

## Post-fledging dependence period and development of flight and hunting behaviour in the Red Kite *Milvus milvus*

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*The post-fledging dependence period of 37 Red Kites was studied in the Doñana Biological Reserve (Spain). The juveniles fledged at a mean age of 55.1 days and remained near the nest, depending on their parents for food, for on average a further 25.6 days. Flight behaviour of the fledglings showed both a gradual increase in time spent flying and a transition from flapping to gliding and soaring flights. Hunting behaviour and manipulative play with objects were very rare during 511 hours spent observing juveniles during the post-fledging dependence period. It seems that juveniles do not start searching for food until they are independent. On average young kites were captured in baited traps for the first time 31.5 days after fledging. Some juveniles dispersed from the natal area as they became independent but most remained in the natal area for a variable period of up to 42 days before dispersal. Mortality during the post-fledging period was 13.5%.*

Very little information has been published on the post-fledging period of the Red Kite *Milvus milvus*. An age at fledging of 50–60 days has been reported from Wales<sup>1</sup> and it has been suggested that young kites remain near the nest for as long as 21–30 days after fledging and then accompany their parents around the breeding territory.<sup>2</sup> Young kites spend a minimum of 15–20 days after fledging in vicinity of the nest being fed by the parents,<sup>3</sup> and the average duration of the post-fledging dependence period has been estimated at 4–10 weeks.<sup>4</sup>

The present study describes and quantifies age at fledging, post-fledging dependence duration, flight progression and maturation of hunting behaviour in the Red Kite in the south of Spain.

