August) and t_2 (monthly survival between August and June of next year) were better supported than models assuming different survival rates among months, or the model which considered a trend in survival rate (Table 2). This shows that after August (i.e., once the most critical post-fledging period is gone), survival did not vary substantially from one month to the next one. Overall, survival from fledging to August was lower than later on (Fig. 3).

With a ΔAICc < 2, the second model had almost equal support (Table 2). Models 1 and 2 assumed effects of either tarsus length or relative body mass on survival in t_1, but not in t_2 (Table 2). Both covariates showed a positive effect on survival (Fig. 4). Moreover, both models revealed an effect of colony on survival in t_2: survival was higher for first-year gulls from Santa Clara than for those from Ulia (Fig. 3).

Considering models 1 and 2, averaged resighting probability, p, ranged from 0.07 ± 0.02 in April to 0.25 ± 0.04 in January (Appendix 2).

According to the model-averaged values obtained for the two colonies (Fig. 3), and considering the mean values of both tarsus length and residual body mass, first-year survival rate ranged from 0.22 (95% confidence interval: 0.09–0.42) at Ulia to 0.46 (95% CI: 0.02–0.69) at Santa Clara (Fig. 5).

DISCUSSION

In this study we used here data from Yellow-legged Gull chicks ringed in colonies from Gipuzkoa, the southeastern Bay of Biscay, northern Iberia, to estimate survival rates of first-year birds in a resident population of this species. The CJS models that best fitted the data had constant monthly survival rate from August of the hatching

Table 2. Cormack-Jolly-Seber models used to estimate juvenile survival of Yellow-legged Gulls during their first year of life. AICc — small sample sizes-corrected Akaike values, ΔAICc — difference of models' AICc values in relation to the top model, φ_{t1} — survival from ringing date in June/July to August, φ_{t2} — monthly survival between August and June of the next year, mass — body mass relative to body size, tars — tarsus length, colo — hatching colony, φ(t) — time-dependent survival, φ(time) — linear trend imputed on survival, p — resighting probability.

Models	AICc	ΔAICc	AICc weight	No. parameters	Deviance
1. φ_{t1}(tars), φ_{t2}(colo), p(t)	2397.51	0.00	0.28	14	2369.00
2. φ_{t1}(mass), φ_{t2}(colo), p(t)	2398.08	0.56	0.21	14	2369.56
3. φ_{t1}(colo), φ_{t2}(colo), p(t)	2400.41	2.90	0.07	15	2369.82
4. φ_{t1}(mass), φ_{t2}(tars), p(t)	2400.49	2.98	0.06	13	2374.05
5. φ_{t1}(colo), φ_{t2}(mass), p(t)	2400.89	3.37	0.05	14	2372.37
6. φ_{t1}, φ_{t2}(mass), p(t)	2400.89	3.37	0.05	14	2372.37
7. φ_{t1}(tars), φ_{t2}(mass), p(t)	2401.50	3.98	0.04	13	2375.05
8. φ_{t1}, φ_{t2}(colo), p(t)	2401.51	4.00	0.04	14	2373.00
9. φ_{t1}, φ_{t2}(tars+mass), p(t)	2401.68	4.17	0.03	15	2371.09
10. φ_{t1}(colo+tars), φ_{t2}(colo+tars), p(t)	2401.81	4.30	0.03	16	2369.15
11. φ_{t1}(tars+mass), φ_{t2}, p(t)	2402.17	4.66	0.03	15	2371.59
12. φ_{t1}, φ_{t2}(colo+mass), p(t)	2402.46	4.95	0.02	15	2371.87
13. φ_{t1}(tars+mass), φ_{t2}(tars+mass), p(t)	2402.58	5.07	0.02	16	2369.91
14. φ_{t1}, φ_{t2}(colo+tars), p(t)	2402.98	5.47	0.02	15	2372.40
15. φ_{t1}(mass), φ_{t2}, p(t)	2403.54	6.03	0.01	14	2375.03
16. φ_{t1}(tars), φ_{t2}, p(t)	2404.90	7.38	0.01	14	2376.38
17. φ_{t1}(colo+mass), φ_{t2}, p(t)	2405.61	8.10	0.00	15	2375.03
18. φ_{t1}(tars), φ_{t2}(tars), p(t)	2406.02	8.50	0.00	14	2377.50
19. φ_{t1}, φ_{t2}, p(t)	2406.25	8.74	0.00	13	2379.81
20. φ_{t1}(colo+tars), φ_{t2}, p(t)	2406.85	9.34	0.00	15	2376.26
21. φ_{t1}(colo), φ_{t2}(tars), p(t)	2406.93	9.42	0.00	14	2378.42
22. φ_{t1}, φ_{t2}(tars), p(t)	2407.11	9.60	0.00	14	2378.60
23. φ (time), p(t)	2407.40	9.89	0.00	13	2380.96
24. φ_{t1}(colo), φ_{t2}, p(t)	2408.19	10.67	0.00	14	2379.67
25. φ_{t1}(mass), φ_{t2}(mass), p(t)	2410.75	13.23	0.00	14	2382.23
26. φ_{t1}(colo+mass), φ_{t2}(colo+mass), p(t)	2414.34	16.82	0.00	16	2381.67
27. φ, p(t)	2414.38	16.87	0.00	12	2390.00
28. φ (t), p(t)	2421.02	23.51	0.00	22	2375.77
29. φ (t), p	2428.81	31.30	0.00	12	2404.43
30. φ, p	2452.28	54.77	0.00	2	2448.27

