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Research paper

# Early-life versus adult survival in a colonising aerial insectivore: the red-rumped swallow

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## Abstract

*Early-life versus adult survival in a colonising aerial insectivore: the red-rumped swallow.* Age-specific survival is a fundamental demographic parameter shaping population dynamics, particularly in species with medium to slow life histories. Despite increasing conservation concern for aerial insectivores, survival estimates remain scarce for many species, including the red-rumped swallow *Cecropis daurica*. Using capture-mark-recapture data collected between 2016 and 2022 in northeastern Iberia, where the species is actively colonising motorway infrastructures, we provide the first estimates of juvenile and adult apparent survival for this species. Multi-event Cormack-Jolly-Seber models revealed a marked difference between age classes: annual apparent survival was 0.068 (SE = 0.034) for juveniles and 0.278 (SE = 0.081) for adults. Recapture probability was moderate ($p$ = 0.579, SE = 0.162), and models indicated stronger support for age-structured survival over constant survival. As expected, survival was much lower for the early post-fledging stage than for adults in a population undergoing recent range expansion. We found no statistically significant differences in adult survival for males and females. In a comparative context, survival values for adults of *C. daurica* were among the lowest reported for hirundinids, especially considering that survival tends to increase with species' body size. Our study establishes a demographic baseline for *C. daurica*, providing parameters essential for predictive population models and for comparative analyses across aerial insectivores, many of which are undergoing widespread declines.

**Key words:** Aerial insectivores, Age-specific survival, Capture-recapture, *Cecropis daurica*, Demography

## Introduction

Age-specific survival is a decisive parameter of population growth in organisms with populations structured by age classes, i.e. with medium and slow life histories (Stearns 1992). Survival is also known to be strongly influenced by weather conditions, which can generate substantial temporal variation in demographic rates (Robinson et al 2007, Balbontín et al 2009). Owing to this sensitivity to climatic and meteorological drivers, survival is a key parameter for forecasting demographic responses to environmental change (Morris and Doak 2002). Juvenile and adult survival may diverge markedly, reflecting age-specific exposure to factors such as reproductive experience, territorial defence, dispersal, and environmental conditions encountered away from breeding grounds (e.g. during migration and/or at wintering sites) (e.g. Cox et al 2020, Forslund and Pärt 1995). The hirundine red-rumped swallow *Cecropis daurica* (Laxman 1769), a cliff- and building-nesting aerial insectivore, remains demographically under-documented despite growing conservation interest in aerial insectivores, most of which are in decline worldwide (Bowler et al 2019, Spiller and Dettmers 2019, Taylor et al 2018, Tella et al 2024). To our knowledge, no published estimates of juvenile or adult survival exist for this species.

Here we provide the first estimates of apparent survival (Φ) for juvenile and adult red-rumped swallow using multi-event capture-mark-recapture modelling and data collected in Catalonia (NE Spain) during 2016-2022. In this area, the species is expanding by recent colonisation due to the leverage of anthropogenic infrastructures as breeding habitat (Wong et al 2022). Due to the relatively short number of years, we could not explore simple ecological predictors relevant to this species' life history, such as annual climate variability in their wintering quarters.

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However, by analysing individuals marked as fledglings and adults, we could test the hypothesis that the latter have a higher survival than the former, as it is usually found in most demographic studies (Stearns 1992). We also tested whether adult males and females differed in survival, as sex-specific demography can provide insight into population processes. By establishing baseline juvenile and adult survival for red-rumped swallows, our study fills a basic demographic gap within Hirundinidae, provides parameters for comparative analyses across aerial insectivores, and offers a starting point for population models assessing how weather variability and/or individual features (e.g. sex, physical condition) may differentially influence early-life versus adult survival in this species.

## Methods

### Biological and breeding traits of the study species

The red-rumped swallow is a medium-sized hirundinid with a body mass ranging from 15-26 g. Sexual dimorphism is absent in juveniles and only weakly expressed in adults, with tail length and tail fork depth being the most reliable traits for sex determination. Adult males tend to be slightly larger than females (Blasco-Zumeta and Heinze 2013, Demongin 2016).