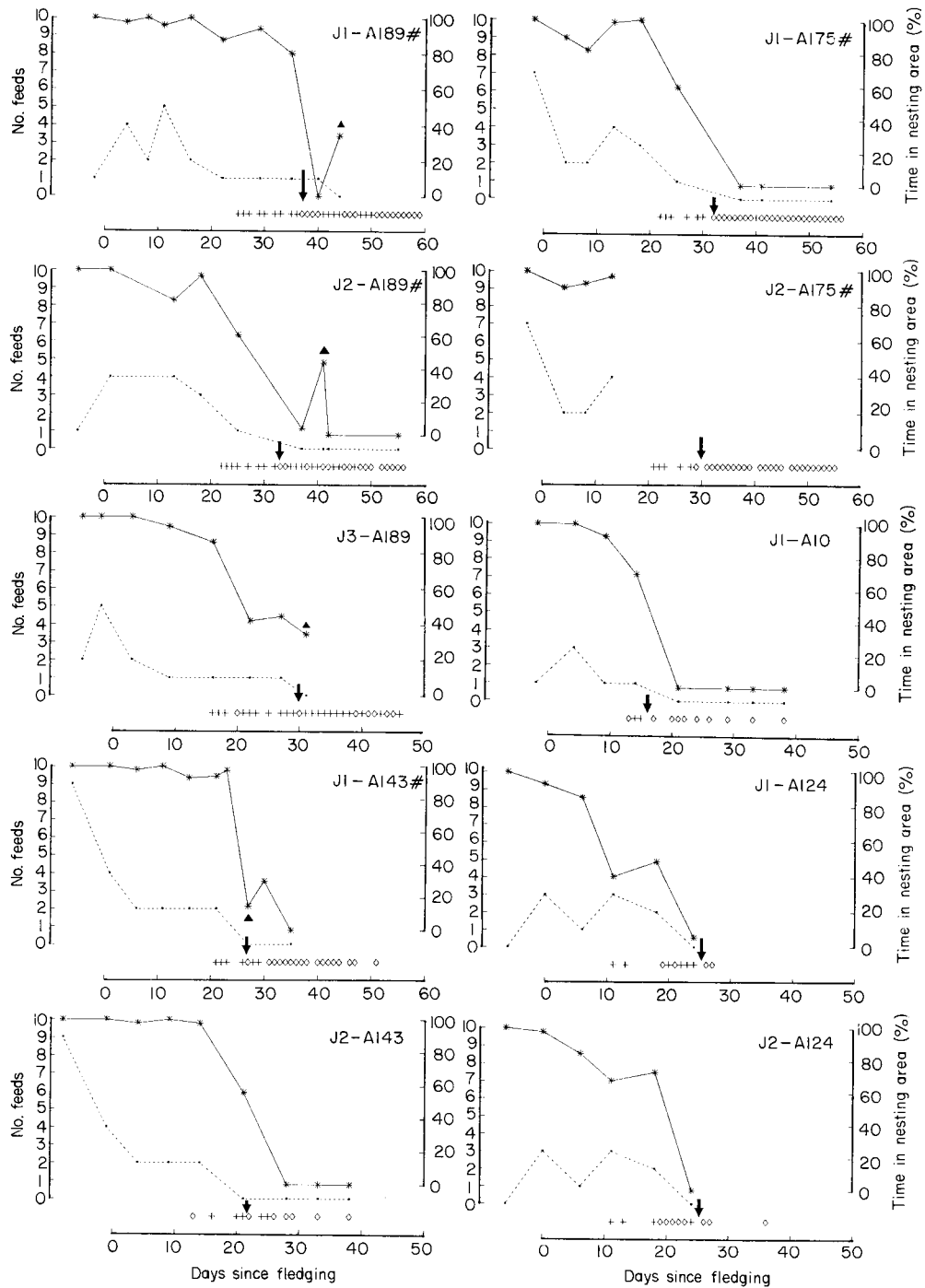
### STUDY AREA AND METHODS

The study was carried out at the Doñana Biological Reserve (37°N, 6°30'W), inside the

Doñana, National Park, south-west Spain. Three main biotopes can be distinguished in the study area: (i) Mediterranean scrubland characterized by *Halimium* spp., *Cistus libanotis* and *Erica* spp., with scattered Cork Oaks *Quercus suber* and small woods of Stone Pine *Pinus pinea*; (ii) seasonally drying marshland covered with *Scirpus* spp; (iii) coastal sand dunes with vegetation mainly of *Ammophila arenaria*, *Corema album* and *Juniperus phoenicea*. A more detailed description of the area can be found in Valverde<sup>5</sup> and Roger & Myers.<sup>6</sup>

The post-fledging dependence period of 37 juvenile Red Kites, belonging to 21 different broods, was studied during the summers of 1987 (9 broods) and 1988 (12 broods). All juveniles were fitted with plastic coloured wing-tags<sup>7</sup> and 11 with radio-transmitters attached with a back-pack harness<sup>8</sup> (weight with harness was 21 g = 2.3% of body mass).

All nests had been monitored daily during hatching and exact hatching dates were known for all the juveniles (J. Viñuela, pers. comm.).



**Figure 1.** Percentage of daily observation time (—\*—) each of 10 juvenile Red Kites was in sight on a 500-m radius of the nest and total number of feeds per day (---●---) provided by both adults at the nest in relation to days since fledging. Data were obtained during dawn to dusk observations (method A) at five different nests in 1987. The roosting pattern of each individual in the vicinity of the nest is shown using symbols (+ indicates the juvenile was located near the nest,

Age at fledging was defined as the age of first flight and juveniles were considered to be independent when they were no longer receiving any parental investment (feeds, vigilance or defence against predators). Independence did not necessarily mean that juveniles have left the natal area or that they had started to hunt by themselves. Ages are given as days since hatching unless stated otherwise.

Two different observation procedures were employed. The first, method A, was used in 1987 to monitor 5 broods (11 fledglings) from dawn to dusk (06.30–20.30 hours GMT) every 5–7 days. Observation started at the end of May before the chicks fledged and continued until adults no longer brought food to the fledglings. Observations were made by two observers at an average distance of 250 m from the nest, using 10× binoculars and 20–60× telescopes. The total number of observation days, in the period from fledging to independence, was 24 (336 hr) and ranged from 3 to 7 per brood. To be sure that juveniles were independent, dawn-to-dusk observations were maintained at 4 nests for up to 3 weeks after the last feed by the adults was observed (Fig. 1). Accounting for the time juveniles were out of sight, there were 511 hr of behavioural observations of juveniles (range 20–90 hr per juvenile). All adult and juvenile behaviour was recorded on audio-tape, including the numbers and locations of feeds, time periods that adults and juveniles were in sight, and the duration of the fledgling flights (timed with a stop-watch and classified as either flapping, gliding or soaring flights). Date of fledging and date of independence were estimated for each juvenile as the mean date between the two dawn-to-dusk observation periods between which fledging or independence had taken place. However, regular short visits to some of the nests permitted greater accuracy in some cases.