year to June next year. This supports the idea that, once juveniles left the colony and survive a critical post-fledging period when they still remain in waters near the colony of origin and reach independence, which is about 20–25 days from fledging (Cramp & Simmons 1983), their survival rate was best described as constant. Although juvenile survival cannot be absolutely excluded to differ from month-to-month (from August onwards), this difference (if exists) is likely to be weak, up to becoming undetectable. This constant juvenile survival is probably linked with the fact that food availability does not show fluctuations throughout the year within the region (e.g., Obeso 1988), or at least it is sufficiently high to allow constant rates of survival even in these periods when food availability could be lower. In this scenario, waste taken by gulls from open dumps as well as fish

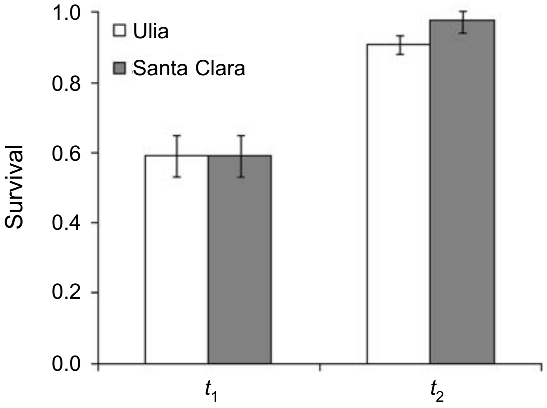

Fig. 3. Averaged (± SE) monthly survival from ringing date to August (t_1) and from August onwards (t_2) for two studied colonies. Model averaging was carried out considering models 1 and 2 from Table 2. Estimates obtained for the population's mean tarsus length and residual body mass.

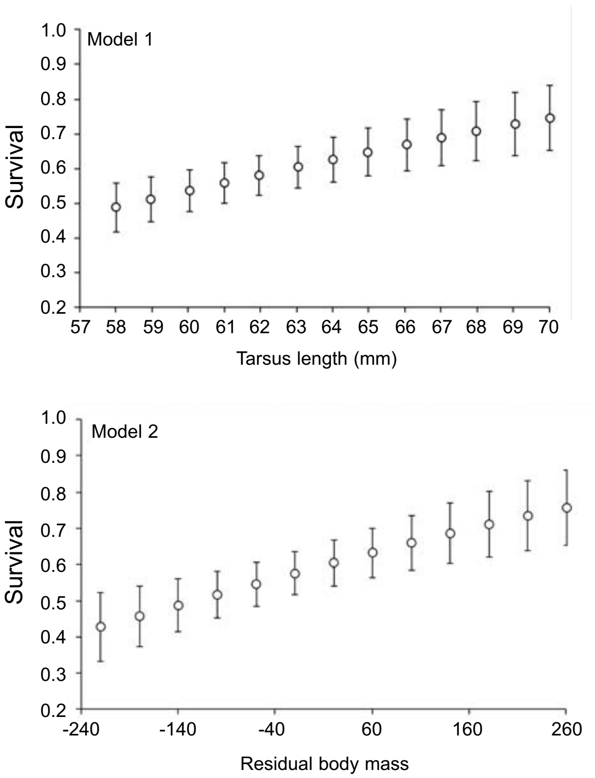

Fig. 4 Effect of tarsus length and body mass relative to body size on survival (mean ± SE) between the ringing date (late June/July) and August of first-year gulls from a resident population from northern Iberia. Values were obtained from models 1 and 2 (Table 2).

discards may have had a role in buffering environmental stochasticity (Arizaga et al. 2013). Nevertheless, we cannot reject the effect of a lack of statistical power to detect differences in monthly survival in our study.