In the study area, breeding occurs from April to August, with one or occasionally two broods per season. Clutch size averages 4.5 eggs, incubation lasts approximately 14 days, and fledging occurs around 24-25 days after hatching (ICO 2025).

In terms of interspecific interactions, *C. daurica* breeds in temporal overlap with other hirundinids (*Hirund rustica*, *Delichon urbicum*) and swifts (*Apus apus*), which are potential competitors for aerial foraging resources. In contrast, when considering nesting substrates, unlike other Iberian regions where displacement from rocky habitats has been reported (Tella et al 2024), the study area lacks such natural substrates. The present population, therefore, likely represents a genuine colonisation facilitated by anthropogenic structures rather than displacement. In this context, interspecific competition for nesting substrates is probably minimal. Nests in our study area are typically isolated, in line with the generally non-colonial nesting behaviour described for the species.

### Study area

The study was conducted in the central and northern Maresme region, a narrow coastal region in northeastern Catalonia characterised by a rugged topography with limited flat areas, numerous seasonal streams and small creeks. The landscape consists of dense Mediterranean forests and shrubland interspersed with agricultural fields, notably strawberry crops. Many of these fields have been abandoned and are reverting to shrubland and woodland. An extensive urban network runs along the coastal plain.

Sampling sites were located beneath tunnels, bridges, and drainage structures along the C-60 and, in particular, C-32 motorway between Argentona (41° 34' 40.9" N, 2° 22' 55.8" E) and Palafolls (41° 41' 13.6" N, 2° 44' 08.6" E). The C-32, built in 1995, runs parallel to the coastline (0 m) and the Montnegre mountain range (700 m). Due to the steep terrain and hydrological network, its construction required multiple engineering structures to overcome elevation differences and facilitate rainwater drainage. These artificial structures have created suitable nesting sites for the red-rumped swallow, which in recent decades has shown an exponential increase in breeding pairs in the area, particularly using these motorway structures (Tobella et al 2018, Álvarez-Cros et al 2021). Historically, the species was first recorded breeding in the region in the early 1980s (Cordero-Tapia 1983). At that time, only a few nests were known, but current evidence indicates a substantial expansion in both number and distribution, likely facilitated by anthropogenic structures such as those found along the C-32.

### Monitoring and capture

All motorway tunnels and bridges were identified using orthophotographs, GIS cartography, and on-site inspections. A complete census of nests was conducted, recording exact GPS coordinates and taking photographs for adequate documentation. During the breeding season, nests were inspected using an endoscopic camera to determine occupancy and to establish the optimal timing for capture and ringing. Inspections were conducted rapidly to minimise the risk of nest abandonment: diurnal checks were performed fortnightly, and nocturnal inspections coincided with ringing sessions (one for adults and one for juveniles per clutch). All fieldwork was carried out between March and October from 2016 to 2022, with up to 80 of the 160 nests (50 %) monitored in detail, varying among years depending on the number of viable and occupied nests, the occurrence of new constructions or losses, and the accessibility of nests for effective monitoring. Nests are frequently reused in subsequent years by the same individuals or by conspecifics (Shields 1984, Tella et al 2024). This reuse behaviour introduces the possibility that our apparent survival estimates could be biased if capture and handling induce nest abandonment, prompting individuals to relocate to less accessible sites rather than representing actual mortality.

Adults were captured at night using a custom-designed hand net with a telescopic pole, enabling access to nests located at varying heights. The net's ring was fitted with broom bristles to close gaps against irregular surfaces, and the collecting bag consisted of a transparent tubular plastic section to prevent birds from escaping. Once captured, individuals were handled for less than five minutes, including banding, measurement, and photographic documentation, to minimize stress and reduce the risk of nest abandonment. Individuals were ringed with standard metal bands to allow for individual identification, measured, and temporarily held overnight. This procedure was adopted to minimize predation risk and to ensure post-capture survival, as releasing individuals outside the nest immediately after handling could leave them exposed to predators. Juveniles were ringed from the third week after hatching, when they had fledged but continued roosting in the nest. All individuals were released at the capture site the following morning. A total of 737 captures were made (415 adults and 322 juveniles), of which 234 were recaptures. Released adults were subsequently observed attending their nests and fe-

eding offspring, suggesting that the capture and handling protocol did not interfere with parental care or generate biased survival estimates due to permanent emigration from the study nests.