Only one nest could be observed at a time, and this limited the number of nests that could be monitored each year and the frequency with which each nest could be observed. The first results suggested great variability in the duration of the post-fledging dependence period and that juveniles began roosting away from the nest when they were no longer receiving food from the adults (Fig. 1).

A second, less-intensive procedure (method B) was used to estimate age at fledging and age of independence for an additional 4 broods in 1987 (5 fledglings) and for 12 broods in 1988 (21 fledglings). Method B involved regular short visits to the nest (10–30 min duration) every 1–2 days, at times when chicks were expected to fledge and when they were expected to become independent. Visits to the nest to estimate age at fledging were started when the eldest chick of the brood was 42–45 days old and were continued until all siblings had fledged. A chick was considered to have fledged if it was observed to fly during a visit, if it was observed on a perch it could not have reached without flying, or it was absent from the nest but was observed during subsequent visits. Visits were resumed 2 weeks after the first flight of the eldest chick (average age at which juveniles start soaring and are able to become independent), always in the 2-hr period following dawn or before sunset, and were continued until no fledglings were seen to roost in the nesting area during at least 3 consecutive days.

After the first 2 weeks of the post-fledging period daily checks were made on the roosting positions of juveniles equipped with radio-transmitters. A 40-m tower near the nesting area received transmitter signals as far as 20 km from the nest, so undetected kits were assumed to be roosting more than 20 km from the nest. Using data collected from fledglings

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◇ indicates the juvenile was not observed near the nest in a short visit before sunset or after dawn, it is sure that it did not roost that day in a 20-km radius from the nest in juveniles fitted with radio-transmitters). ↓ indicates estimated age of independence and ▲ indicates that although the juveniles were present at the nest no adults were observed that day. J1, J2 and J3 represent first-second- and third-hatched siblings of a brood. Juveniles marked with a '#' were fitted with radio-transmitters: One juvenile, J3-A175, died before independence and its graph has not been drawn. J2-A189, J2-A175 and J1-A143 switched to neighbouring nests during the post-fledging, and the frequency of observations and feeds differs from that of their siblings. J2-A175 switched to a nest that was not being monitored from dawn to dusk.

equipped with transmitters and individuals monitored from dawn to dusk (method A), we estimated that the probability observing a juvenile without a radio-transmitter which had been roosting near the nest during a short visit was 0.62. If a juvenile without a radio-transmitter was not observed in 3 consecutive days, there was a 95% probability it had roosted away from the nesting area and was therefore considered to be independent. For broods checked during short visits (method B) behavioural data were recorded opportunistically. For these birds the only data collected on flight progression were the ages at which the first gliding and soaring flights were observed.

### Trapping effort

Initial observations suggested that juveniles did not usually hunt actively before independence. To obtain more information on the age at which juveniles started searching for food, we set automatic bow-net traps (a modified Tordoff<sup>9</sup> model) when kites began to fledge (first days of June). Meat was used as a bait because Red Kites frequently feed on carrion. To be sure that the trapped kites were actively searching for food, and were not attracted to the bait as to food left by parents at the nest, traps were placed at least 250 m from the nearest nest and the bait was only visible for a kite flying over the trap, and not from nearby perches. Traps were assumed to sample randomly juvenile kites flying in search of food in the area. Traps that were set in 1986 for Black Kites *Milvus migrans* also captured some Red Kite juveniles of known age. Traps were set along a transect near the marsh border in an area regularly used by adult and juvenile kites. Trapping effort was 936 trap hr in 1986, 612 in 1987, and 2521 in 1988, evenly distributed throughout the post-fledging period.

## RESULTS

### Age at fledging

Red Kite chicks fledged 47–78 days after hatching (mean = 55.1 days, SD = 5.9,  $n = 37$ ). No differences in age at fledging could be attributed to the method of estimation employed (i.e. dawn-to-dusk observations *vs.* short visits,  $t_{35} = 0.21$ ,  $P = 0.84$ ), or to the year of study

( $t_{35} = 0.45$ ,  $P = 0.65$ ). Individuals fitted with radio-transmitters tended to fledge at a significantly older age (average age at fledging 'with radio-transmitters' = 58.8 days, 'without radio-transmitters' = 53.6 days,  $t_{35} = 2.67$ ,  $P = 0.012$ ). Age at fledging increased as the season progressed, and was significantly correlated with fledging date ( $r_{35} = 0.673$ ,  $P < 0.001$ ). The chicks fitted with radio-transmitters in 1988 were those that were expected to fledge latest in the season. This might explain the significant effect of the radio-transmitters on age at fledging. An analysis of variance in which radio-transmitter was a factor (two levels) and fledging date a covariate, indicated that radio-transmitters tended to increase age at fledging when the effect of fledging date was accounted for, although the effect was only marginally significant ( $F_{1,34} = 4.05$ ,  $P = 0.052$ ).

