

COMMUNAL PARENTAL CARE BY MONOGAMOUS MAGPIE HOSTS OF FLEDGLING GREAT SPOTTED CUCKOOS¹

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Abstract. Fledglings of the brood-parasitic Great Spotted Cuckoo (*Clamator glandarius*) often formed groups with other fledgling cuckoos. Group size ranged from one to five fledglings that originated from one to four different host nests. Each group of cuckoo fledglings was attended by a group of Black-billed magpies (*Pica pica*). Frequently, a fledgling group was attended by more magpies than ones involved in nestling care. The feeding rate of fledgling cuckoos increased with the number of cuckoos per group and number of adult magpies attending the group. Flocking behavior presumably was advantageous for cuckoo fledglings because each fledgling in larger groups received more food.

Key words: Brood parasitism; communal parental care; fledgling behavior; Great Spotted Cuckoo; Black-billed Magpie.

INTRODUCTION

In birds, parental effort, the sum of parental investment in each offspring (Trivers 1972), can be divided into that provided during the nestling and fledgling periods. The length of each of these periods varies among species, but as a rule parental care of fledglings tends to last at least as long as that of nestlings and in some cases up to twice as long (Skutch 1976). The fledgling period is the critical one for juvenile survival (Royama 1966, Sullivan 1989), and the probability of survival to independence appears to be an adequate estimate of relative probabilities of survival to breeding in many bird species (Magrath 1991). In spite of its great importance, the behavior of parents after their young have left the nest has rarely been studied, undoubtedly because it is difficult to monitor broods after they have left the nest.

Brood parasitism in birds has recently received much attention. An extensive literature has developed on the breeding ecology of brood parasites and the coevolutionary relationship between some parasites and their hosts (reviewed by Rothstein 1990). The fledging period (from fledging until independence) and the amount of post-fledging parental care are factors of utmost importance to avian brood parasites, and with the exception of the Brown-headed Cowbird (*Molothrus ater*) (Woodward 1983), very little is

known about the behavior of foster parents in relation to the fledged parasites in their care. Fledged cowbirds are fairly conspicuous after they leave the nest (Woodward 1983), in contrast to fledgling of other parasites such as European Cuckoos (*Cuculus canorus*), which hide in the vegetation and remain immobile for long periods of time (Wyllie 1981).

The Great Spotted Cuckoo (*Clamator glandarius*) is an obligate brood parasite that in Europe parasitizes mainly magpies (*Pica pica*, Cramp 1985), although sometimes it parasitizes other corvid species, which, as with magpies, are larger than the parasite (Cramp 1985, Soler 1990). In contrast to the European Cuckoo, individual Great Spotted Cuckoo do not lay eggs adapted to different host species and nestlings do not eject the eggs or young of the host (Soler 1990). As a rule, the Great Spotted Cuckoo's eggs hatch several days before the magpies' and the reproductive success of the host is markedly reduced by intense competition for food between the large, fast-growing cuckoos and the smaller magpie chicks (Cramp 1985, Soler 1990, Soler and Soler 1991). Frequently, there are more than one cuckoo egg laid by the same female in each nest. In addition, more than one female cuckoo may lay its eggs in the same host nest.

In a previous study (Soler et al. 1994), we have shown the following, (1) Fledgling Great Spotted Cuckoos were very sedentary, usually occupying the same area over the season and that unexpectedly they did not feed themselves. (2) Of 38

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fledgling cuckoos, 24 (63.2%) survived to independence and 14 (36.8%) died, either from predation (26.3%) or starvation (10.5%). (3) Great Spotted Cuckoos that died after fledging weighed significantly less when ringed (one or two days before they left the nest) than those which survived to independence. (4) Post-fledging dependence of Great Spotted Cuckoo fledglings ranged from 25 to 59 days ($X = 33.2$, $SD = 11.63$, $n = 25$). (5) Fledgling and adult cuckoos do not migrate together, adults leaving the breeding area about two months earlier than the majority of the juveniles. In this paper we report the results of a study of the behavior of fledgling Great Spotted Cuckoos and the magpie hosts from fledging until independence.

METHODS

STUDY AREA

The field work was carried out in Hoya de Guadix, southern Spain (37°10'N, 3°11'W), a high-altitude plateau approximately 1,000 m a.s.l. The vegetation is sparse, with some holm oaks (*Quercus rotundifolia*) and many groves of almond trees (*Prunus dulcis*) in which magpies nest at a high density. A more detailed description of the study site is given in Soler (1990) and Soler et al. (in press).

MARKING NESTLINGS AND RADIO-TRACKING

In all nests found, both magpie and cuckoo chicks were ringed with numbered aluminium rings (Spanish Institute for Nature Conservation-ICONA). Nineteen cuckoo chicks reared in 13 parasitized magpie nests were fitted with radiotransmitters in 1991, and 21 in 1992. In 1992, only one cuckoo chick in each nest was provided with a radiotransmitter; the rest of the cuckoo chicks in these nests were given a unique combination of color rings to enable individual recognition after fledging. To facilitate identification, we attached a 8-cm color tag of durable nylon coated vinyl (Saflags) to each color ring (both ring and tag were in every case of the same color).

