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Survival rates of young Magpies *Pica pica* in a mountain population of eastern Spain

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Abstract. The aim of this study was to estimate the survival of young Magpies between fledging and the next breeding season and to identify some of the factors affecting it. A total of 50 nestlings were colour-ringed in two breeding seasons in the valley of the Pitarque River (Teruel, E Spain), and were monitored weekly until May of the following year. 59 nestlings were also colour-ringed in two nearby localities (4–5 km) to detect possible dispersal to and from our study area. Mark-recapture analyses were used to estimate weekly survival, which was assumed to be constant for periods of four weeks in order to reduce the number of parameters. Models with the effect of time, age class, season and year were fitted, and the best models were selected using quasi-likelihood Akaike's Information Criterion adjusted for small sample sizes ($QAIC_c$). The best three models included seasonal variation in survival, and the second and third models also selected the effect of age class. The seasonal variation in the survival of young Magpies exhibited two critical moments: firstly, on becoming independent of the parent birds (August–September), and secondly, when individuals abandoned the communal roost and started to establish their own territories (February–March). The weight of 14-day-old nestlings positively affected survival until 4 and 6 months after leaving the nest. No evidence for dispersal was found; this supports the view that survival does indeed decrease in the cited periods, possibly because of the increased risk of predation.

Key words: Magpie, *Pica pica*, survival, population tendency, mountain area, population, Spain

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INTRODUCTION

Numerous studies deal with bird breeding success until nestlings have left the nest (e.g., Nice 1957, De La Puente & Yanes 1995, Gil-Delgado & Lacort 1996, Ponz et al. 1996, Yanes & Suárez 1996). However, studies covering the period between fledgling and the next breeding season are scarce (e.g., Husby & Slagsvold 1992, Anders et al. 1997, Adams et al. 2001, Naef-Daenzer et al. 2001, Todd et al. 2003, Adams et al. 2006, Wiens et al. 2006). It has been suggested that in this period there are two moments when mortality may be most important. One of them is during the first days after leaving the nests, when fledglings completely depend on parents. There is evidence that juvenile mortality is particularly high during the first weeks after leaving the nest (Perrins 1979, 1980, Drent 1984, Magrath 1991, Naef-Daenzer et al. 2001). The second critical moment is when juvenile disperse, that begins just after offspring become independent from their parents and they abandon the parental territory (Eden 1987, Hagen et al. 2005).

Several studies deal with the ecology and behaviour of Magpies (Baeyens 1981, Hogstedt 1981, Reese & Kadlec 1985, Birkhead 1991, Jerzak 1994, Eguchi 1995, Soler et al. 1996, Antonov & Atanasova 2003, Ponz & Gil-Delgado 2004), among them that studying nest success and post-fledging survival (Birkhead & Goodburn 1989). Husby & Slagsvold (1992) pointed out that the knowledge of post-fledging survival is essential for the evaluation of different breeding strategies. Studying

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the Magpie in an urban environment, they observed that smaller nestlings tended to suffer a higher rate of post-fledging mortality than larger ones, and that post-fledging survival seemed to be independent of sex, brood size, age at fledging and age differences between the fledglings. However there are differences between rural and urban environments that may be important for the Magpie ecology. For instance, food availability and predator abundance may be different and so the study of factors affecting survival in a rural area may provide new valuable information.

In this paper we aim to study the survival of young Magpies between fledging and next breeding season. This work has been carried out in a rural environment of mountain, which is close to zones where the Magpie has been extinguished recently (Ponz 2005). Our objective is to investigate which are the most critical periods in the time interval between the moment when fledglings abandon the nest and the start of the following breeding season.

METHODS

The study area was located in the valley of the Pitarque River (Teruel, eastern Spain, 40°30′N 0°35′W, 950–1 200 m a.s.l). The structure and distribution of the vegetation has been conditioned by agriculture and sheep raising. The main cultivated species were sainfoin *Onobrychis viciaefolia*, lucerne *Medicago sativa*, and potatoe *Solanum tuberosum*. Today some fields are being abandoned and colonized by the semi-evergreen zeen oak *Quercus faginea*, a forest characteristic of the valley. More information about the study area is provided in Belda et al. (1998) and Ponz & Gil-Delgado (2004).