Neither brood size (1 to 3 chicks) nor hatching order had any significant effect on fledging age ( $F_{2,34} = 0.44$ ,  $P = 0.65$ , and  $F_{2,24} = 1.57$ ,  $P = 0.23$ , respectively).

### Post-fledging dependence period

The Red Kite post-fledging dependence period varied between 11 and 40 days (mean = 25.6 days, SD = 7.5,  $n = 32$ ). Although the method of short visits (B) measured only the length of the period juveniles were roosting near the nest and not the dependence period, the mean post-fledging dependence period estimated using this method did not differ significantly from that obtained from dawn-to-dusk observations ( $t_{30} = 0.57$ ,  $P = 0.57$ ). Juveniles equipped with radio-transmitters did not have longer post-fledging dependence periods ( $t_{30} = 0.33$ ,  $P = 0.74$ ), as might have been expected if radio-transmitters were affecting flight maturation or if it was more difficult to locate dependent juveniles that were only wing-tagged.

In multiple broods, hatching order had no significant effect on the duration of the post-fledging dependence period ( $F_{2,21} = 1.75$ ,  $P = 0.18$ ). The post-fledging dependence period tended to increase slightly with brood size, although differences were not statistically significant ( $F_{2,29} = 2.7$ ,  $P = 0.08$ ). The duration of the post-fledging period decreased with increasing age at fledging ( $r_{30} = -0.446$ ,  $P = 0.01$ ) and/or with increasing fledging date ( $r_{29} = -0.362$ ,  $P = 0.04$ ). As age at fledging and

fledging date were highly correlated (see above) the relative effects of each cannot be distinguished.

**Adult behaviour**

During the post-fledging period adults continued to bring food to the nest with decreasing frequency (Fig. 1). All feedings observed after fledging ( $n = 53$ ) took place at the nest (87%) or on nearby perches within a 200-m radius of the nest (13%). Adults also became less vigilant (time spent perched near the nest) and spent less time defending against intruders during the post-fledging period.<sup>10</sup>

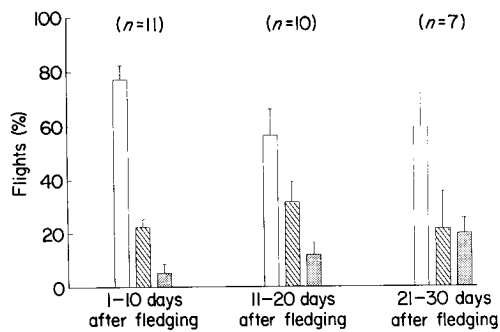
**Post-fledging mortality**

Five of the 37 Red Kite fledglings (13.5%) died during the post-fledging dependence period, and one more was electrocuted on a power line 20 km from the nest after being independent for 13 days. There was no evidence that mortality was greater amongst kites fitted with radio-transmitters (1 of 11 birds with transmitters died compared to 4 of 26 without radio-transmitters, Fisher's  $P = 0.83$ ).

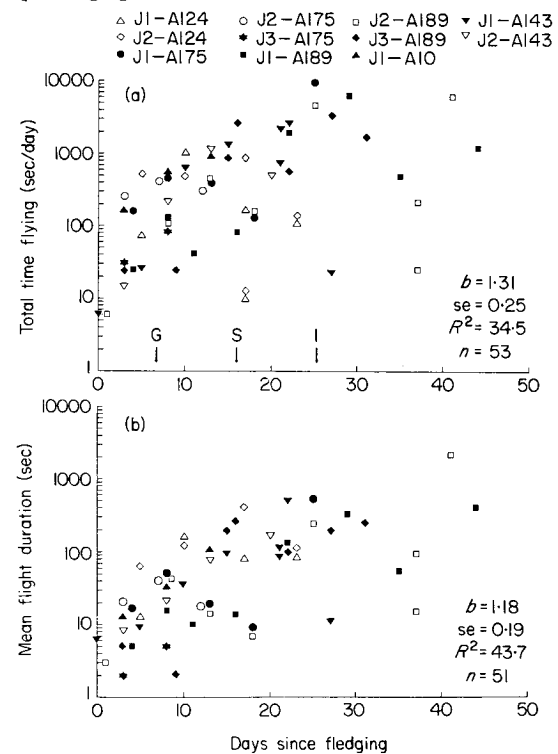
Two fledglings were probably killed by predators, one by a Spanish Imperial Eagle *Aquila adalberti* (its remains were found under a feeding perch of this species), and the other by an unidentified carnivore. Two other fledglings probably starved, and the remains of the fifth bird were not found.