One or two days before leaving the nest (when 15 days old), 40 chicks (see above) were fitted with radiotransmitters weighing approximately 4 g each (back-pack harness included), with a trailing 20-cm wire antenna (Biotrack, Dorset, UK). Transmitters had a range of 1,000 m and life-span of 10–12 weeks. When a radio-tagged

fledgling cuckoo was found dead, its transmitter was transferred to another chick.

FIELD METHODS

The study was conducted throughout the breeding seasons of 1991 and 1992. Totals of 111 and 166 magpie nests were studied in 1991 and 1992, of which 58.6% and 66.9%, were parasitized, respectively, by the Great Spotted Cuckoo. All nests were inspected at least once a week, and parasitized nests were checked two–four times a week. This frequent monitoring provided detailed knowledge of the stage of the breeding cycle and number of both parasite and host chicks in each nest.

Fledgling cuckoos from more than one nest often formed a “group” that we defined as any group of young that consists of one or more fledglings from one or more nests. Each group of fledgling cuckoos was attended by several magpies. Most magpies were not banded, and therefore we had to consider the maximum number of magpies observed simultaneously attending the group of fledged cuckoos at the same time as “the total number of adult magpies attending the fledglings.” Thus, the number of adult magpies attending each fledgling group probably was underestimated.

The fledglings often remained well hidden in the tree canopy. Even when fledglings detected a predator or one of us, they remained silent and immobile in the tree canopy. For this reason, we radio-tagged at least one cuckoo chick in every group. We used the radio-tracking method only to locate the trees occupied by the group of fledglings. After finding the group, we retreated and started observing when conditions were appropriate. Observations were made between 25 May and 8 August (the day in which the last cuckoo group left the breeding area) in both years. Each group was located at least two or three times per week and, when the group of fledglings was easily visible, each fledgling was watched for 0.5 to 3 hr.

A total of 104 hr of effective observations was recorded in 1991 and 164 hr in 1992. We observed parental feedings and the behaviour of young at a distance of 20–100 m (mostly from 40–50 m away, from a car whenever possible) with binoculars (10×). The following data were recorded: individual, time of day, location, whether the fledgling was on the ground or perched in a tree, whether the bird was flying

alone or following one of the foster parents, and what fledgling was fed by an adult Magpie arriving with food.

The age of each young was expressed as days after leaving the nest, with day 1 being the first day after leaving the nest. Data obtained on the distribution of feedings (which fledgling cuckoos were fed by the same magpie in each visit to the group), spatial separation of young, and interactions between young refer to the entire study period, unless otherwise stated. The locations of the different groups were recorded on aerial photographs taken in 1990 at a scale of 1:8,000. The area occupied by every group did not increase with date or number of observations. All measurements of distances and areas were marked on these photographs and areas were measured based on maximum polygon method.

STATISTICAL ANALYSES

Relationships between parameters of groups of fledgling cuckoos and parameters of attending magpies were analyzed by calculating the correlation coefficients (r) for each group separately. These values were z -transformed (Sokal and Rohlf 1981), and then tested to see if they differed from 0 in a one-sample t -test. When analyses involved fledglings were made in the same way, but we used only one fledgling per group (the radio-tagged fledgling, which is the one that was most frequently observed) because the behavior of different fledglings in a group is not independent statistically.

RESULTS

GROUP-FORMATION BEHAVIOR OF GREAT SPOTTED CUCKOO FLEDGLINGS

After leaving their nest, Great Spotted Cuckoos often joined with other fledgling cuckoos. Group size ranged from one to five fledglings that were reared in one to four different nests. In 19 groups reared by magpies, the average group size was 3.3 cuckoo fledglings ($SD = 1.28$, $n = 19$), and these were reared in an average of 2.2 ($SD = 0.79$, $n = 19$) different nests (Table 1). Magpie fledglings were never part of these groups. Three of the 19 groups (15.8%) were composed only of fledglings reared in the same nest, but 16 groups (84.2%) contained fledglings from more than one magpie nest.

Fledgling cuckoos seemed to form flocks regardless of the host species because we also recorded it in three cuckoo fledglings reared in two

different Chough (*Pyrhocorax pyrrhocorax*) nests in 1992 on the same study area. These fledglings were not fitted with radio transmitters, but we monitored them from the first observation of two young cuckoo fledglings that left the Chough nest. The third left the nest 9 or 10 days later and after another 5–7 days joined the other two fledglings and were attended by at least three Choughs. The Chough nests were more than 2 km far apart from the closest group of cuckoos reared by magpies.

Usually cuckoo chicks reared in the same nest remained together in the same group. In only one of four cases for which we had complete information, did two fledgling cuckoos reared together in the same nest join different groups.