### Capture-recapture modelling

We fit Cormack-Jolly-Seber (CJS hereafter) models in a multi-event framework that accounts for imperfect detection and allows survival to vary by age and time. As a first step, we assessed the goodness of fit of the underlying standard (uni-state) CJS model by treating age classes (juveniles vs adults) as groups and running GOF tests in U-CARE (table S1). Since the GOF test did not show deviations from CJS models (i.e. there was no overdispersion), we considered the data to be adequately described by the CJS assumptions and did not correct models using a c-hat different from 1 (see table S1). We then used this result ($\hat{c} \approx 1$) as the basis for the subsequent multi-event analyses. We subsequently built CMR multi-event models using E-SURGE software (see details in table S2), which provides a multi-event parameterisation of the same age-structured CJS model. In our case, this multi-event formulation is equivalent to a CJS model with two age classes (juveniles and adults) and a single "alive" state; the matrix shown in table S2 describes this state and event structure. In our case, the multi-event formulation used three latent states: "juvenile alive" (J), "adult alive" (A) and "dead" (D). Individuals first marked as juveniles occupied state J at first capture and then moved deterministically to state A after the first annual interval (transition probability J → A fixed to 1), whereas adults entered directly in state A; state D was absorbing. The associated transition matrix thus took the form:

$$\Psi = \begin{pmatrix} 0 & \Phi_J & 1-\Phi_J \\ 0 & \Phi_A & 1-\Phi_A \\ 0 & 0 & 1 \end{pmatrix}$$

where $\Phi_J$ and $\Phi_A$ are apparent annual survival probabilities for juveniles and adults, respectively. Observation was modelled with three events: "not detected" (e = 0), "captured as juvenile" (e = 1) and "captured as adult" (e = 2). Conditional on being alive, the event matrix was:

$$\mathbf{B} = \begin{pmatrix} 1-p_J & p_J & 0 \\ 1-p_A & 0 & p_A \\ 1 & 0 & 0 \end{pmatrix}$$

where $p_J$ and $p_A$ denote capture and recapture probabilities for juveniles and adults, respectively, and dead individuals (state D) can only produce the "not detected" event. We note that we fixed the first capture of juveniles because E-Surge uses the initial capture within the events step, but in reality, juveniles are adults when recaptured. Table S2 summarises this state-event structure and its implementation in E-SURGE. Individuals first marked as juveniles were allowed to move deterministically to the adult age class after their first annual interval (transition probability fixed to 1), so juvenile and adult apparent survival were estimated as distinct parameters rather than mixing both age classes. These models were first fitted to the full dataset, without including sex, in order to estimate age- and time-specific apparent survival and recapture probabilities. We then evaluated a set of biologically plausible CJS hypotheses about temporal and age effects on apparent annual survival (Φ) and on recapture probability (*p*). Specifically, our candidate set included models in which Φ was (i) constant over time, (ii) varied among years (time effect), (iii) differed between age classes (age effect; in our case, juveniles and adults), and (iv) included both age and time effects (additive and, where appropriate, age × time interaction). We also tested whether survival varied with sex, owing that hirundinid males commonly showed higher survival than females (see below). Because sex could not be reliably determined for juveniles, only adults were sexed. Sex was determined using reproductive characters when present, namely the presence of an incubatory brood patch in females or a cloacal protuberance in males, or otherwise based on non-overlapping biometric differences in rectrix length (Demongin 2016), resulting in a dataset of 95 females and 93 males of known sex. For this sex-specific analysis, we therefore restricted capture-recapture histories to these marked adults and treated sex as a group covariate on Φ and *p* in a standard two-group CJS model (with a single adult "alive" state and no juvenile state), so that sex differences were evaluated only for adult apparent survival. We did not implement more complex multi-event models with an additional "unknown sex" state, and our sex-specific inferences therefore apply only to the subset of adults of known sex.