The data on survival of young Magpies were collected during 1994–1996, through offspring's tracking that they flew with success of 17 nests in the breeding periods of the years 1994 and 1995. More information on the nests, the reproductive biology and the methods of study, can be found in Ponz & Gil-Delgado (2004). Fifty chicks were ringed in Pitarque using metallic and individual combinations of colour rings. All chicks were checked weekly, by locating them in the family groups during the summer period, and during the autumn-winter period, in the communal roosting sites (Ponz & Monrós 2000). To test if some young of the study population disperse to other localities nearby, we watched two close populations: Villarluengo (6 pairs, 5.5 km) and Las Coronas (7 pairs, 4 km). Moreover, we ringed 27 and 32 nestlings in Villarluengo and Las Coronas to detect if some of these individuals immigrate to the main study area.

Mark-recapture analyses were conducted using MARK software (Cooch & White 2005) in the three following steps: 1) selection of the global model, 2) goodness-of-fit tests, and 3) fitting and selection of reduced models with fewer parameters. We have considered three possible effects on survival in the global model. The effect of age was included by considering two age classes, age "1" that corresponds to the first six weeks after leaving the nest, the average period that young depend on the parents (Birkhead 1991) and age "2" for the rest of the time. Seasonal variation in weekly survival (t) was modelled forcing the survival of four consecutive weeks to be the same. We choose this strategy in order to reduce the excessive number of parameters needed given that birds were monitored weekly. Between-year variation (y) was modelled only within the age class "2", since the number of individuals included in age "1" is low in most weeks. Thus, the global model for survival has the structure ϕ(*age 1*)**t*, (*age 2*)**t***y*. In our recapture data set, all marked individuals were observed weekly until they disappeared, i.e. recapture histories have no zeros interspersed among ones. Thus, recapture probabilities (p) were forced to be equal to one.

A parametric bootstrap goodness-of-fit test (200 replicates) was used to test whether mark-recapture data met the assumptions of independence and no heterogeneity (Cooch & White 2005). The deviance of the general model was bigger than the maximum obtained in all the bootstrap simulations, thus meaning a lack of adjustment of the global model to the data and that some of the assumptions of the model were violated. The probable cause is a lack of independence of the chicks from the same nest, even after becoming independent from the parents. In this type of situations there exists an excess of variation in relation to the expectation in the binomial distribution (overdispersion), thus it is necessary to correct the variances and the criteria of model selection by the parameter c of overdispersion or variance inflation factor (Lebreton et al. 1992, Burnham & Anderson 2002). We have estimated c, as described by Cooch & White (2005) as 1.2706.

Model selection was based on quasi-likelihood Akaike's Information Criterion adjusted for small sample sizes ($QAIC_c$, Burnham & Anderson 2002).

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Models where $QAIC_c < 2$ from the best fit model (lowest $QAIC_c$) were considered equally parsimonious. The ratio of AIC_c weights between two models was used to quantify a relative degree to which a pair of models was supported by the data (Burnham & Anderson 2002).

We have applied the analysis of logistic regression to study the factors that influence survival until three time thresholds: 4, 6 and 9 months after leaving the nest. This is related to three events: getting independence from parents, survival up to the end of autumn, and establishing of own territories.

Survival was the dependent variable (0 = missing, 1 = survives). The independent variables were the body mass of the nestlings at the age of 14 days, hatching date and date of nest leaving (day 1 = May 1). We have fitted the models of logistic regression using the method of variable elimination according to the significance of the Wald χ^2 statistic, using criteria of $p < 0.25$. The calculation of the significance of the models is based on the log-likelihood χ^2 statistic and in the Hosmer-Lemeshow test. The coefficients *B* of the significant variables ± SE are presented along with their significance based in the Wald statistic. Analyses were performed using the SPSS/PC 11 (SPSS Inc. 2001).