Survival was lower until August than later on. Chicks were ringed not just the fledging day, but some days before. We cannot absolutely exclude that part of this mortality may be linked to the fact that a number of chicks could have been dead when still in the colony and thus survival from June/July to August (t_1) cannot be considered to be represent exclusively post-fledging survival. However, we must also have in mind that we selected chicks with a tarsus length > 58 mm, i.e. almost fully grown chicks. Survival up to fledging in chicks with a long tarsus (i.e., older birds) should be higher than in smaller chicks. Thus, the low survival rate between the ringing date and August was likely to be mainly due to the period when chicks remain in waters surrounding the colony of origin and become independent.

Juvenile survival was observed to be positively affected by chicks condition, measured as the residual body mass and body size, but only up to August. Thus, we did not find evidence that before-fledging body size and condition may have long-term consequences on survival (Nisbet et al. 1999, Cam et al. 2003). In part, this could have been influenced by a strong effect of the colony of origin on survival from August onwards. Models assuming an effect of either residual body mass or body size on survival fitted to the data better than the models assuming constant or time-dependent survival from month to month. However, when the colony of origin was introduced into the models the previous effect became irrelevant. Therefore, we cannot reject a possible long-term impact of pre-fledging residual body mass and body size on survival, although this effect was masked by a much stronger factor.

The Yellow-legged Gull is resident in northern Iberia (Munilla 1997), particularly in our study area: normally, first-year birds move no more than 50 km from their hatching sites (Arizaga et al. 2010). Food analysis revealed that particular colonies within our region seemed associated to specific food resources (Arizaga et al. 2013). This

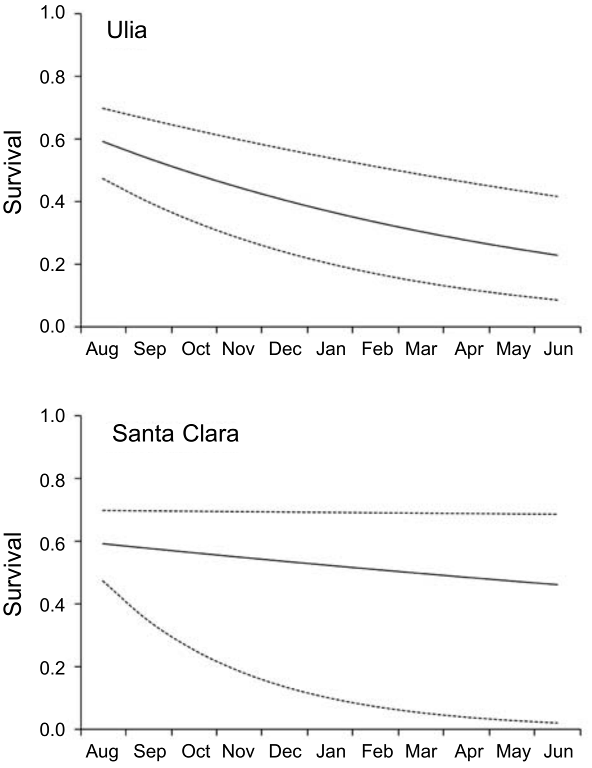

Fig. 5. Cumulative annual survival rate (mean ± 95% confidence interval) of first-year gulls from two studied colonies. Values were obtained after model averaging (models 1 and 2 from Table 2), and given the mean covariate values.

strong dependence for the local conditions would be one of the main causes explaining survival variations within such a small geographic scale.

Juvenile survival rate in our study was below the adult survival rate (normally > 0.85) reported in other closely related species (e.g., Chabrzyk & Coulson 1976, Pons & Migot 1995, Wanless et al. 1996, Allard et al. 2006, Neubauer et al. 2014), or in the Yellow-legged Gull (Brooks & Lebreton 2001, Oro 2008). However, if we only consider the survival values from August onwards, i.e. once the most critical post-fledging period is overcome, we obtained an overall first-year survival rate that would range from 0.4 to 0.8. Thus, even first-year birds in good body condition were not able to reach the rates documented in adult birds. However, juvenile survival (if we consider chicks in better condition) was not lower than found in other studies carried out with first-year Herring Gulls (> 0.65) (but see Paynter 1966, where survival rates of 0.38 were reported; Brown 1967; Kadlec & Drury 1968; Harris 1970; Chabrzyk & Coulson 1976).

In conclusion, juvenile monthly survival was best considered as different for two predefined periods for first-year gulls: from ringing date shortly before fledging to August and onwards. This second rate was higher than the first one, reaching values > 0.9. Moreover, chick condition measured as residual body mass and body size before fledging was observed to have a positive effect on survival up to August, but not long-term, possibly due to the strong effect of the colony of origin on the long-term survival.