We used Akaike's Information Criterion (AIC) for model selection by information theory (Burnham and Anderson 2002). For each fitted model, we calculated AIC, ΔAIC (difference from the minimum AIC), and Akaike weights ($w_i$) as follows:

$$w_i = \exp(-0.5 * \Delta_i) \,/\, \Sigma_j \exp(-0.5 * \Delta_j)$$

where $\Delta_i = AIC_i - \min_j(AIC_j)$.

Models with $\Delta AICc \leq 2$ of the best model were considered to receive substantial support and be statistically equivalent.

For a comparison of adult survival among hirundinid species and their body size, we used available estimates from the literature (table S3), and these were plotted using RStudio (4.5.1).

## Results

The selected multi-event model (CMR) included the two age classes for apparent survival and a constant, time-invariant, recapture probability (table 1). Annual juvenile survival for the red-rumped swallow was estimated at 0.068 (SE = 0.034; 95 % CI: 0.025-0.173), whereas adult survival was, as expected, much higher (mean: 0.278, SE = 0.081; 95 % CI: 0.149-0.459). Although the confidence intervals for both age classes showed slight overlap, which explains why a model with constant survival performed almost as well (table 1), we report estimates from the age-structured model, as juvenile survival is typically lower than adult survival in most demographic studies. The selected model estimated an overall recapture probability of *p* = 0.579 (SE = 0.162; 95 % CI: 0.272-0.836).

**Table 1.** CMR models tested to estimate survival for the red-rumped swallow during 2016-2022. Survival (Φ) and recapture (*p*) were modelled as constant (·), time-dependent (t), and age-dependent (age). # Par, number of parameters of the model; Dev, deviance of the model; AIC, AICc is Akaike Information Criterion for small sample sizes; ΔAICc, difference in AICc value with the best model; $AICc_w$, weight of the model.

| Model | # Par | Dev | AICc | ΔAICc | $AICc_w$ |
|---|---|---|---|---|---|
| Φage, p. | 3 | 275.090 | 281.090 | 0.000 | 0.484 |
| Φ·, *p.* | 2 | 277.753 | 281.753 | 0.639 | 0.351 |
| Φage, *p.* | 7 | 270.066 | 284.066 | 3.153 | 0.100 |
| Φ., *p.* | 6 | 274.555 | 286.555 | 5.586 | 0.030 |
| Φt, *p.* | 6 | 275.468 | 287.468 | 6.499 | 0.039 |
| Φage+t, *p.* | 8 | 272.249 | 288.249 | 7.401 | 0.025 |
| Φt, *pt* | 9 | 272.413 | 290.413 | 9.638 | 0.008 |
| Φage+t, *p.* | 12 | 269.391 | 293.391 | 12.886 | 0.002 |

**Table 2.** CMR models were built to test whether adult survival for males was higher than that of females in the red-rumped swallow during 2016-2022. Survival (Φ) and recapture (*p*) were modelled as constant (·), sex-dependent (s), and time-dependent (t). # Par, number of parameters of the model; Dev, deviance of the model; AICc, Akaike Information Criterion corrected for small sample sizes; ΔAICc, difference in AICc value with the best model; $AICc_w$, weight of the model.

| Model | # Par | Dev | AICc | ΔAICc | $AICc_w$ |
|---|---|---|---|---|---|
| Φ., *p.* | 3 | 247.045 | 253.045 | 0.000 | 0.491 |
| Φs, *p.* | 4 | 246.223 | 254.223 | 1.178 | 0.273 |
| Φs*t, *p.* | 11 | 234.433 | 256.433 | 3.388 | 0.090 |
| Φt, *p.* | 7 | 243.274 | 257.274 | 4.229 | 0.059 |
| Φs+t, *p.* | 8 | 242.220 | 258.220 | 5.175 | 0.037 |
| Φ., *pt* | 7 | 244.714 | 258.714 | 5.669 | 0.029 |
| Φs, *pt* | 8 | 244.110 | 260.110 | 7.065 | 0.014 |
| Φt, *pt* | 10 | 241.682 | 261.682 | 8.637 | 0.007 |