**Development of flight skills**

During the first days after fledging, flights were short and straight, and involved flapping between perches close to the nest. Gliding flights interspersed with wing-flapping were first seen  $6.6 \pm 2.8$  days (mean  $\pm$  sd) after fledging at a mean age of  $61 \pm 5.0$  days ( $n = 9$ ) whilst soaring flights were first seen  $16.3 \pm 5.8$  days after fledging at a mean age of  $70.8 \pm 7.7$  days ( $n = 22$ ). The frequency of gliding and soaring flights increased with age while exclusively flapping flights decreased with age (Fig. 2). The number of daily flights, total daily time flying, mean flight duration and maximum flight duration increased with days since fledging (Fig. 3).



**Figure 2.** Mean (+se) percentage of flapping (□), gliding (▨) and soaring (▩) flights, during the post-fledging dependence period ( $n$  = number of fledglings). Percentage for each fledgling is calculated from 1-3 complete observation days in the corresponding age interval.



**Figure 3.** (a) Total daily time flying and (b) mean flight duration in relation to days after fledging in the Red Kite. Flight variables are on a logarithmic scale. 'G', 'S', and 'T' indicate the mean age at which first gliding flight, first soaring flight and independence take place, respectively.  $b$  is the slope of regression of the log of the flight variable on the log of days since fledging. Only data points in the post-fledging dependence period were used and data from all juveniles were pooled.

### Development of hunting behaviour

During the first 3 weeks of the post-fledging dependence period, juvenile kites spent most of their time at the nest or perched on trees within a 500-m radius of the nest, and spent no more than 18% of the observation time in flight. Observations of play or of possible hunting behaviour during the post-fledging period were scarce. In 511 observation hours of juveniles, one fledgling was seen snatching a twig from a cork oak in flight as if it was a prey (21 days after fledging) and two other birds were observed attempting to catch insects in flight (10 and 15 days after fledging). Juveniles were never observed following adults to hunting areas, and when they started wandering they did so independently of parents and siblings.

Some marked juveniles that remained in the study area or returned regularly to it, were observed trying to obtain food by themselves after they became independent. One juvenile was observed unsuccessfully trying to hunt a rabbit 52 days after fledging, and on six occasions different juveniles were observed feeding on carrion 58–72 days after fledging.

Trapping with bow-net traps tended to confirm that kites did not start to search for food until they had become independent. In 1986 four juveniles of known age were first captured at a mean age of  $77 \pm 4.2$  ( $\pm$ sd) days since hatching. In 1987 and 1988 four marked juveniles were first trapped at a mean age of  $90.5 \pm 14.0$  days after hatching ( $31.5 \pm 3.0$  days after fledging).

### Dispersal

Some Red Kite juveniles disappeared from the nesting area at the same time as they became independent (37.8% of fledglings), while others were observed at or near the nest every 2–3 days, for a period ranging from 2 to 45 days ( $20.6 \pm 13.9$  days,  $n=18$ ). Although juveniles which had left the nesting area returned occasionally to the natal nest, they were never observed receiving food from the adults and were therefore considered to be independent. These differences in the onset of dispersal were not an artefact of some juveniles being increasingly difficult to observe near the nest as a consequence of their improving flight skills. Three fledglings equipped with radio-transmit-

ters were never recorded within a radius of 20 km of their nest after becoming independent, while the remaining 7 were observed returning to their nest, and occasionally roosting there, for a mean of  $19.4 \pm 13.1$  days after having roosted away (more than 20 km from the nest) for the first time.