RESULTS

Among the three populations, Pitarque, Villarluengo and Las Coronas, no interchange of individuals was observed. The marked Magpies were not observed at any distance longer than 3 km from their birthplace.

The goodness-of-fit test shows that the deviance of the general model was bigger than the maximum obtained by the bootstrap method. Thus, there is a lack of fit of the global model to the data, which results from some assumptions of the model being violated. Most probably, there is a lack of independence of the fates of siblings, even after becoming independent from the parents.

QAICc's difference among the three first models (Table 1), is less or equal to 2, which shows that evidence does not exist to decide that one is definitively better than the other two. These three models include the variation of the survival with time and the second and third models also include different survival rates for the two age-classes considered (Fig. 1). None of these models includes the year effect. It is necessary to go to the sixth model with a ΔQAICc of 5, to find a model with this effect (Table 1). Therefore, no differences between years were found. The model that includes the interaction between age class "1" and the nest effect (i.e. a different survival for each group of siblings during the first 6 weeks) and temporary variation of the survival in the age class "2" is placed at the eighth position with a ΔQAICc of almost 8, and so it is clearly worse that the three first models (Table 1).

The best models (Fig. 1) show two critical moments in the survival of young Magpies: the first occurs after getting independence from parents (August–September), and the second when individuals abandon the communal roosting and start to establish their own territories (February–March).

Logistic regression models for survival after 4 and 6 months after leaving the nest only

Table 1. Mark-recapture models to determine the effects of age class (age), seasonal variation (*t*) and year (*y*) on apparent survival of the Magpie. A model to test if there were an effect of nest (n) on survival in age1 is also included.

Models	$QAIC_c$	$\Delta QAIC_c$	QAICc Weight	Model Likelihood	N of parameters	QDeviance
ϕ(*t*) *p*(1)	259.054	0	0.4189	1	13	143.717
ϕ (*age1*t, age2*t*) *p*(1)	260.06	1.01	0.2533	0.6047	14	142.664
ϕ (*age1, age2*t*) *p*(1)	261.058	2.00	0.1538	0.3671	12	147.777
ϕ (*age1,age2*) *p*(1)	262.736	3.68	0.0665	0.1587	2	169.774
ϕ (),*p*(1)	263.196	4.14	0.0528	0.1261	1	172.242
ϕ (*age1, age2*y*) *p*(1)	264.391	5.34	0.0290	0.0693	3	169.417
ϕ (*t*y*) *p*(1)	265.941	6.89	0.0134	0.0320	26	123.474
ϕ (*age1*n, age2*t*) *p*(1)	267.032	7.98	0.0078	0.0185	22	138.318
ϕ (*age1*t, age2*t*y*) *p*(1)	269.069	10.02	0.0028	0.0067	25	128.716
ϕ (*age1, age2*t*y*) *p*(1)	269.968	10.91	0.0018	0.0043	23	133.829

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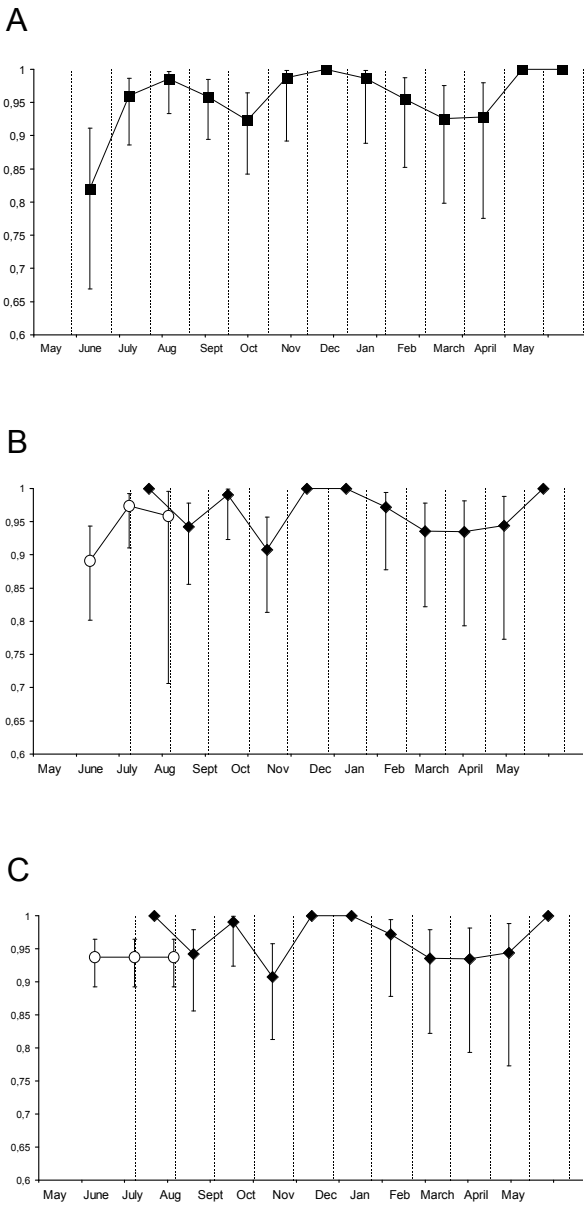