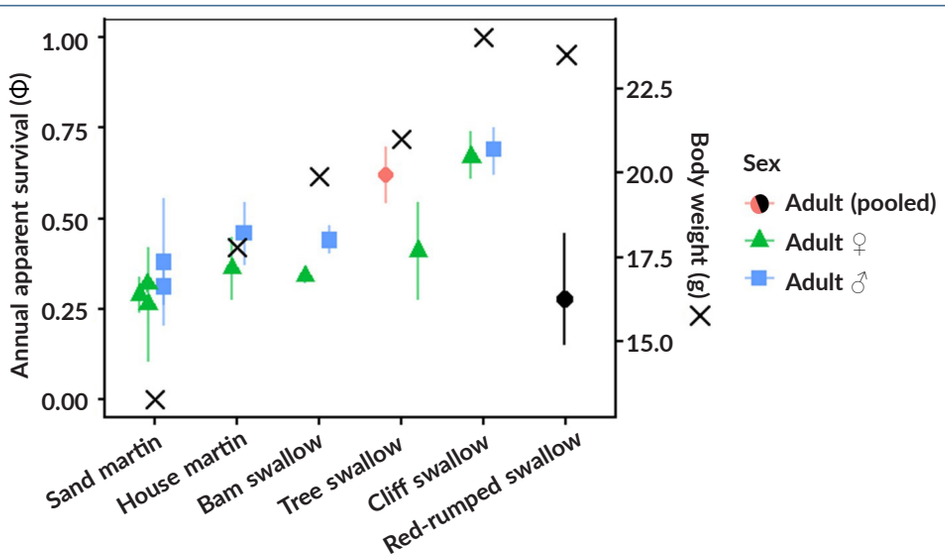


**Fig. 1.** Survival estimates (mean and 95% confidence intervals) for several species of swallows from CMR modelling that are available in the literature (see table S2 for details). The values for the red-rumped swallow correspond to the data from the present study. Black crosses indicate the mean body weight of each species. Body weight values (in g) for adult hirundinids are taken from the BTO species accounts (https://www.bto.org/learn/about-birds/bird-families/hirundinidae-swallows-and-martins), except for the red-rumped swallow, for which we use our own measurements. These values are assumed to represent average weights across adult males and females.

Models that tested the sex differences in survival for males and females showed that the most parsimonious model had constant survival (table 2). A model considering sex differences between males and females performed well (ΔAICc = 1,178, see table 2) and showed that males, as expected, had a higher survival estimates than females, but CI largely overlapped (for males, mean: 0.345, SE = 0.07, 95% CI: 0.220-0.496; for females, mean: 0.257, SE = 0.07, 95% CI: 0.147-0.410).

When compared with other CMR survival estimates for other hirundinid adults, that from our study on the red-rumped swallow was the lowest, although values were very close to several estimates available on sand martins *Riparia riparia* (fig. 1).

## Discussion

Our study provides the first age-structured estimates of local (apparent) survival for the red-rumped swallow, filling a basic demographic gap for the species. Because CMR survival estimates confound mortality with permanent emigration, we interpret them as conservative,

minimum corrected values with respect to true survival, a standard caveat in mark-recapture inference (Lagrange et al 2017). However, our fieldwork methods suggested that manipulation during marking and recapturing did not generate nest abandonment and, in turn, permanent breeding dispersal to other, non-accessible nests.

When we compared survival estimates with other hirundinids, adult apparent survival varies widely among species and regions. Males commonly showed higher survival than females. We also see a slight association between higher survival and larger body size; although red-rumped swallows from our study seem to be an outlier of such an association (fig. 1 and table S3). However, any cross-species comparison should be cautious, given that permanent dispersal, density-dependence and the environmental stochasticity over the study temporal window can bias apparent survival estimates differently among studies (Badia-Boher et al 2023). For instance, between-year rates of both nest occupation and nest abandonment differ among hirundinid species (Tella et al 2024), which suggests that differential permanent nest dispersal may hinder inter-species demographic comparisons.