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STRESZCZENIE

[Wpływ kondycji piskląt na ich przeżywalność po uzyskaniu zdolności do lotu u mewy romańskiej]

Przeżywalność jest jednym z głównych czynników wpływających na dynamikę populacji. W przypadku młodych ptaków parametrem, który ma istotny wpływ na ich przeżywalność jest kondycja w okresie poprzedzającym uzyskanie zdolności do lotu.

W badaniach wykorzystano dane uzyskane w ramach 4-letniego obrączkowania piskląt mew romańskich kolorowymi obrączkami prowadzonego w dwóch koloniach lęgowych (Ulia i Santa Clara) zlokalizowanych w północnej Hiszpanii (Fig. 1). Celem pracy było określenie znaczenia masy ciała i wielkości piskląt na krótko przed uzyskaniem przez nie zdolności do lotu na ich późniejsze przeżywanie. Pisklęta były obrączkowane w każdej kolonii w ciągu jednego lub kilku dni pod koniec czerwca /na początku lipca przy zastosowaniu reguły, że obrączkowane były tylko pisklęta, których długość skoku pozwalała na założenie metalowej i kolorowej obrączki. Następnie prowadzono obserwacje w celu określenia przeżywalności tych ptaków przez kolejnych 12 miesięcy. Monitoring prowadzony był poza koloniami lęgowymi, gdyż po uzyskaniu zdolności do lotu młode mewy romańskie opuszczają ich teren. Na terenie badań młode mewy romańskie są osiadłe, a najdalej młode tego gatunku stwierdzane były do 50 km od miejsca wyklucia. Ogółem w latach 2007–2010 zaobrączkowano 901 piskląt (Tab. 1, Apendyks 1).

Analizy prowadzono z wykorzystaniem modelu Cormacka-Jolly'ego-Sebera uwzględniając kolonię lęgową, długość skoku oraz kondycję piskląt określaną jako wartość resztowa długości skoku i masy ciała (Fig 2), w dwóch kategoriach czasowych — od uzyskania zdolności do lotu do końca lipca danego roku oraz od sierpnia do czerwca roku następnego. W analizach statystycznych uwzględniono tylko pisklęta, których długość skoku w momencie obrączkowania wynosiła > 58 mm, co odpowiada wiekowi > 25 dni, czyli na krótko przed uzyskaniem zdolności do lotu (n = 515).

Stwierdzono, że wartości przeżywalności oszacowane dla kolejnych miesięcy począwszy od sierpnia były wyższe niż te określone dla okresu od uzyskania zdolności do lotu do końca lipca danego roku (Tab. 2). Wartości prawdopodobieństwa zaobserwowania znakowanego ptaka wahały się od 0,07 do 0,25 w poszczególnych miesiącach (Apendyks 2). Tylko przeżywalność określana dla pierwszego okresu tj. od uzyskania zdolności do lotu do końca lipca wykazywała istotny związek z długością skoku oraz kondycją piskląt (Fig. 4). Wartości przeżywalności dla drugiego wyróżnianego okresu, tj. od sierpnia do czerwca następnego roku różniły się między analizowanymi koloniami (Fig. 3, Fig. 5).

Appendix 1. The m-array table summarising data on ringed and resighted young gulls from the colonies Ulia-Santa Clara, from June/July of 2007 (ringing) to June of 2011. The term R(*i*) refers to the number of birds "released" at each time. Each individual is considered only from June of year when ringed to June of the next year (i.e. during its first year of life). Resightings have been pooled across months.

Occ.	R(*i*)	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	Jun	Total
Ring.	515	29	32	30	34	15	23	12	7	4	6	3	195
Aug	29		2	2	4	1	3	0	0	1	1	1	15
Sep	34			10	6	1	4	1	0	0	0	1	23
Oct	46				10	3	8	5	0	0	0	1	27
Nov	50					5	4	3	5	2	2	1	22
Dec	25						10	3	2	0	0	1	16
Jan	52							8	5	0	1	4	18
Feb	32								4	2	2	3	11
Mar	23									3	1	0	4
Apr	12										2	1	3
May	15											2	2

Appendix 2. Monthly values of p (detection probability) as assessed after averaging model 1 and 2 from Table 2.

Month	Estimate	SE
Aug	0.10	0.02
Sep	0.12	0.02
Oct	0.18	0.03
Nov	0.21	0.03
Dec	0.11	0.02
Jan	0.25	0.04
Feb	0.17	0.03
Mar	0.13	0.03
Apr	0.07	0.02
May	0.10	0.03
Jun	0.13	0.04