### DISCUSSION

Mean age at fledging in the Red Kite is greater than that of the Black Kite ( $48.7 \pm 4.5$  ( $\pm$ sd) days,  $n=84$ )<sup>11,12</sup>, following the general trend for raptors and other birds of increasing length of nestling period with body size.<sup>4,12</sup> Ages at fledging in Spain are similar to those reported for the Red Kite in Wales,<sup>1</sup> but show greater variability. The observed range in age at fledging in Spain was 31 days (or 55.8% of average nestling period length), against 10 days (18% nestling period) in Wales.<sup>1</sup>

The last chicks to fledge each season correspond to chicks that have grown at less than the average growth rate. Individual variation in growth rates seems to explain most of the variation in age at fledging in both Red and Black Kites.<sup>13</sup> Last-hatched chicks in the brood are also usually the ones with slower growth rates,<sup>13,14</sup> especially in broods of three. This might explain the tendency for longer nestling periods in last hatched chicks in Wales.<sup>1</sup> The slight delay in the fledging of juveniles equipped with radio-transmitters was probably partly a consequence of marking individuals that fledged late in the season whose growth rates were lower. It is still possible, however, that the weight of the radio-transmitter and/or the disturbance effect of the harness, delayed age at fledging. It is recommended that lighter radio-transmitters or other forms of attachment should be used in future.

The mean duration of the post-fledging dependence period is similar to that of the Black Kite in the same area ( $26.5 \pm 6.3$  ( $\pm$ sd) days,  $n=81$ )<sup>11,12</sup> but is considerably shorter than the estimate given for the Red Kite by Newton<sup>4</sup> (28–70 days). Juvenile Red Kites do not necessarily disperse as soon as they become independent (Fig. 1). In this they differ from juvenile Black Kites, which almost always initiate dispersal or migration immediately after independence.<sup>11,12</sup> Estimates of the post-fledging dependence period for Red Kites based

on the length of time juveniles are seen around the natal nest after fledging, can overestimate this period if, as happened in our study area, juveniles remain near the natal nest, or return to it regularly after becoming independent.

Flight progression is very similar to that of other raptors,<sup>15,16</sup> especially the Black Kite.<sup>11,12</sup> There is an increase in time spent flying and a gradual transition to gliding and soaring flights which are of lower energetic cost than wing-flapping.<sup>17</sup> Juvenile kites need soaring flight to be able to search for food, and the acquisition of these flight skills may limit the average minimum age of independence to approximately 16 days, after fledging.

In the Red Kite, as in the Black Kite,<sup>11,12</sup> manipulative play with objects as recorded in many other raptor species (e.g. *Circus cyaneus*,<sup>8</sup> *Accipiter* spp.,<sup>18–20</sup> *Buteo* spp.,<sup>15,21</sup> *Aquila* spp.,<sup>22,23</sup> *Falco* sp.,<sup>12,24–27</sup>, is very infrequent. Red Kite fledglings do not follow their parents to hunting areas, as observed in the other raptors,<sup>12,15,28</sup> and do not appear to learn actively or practice hunting techniques during the post-fledging period, something frequent in most raptor species studied to date (e.g. *Pandion haliaetus*,<sup>12,29</sup> *Elanus caeruleus*,<sup>12</sup> *Circus* spp.,<sup>8</sup> *Accipiter* spp.,<sup>20,30–32</sup> *Aquila* spp.,<sup>16,22,23</sup> *Micrastur ruficollis*,<sup>33</sup> *Falco* spp.<sup>26,27,34–36</sup>). The ages at which juveniles were first captured in traps, or observed feeding at carrion, corroborate independently the hypothesis that most Red Kite fledglings must become independent before having obtained any food by themselves during the post-fledging dependence period. As was suggested previously for the Black Kite,<sup>11</sup> the absence of a gradual maturation of hunting techniques during the post-fledging dependence period can be related to the generalist feeding habits of kites of the genus *Milvus*. The habitual preys of the Red and the Black Kite (carrion, insects and young animals) do not require specialized capture techniques or manipulation, and a more progressive maturation before independence may not be necessary.

#### ACKNOWLEDGEMENTS

I am grateful to Dr F. Hiraldo for his guidance, and to M. Hiraldo, G. Doval, F. Domínguez, F. Martínez, J. Jañez, M. Aragoneses, J. Viñuela, J. Chans, G. Vilchez and P. Ferreras for help with

field work. This work is part of a doctoral dissertation at the *Universidad Autónoma de Madrid*. Funds were provided by CSIC–CAYCYT project No 944, and Fellowships of the *Ministerio de Educación y Ciencia* and the CSIC. Final writing was carried out at CSIRO Division of Wildlife and Ecology.

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