An interesting aspect of our study system is that it lies at the colonising front of the species' range. In general, little is known about the demography of species colonising a region. When the region holds suitable environments, demographic traits commonly show high values far from the carrying capacity, although they can also be negatively impacted by positive density-dependence (i.e. Allee effects). In our study, colonisation has likely been fostered by the creation of anthropogenic infrastructures suitable as breeding habitat (see also Tella et al 2024), but we lack data about the amount of available food, interspecific competition and other ecological processes compared to the core regions within the distribution range of the species, and no survival estimates are available for other areas of the Iberian Peninsula. In core areas of the Iberian Peninsula, the usurpation of red-rumped swallow nests by house sparrows *Passer domesticus* has dramatically increased from 2 % in the 1970s to 35 % of the nests in recent years (Tella et al 2024).

Across temperate regions, long-term studies on aerial insectivores show that they have declined more than many other ecological guilds (Bowler et al 2019, Nebel et al 2010, Spiller and Dettmers 2019). These studies suggest that this decline has been caused by interacting drivers, such as reduced aerial prey due to insecticides, habitat change, phenological shifts, and conditions on migration routes and wintering grounds (Bowler et al 2019, Wong et al 2022). From a demographic perspective, our age-structured estimates suggest that variation in adult survival is expected to contribute disproportionately to long-term population trends compared to similar proportional changes in juvenile survival, whereas our inability to detect sex differences in survival should be interpreted cautiously because it may partly reflect limited statistical power rather than the true absence of sex-specific effects on population dynamics. This pattern underscores the importance of obtaining baseline demographic data for hirundinids, particularly in applying matrix population models to predict the fate of populations for which demographic estimates are available.

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**Author contributions**
**C Tobella**, **F Turon** and **D Oro** conceived the study; **F Turon** coordinated the fieldwork; Data collection, capture and marking of individuals were carried out by **F Turon**, **J Grajera**, **C Tobella**, **E Badosa** and **R Calderón**; Data curation was performed by **D Oro** and **C Tobella**; Formal statistical analyses were conducted by **D Oro**; Visualisation was carried out by **C Tobella** and **D Oro**; The original draft of the manuscript was written by **D Oro** and **C Tobella**; All authors reviewed, edited and approved the final version of the manuscript.

**Conflicts of interest**
The authors declare that they have no conflicts of interest.

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## Supplementary material

**Table S1.** Results from GOF tests for the study dataset. Group 1 corresponds to individuals first captured as juveniles, and group 2 to individuals first captured as adults. The group corresponds to age. GOF tests were performed on a standard uni-state CJS model (age classes treated as groups) in U-CARE, and the resulting ĉ was then used for the multi-event models fitted in E-SURGE. Because the number of juveniles was small, only TEST3.SR could be reliably computed for group 1, whereas all test components (TEST2.CT, TEST2.CL, TEST3.SR and TEST3.SM) were available for group 2 (adults).

| Test | $\chi^2$ (Quadratic) | df | $\hat{c} = \chi^2/df$ |
|---|---|---|---|
| TEST3.SR, group 1 | 8.0941 | 5 | 1.6188 |
| TEST3.SR, group 2 | 3.9235 | 4 | 0.9809 |
| TEST3.SM, group 2 | 0.0000 | 2 | 0.0000 |
| TEST2.CT, group 2 | $1.7425\times10^{-31}$ | 2 | 0.0000 |
| Global TEST (2 groups) | 12.0176 | 13 | 0.9244 |

**Table S2.** Matrix (GEPAT) and notation (GEMACO) of the best model as an example for multi-event CMR modelling in our study. State and event structure of the multi-event age dependent Cormack-Jolly-Seber model fitted in E-SURGE. The three latent states are "juvenile alive" (J), "adult alive" (A) and "dead" (D). The three observation events are "not detected" (0), "captured as juvenile" (1) and "captured as adult" (2). Individuals first marked as juveniles enter state J (first state) and move deterministically to state A (second state) after their first annual interval; adults enter directly in state A (second state), and state D (third state) is absorbing. The corresponding 3×3 transition and event matrices are given in the Methods. Note that for all models probability of capture at first capture (i.e. the first event in capture histories, noted "firste" in GEMACO) was fixed to 1 within the IVFX step of E-Surge.