Fig. 1. Monthly variation of survival (mean ± SE). Global model: ϕ(age1)*t, (age2)*t*y. Models fit represented: (A) ϕ(*t*) *p*(1); (B) ϕ (*age1*t*, *age2*t*) *p*(1); (C) ϕ (*age1*, *age2*t*) *p*(1). In (B) and (C) the circles indicate the survivals of the age "1" and rhombuses the ones belonging to the age "2". Intermittent lines show the four-weeks groups with survival assumed constant.

displayed the nestling weight at the age of 14 days as a significant variable (4 months: $B = 0.034 \pm 0.016$, Wald $\chi^2_1 = 4.65$, $p = 0.031$; 6 months: $B = 0.039 \pm 0.018$, Wald $\chi^2 = 4.75$, $p = 0.029$; Fig. 2). None of the independent variables explained the variation in survival to the age of 9 months.

Incorporation of individuals to the reproductive population

Three out of 26 nestlings ringed in the reproductive period of 1994 were detected during the next breeding season, but none bred that year, and only one of them was found in the 1996 breeding season. However the reproductive status of the survivors in 1996 was not known. Six out of the 24 nestlings ringed in 1995 were found in 1996 but none was detected in 1997.

DISCUSSION

All the best models fitted to capture-recapture data on young Magpies show that weekly survival was confronted with two critical periods. The first one occurred during September and October and the second one spread through most of the winter and the beginning of spring. Outside of these critical periods, weekly survival is close to one, but within them it drops to 0.92 and 0.93. This finding agrees with Birkhead (1991), who pointed out that the period of higher mortality after leaving the nests coincides with the time of offspring becoming independent from the parents. The cause would be the juvenile inexperience that makes young Magpies more vulnerable to predators (Dhindsa & Boag 1989). In addition, we also found a second peak of mortality during winter that coincides with the beginning of the reproductive season. At that time winter flocks split and one-year-old Magpies separate from the

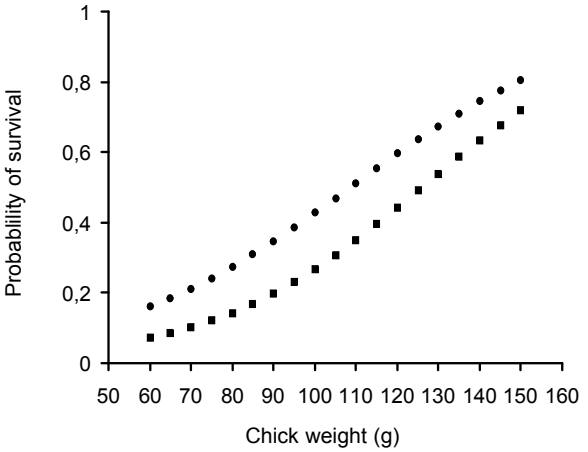


Fig. 2. Probability of survival of Magpies to the fourth month of life (circles) and to the sixth (squares), in terms of the body weight of 14-day-old chicks.