| | | | |
|---|---|---|---|
| # of step for initial state: | 1 | | |
| Phrase for step 1 | to | | |
| Number of shortcuts | 0 | | |
| Size of pattern matrix | 1 | 2 | |
| | i | * | |
| Name file for covariates: | defaultfile | | |
| # of step for transition: | 1 | | |
| Phrase for step 1 | f.to | | |
| Number of shortcuts | 0 | | |
| Size of pattern matrix | 3 | 3 | |
| | - | f | * |
| | - | f | * |
| | - | - | * |
| Name file for covariates: | defaultfile | | |
| # of step for encounter: | 1 | | |
| Phrase for step 1 | firste+nexte | | |
| Number of shortcuts | 0 | | |
| Size of pattern matrix | 3 | 2 | |
| | * | b | |
| | * | b | |
| | * | - | |
| Name file for covariates: | defaultfile | | |

**Table S3.** CMR survival estimates for Hirundinidae. All values are annual apparent survival (ϕ) from CMR (CJS/multistate), with SE and/or 95% CI when available.

| Species | Region | Years | Age_sex | Survival | SE | CI_LOW | CI_HIGH | Citation |
|---|---|---|---|---|---|---|---|---|
| Sand martin | Po River, | 2002-2014 | Adult ♂ | 0.379 | 0.090 | 0.203 | 0.555 | (Masoero et al 2016) |
| (*Riparia riparia*) | Italy | | Adult ♀ | 0.262 | 0.081 | 0.103 | 0.421 | |
| Sand martin | UK | 1973-2003 | Adult ♂ | 0.312 | 0.026 | 0.261 | 0.363 | (Cowley and |
| (*Riparia riparia*) | (BTO data) | (approx.) | Adult ♀ | 0.289 | 0.026 | 0.238 | 0.340 | Siriwardena 2005) |
| Sand martin | UK | 1986-2011 | Adult ♂ | 0.38 | 0.012 | 0.357 | 0.403 | (Norman and Peach 2013) |
| (*Riparia riparia*) | | (approx.) | Adult ♀ | 0.318 | 0.012 | 0.294 | 0.342 | |
| Cliff swallow | Nebraska, | 1997-2010 | Adult ♂ | 0.690 | 0.033 | 0.62 | 0.75 | (Brown et al 2013) |
| (*Petrochelidon* | USA | | Adult ♀ | 0.670 | 0.033 | 0.61 | 0.74 | |
| *pyrrhonota*) | | | | | | | | |
| Barn swallow | Switzerland | 1997-2004 | Adult ♂ | 0.440 | 0.020 | 0.401 | 0.479 | (Schaub and |
| (*Hirundo rustica*) | | | Adult ♀ | 0.340 | 0.010 | 0.320 | 0.360 | Hirschheydt 2009) |
| House martin | UK | Long-term | Adult ♂ | 0.458 | 0.044 | 0.372 | 0.544 | (British Trust for |
| (*Delichon urbicum*) | | RAS | Adult ♀ | 0.362 | 0.045 | 0.274 | 0.450 | Ornithology 2025) |
| Tree swallow | Wisconsin, | 7-yr series | sex pooled | 0.620 | 0.040 | 0.542 | 0.698 | (Clark et al 2018) |
| (*Tachycineta bicolor*) | USA | | | | | | | |
| Tree swallow | Southeastern | 1975-2017 | Adult ♀ | 0.410 | 0.015 | | | (Cox et al 2020) |
| (*Tachycineta bicolor*) | Ontario, Canada | | | | | | | |
| Red-rumped swallow | Catalonia, | 2016-2021 | sex pooled | 0.272 | 0.069 | 0.137 | 0.407 | This study |
| (*Cecropis daurica*) | Spain | | | | | | | (Tobella et al 2026) |