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adults to look for their first own territories and to pair for the first time. Ponz & Monrós (2000) report that also at that time Magpies leave their winter communal roosting. Therefore, both those periods of low apparent survival occur when there are changes in the social interactions between young and adults (parents or flock members).

Survival models for live recaptures cannot separate mortality from permanent migration (Lebreton et al. 1992, Burham & Anderson 2002), thus if young Magpies disperse preferentially during the critical periods, the decreases in survival estimates would be affected by the dispersal of young too. However, Magpies present a marked philopatry (Eden 1987, Birkhead 1991). In the United Kingdom, Birkhead (1991) pointed out that most dispersal occurs in September and October and that natal dispersal averaged 425 m (range 0–798 m). In agreement with these results, we have not found any colour-ringed individual moving between the three adjacent populations. Thus, we have no evidence for losses of individuals due to dispersal, which should involve rather few Magpies, although such losses cannot be completely excluded. One reason that could explain the lack of dispersal from our study area would be the physical obstacles for dispersal represented by the surrounding mountains.

Among mortality causes, the most probable were predation and starvation. Many potential predators including several raptor species (*Aquila chrysaetos*, *Accipiter gentilis*, *Hieraaetus fasciatus*) and carnivorous mammals (*Martes foina*, *Genetta genetta*) among others, inhabit the Pitarque study area.

Eden (1985) found that only 22% of fledglings survive to the next April and that the probability of survival to September increases with hatching date and the nestling weight. Similar results were obtained by Husby & Slagsvold (1992). In Pitarque, we also found that the heavier nestlings present a higher survival but only until the sixth month of life. The effects of hatching and nest abandonment date were not significant. Considering these results, we can conclude that the pattern of survival of Magpies that live in urban zones seems not to differ from Magpies living in the rural zone studied.

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STRESZCZENIE

[Przeżywalność młodych srok w populacji z górskich obszarów wschodniej Hiszpanii].

Celem pracy było oszacowanie przeżywalności srok pomiędzy wylotem z gniazda a następnym sezonem lęgowym, oraz czynników, które mogą na nią wpływać. Badania prowadzono w dolinie rzeki Pitarque w latach 1994–1996.

50 piskląt zostało indywidualnie znakowanych kolorowymi obrączkami i monitorowanych co tydzień aż do maja kolejnego roku. Prócz tego 54 pisklęta z dwóch najbliższych populacji zostało zaobrączkowanych, aby określić ewentualne tempo emigracji i imigracji w badanej populacji. Analizowanymi parametrami wpływającymi na przeżywalność były: zmienność w czasie, wiek ptaków, sezon i rok. Zastosowano metodę powtórnych złowień dostępną w programie MARK. Dopasowanie uzyskanych modeli było oceniane przy pomocy Akaike Information Criterion.

Otrzymane trzy najlepsze modele wskazywały na sezonową zmienność w przeżywalności, zaś drugi i trzeci dodatkowo jeszcze brały pod uwagę wpływ wieku ptaków. Sezonowa zmienność w przeżywalności związana jest z dwoma okresami krytycznymi w życiu ptaków. Pierwszy z nich ma miejsce w okresie uzyskiwania niezależności od rodziców (sierpień–wrzesień), zaś drugi, gdy osobniki opuszczają wspólne noclegowiska i zaczynają zajmować własne terytoria (luty–marzec). Ciężar ciała 14 dniowych piskląt pozytywnie wpływał na przeżywalność do 4 i 6 miesiąca po wylocie z gniazda. Z 50 zaobrączkowanych piskląt tylko 9 przeżyło do następnego sezonu lęgowego, zaś tylko jeden ptak obserwowany był dwa lata po wylocie z gniazda. Nie stwierdzono, aby młode ptaki przemieszczały się pomiędzy badanymi populacjami, co wskazuje, ze przeżywalność rzeczywiście spadała w dwóch okresach, prawdopodobnie w związku ze zwiększona presją drapieżników.

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