"PARENTAL" BEHAVIOR OF FOSTER PARENTS ATTENDING THE GREAT SPOTTED CUCKOO FLEDGLINGS

Each group of fledgling cuckoos was attended by a group of magpies (Table 1). The number of adult magpies attending a group ranged from two to nine (Table 1; $\bar{x} = 4.0$, $SD = 1.91$, $n = 18$). We expected the group of magpies attending each group of Great Spotted Cuckoo fledglings to be comprised of all the foster parents that reared the fledgling cuckoos in the group. As the number of Great Spotted Cuckoo fledglings per group increased, the number of magpies attending the group also increased (mean $r = 0.52$, $H_0: r = 0$, $t = 2.68$, $P = 0.002$). However, four groups (21.1%) were attended by more magpies than could be accounted for by involved in rearing the nestlings (Table 1). This was particularly striking in group ChN, where nine magpies at the same time were observed attending three fledgling cuckoos from two different nests. As magpies whose nests had not been parasitized cared exclusively for their own fledglings in their territories (magpies breed very synchronously in our study area, J. G. Martinez et al., unpubl. manuscript), magpies attending cuckoo fledglings but not involved in rearing the chicks presumably were unpaired individuals or those that had failed to rear any chicks.

In 68 cases we observed the same magpie consecutively feeding at least two cuckoo fledglings that were identified. In 37 of these (54.4%), the two cuckoo fledglings had not been reared in the same nest. Thus, magpies did not only feed cuckoos reared in their own nests.

Normally, at least one magpie stayed with the

TABLE 1. Information about every group of cuckoo fledglings.

Group	1991						1992												
	CH1	CH2	CH3	CH4	CH5	FA	CH15	CH2	CH1	CH49	CH29	CH44	CH31	H12	FU	FA	CHN	CA1	CA2
Number of great spotted cuckoo fledglings	4	5	5	2	1	4	2	3	4	4	1	2	5	2	4	3	3	4	4
Number of nests in which they were reared*	3	3	3	2	1	2	2	2	3	2	1	1	2	2	2	2	2	3	4
Number of host fledglings	0	0	0	0	0	0	2	0	0	0	2	0	0	0	0	0	0	0	
Number of adult magpies attending fledglings**	6	5	7	3	2	3	4	4	3	—	2	2	5	2	4	5	9	3	3

* Numbers represent the minimum number of nests to which nestlings belong. Where there was one or more than one unringed fledgling we added only one nest to the sum of the known nests of ringed fledglings.
 ** Numbers represent the minimum number of magpie adults caring for the fledglings. We considered the maximum number of magpie adults simultaneously attending the fledgling group.

group of fledgling cuckoos, and while foraging near the group this magpie acted as a guard (giving alarm calls when necessary) and was also the principal food supplier for the group. This guarding role was not played by the same magpie throughout, different magpies take turns assuming this position as we realized by observing two easily recognizable birds (with some missing feathers). The main parental activity of the magpies was to feed the fledgling cuckoos. In a total of 268 hr of observation, we recorded 454 feedings.

SPATIAL DISTRIBUTION OF YOUNG

Cuckoo groups generally were sedentary, usually occupying the same area throughout the season. In La Calahorra, nine groups of cuckoo fledglings were distributed over an area of 3,965 ha. Each neighboring group was separated by between 460 and 570 m. Each group occupied an average area of 0.68 ha (SD = 0.48, n = 9). For 13 of the

chicks that joined these nine groups, an average distance of 205 m (SD = 290, n = 13) prevailed between the nest in which they were reared and the center of the group area (range 4–1,032 m). Thus, some chicks moved more than the average distance between neighboring groups.

La Calahorra is an homogenous habitat formed by almond groves and irrigated land. Only one of the six characteristics considered (tree density) showed significant differences between the nine areas occupied by the fledgling cuckoos and the nine randomly chosen non-occupied areas (Table 2). The number of trees per 10 m² was significantly higher in occupied (2.2 ± 1.7) than in non-occupied areas (0.8 ± 0.7; Mann-Whitney U-test, Z = 2.2, P = 0.03). Fledgling cuckoos chose the areas with higher tree density. No significant differences were found in other characteristics such as percentage of cultivated area, distance to the rubbish dump or distance to the water (Table 2). Thus, groups of fledgling cuck-

TABLE 2. Tree density, percentage of cultivated area, and distances to the water, plain, rubbish dump and village in the areas occupied by fledgling cuckoos (n = 9) and in areas non-occupied (randomly chosen n = 9).

	Occupied areas fledgling cuckoos		Unoccupied areas by fledgling	
	x	SD	x	SD
Tree density (trees/10 m ²)	2.2	1.7	0.8	0.7
Percentage of cultivated area	54.4	27.4	73.3	34.3
Distance to the water (m)	19.6	31.0	31.1	25.1
Distance to the plane (m) (area without trees)	591.1	334.5	693.3	362.8
Distance to the rubbish dump (m)	1,597.0	793.5	1,773.3	646.8
Distance to the village (m)	912.9	402.1	980.4	457.9

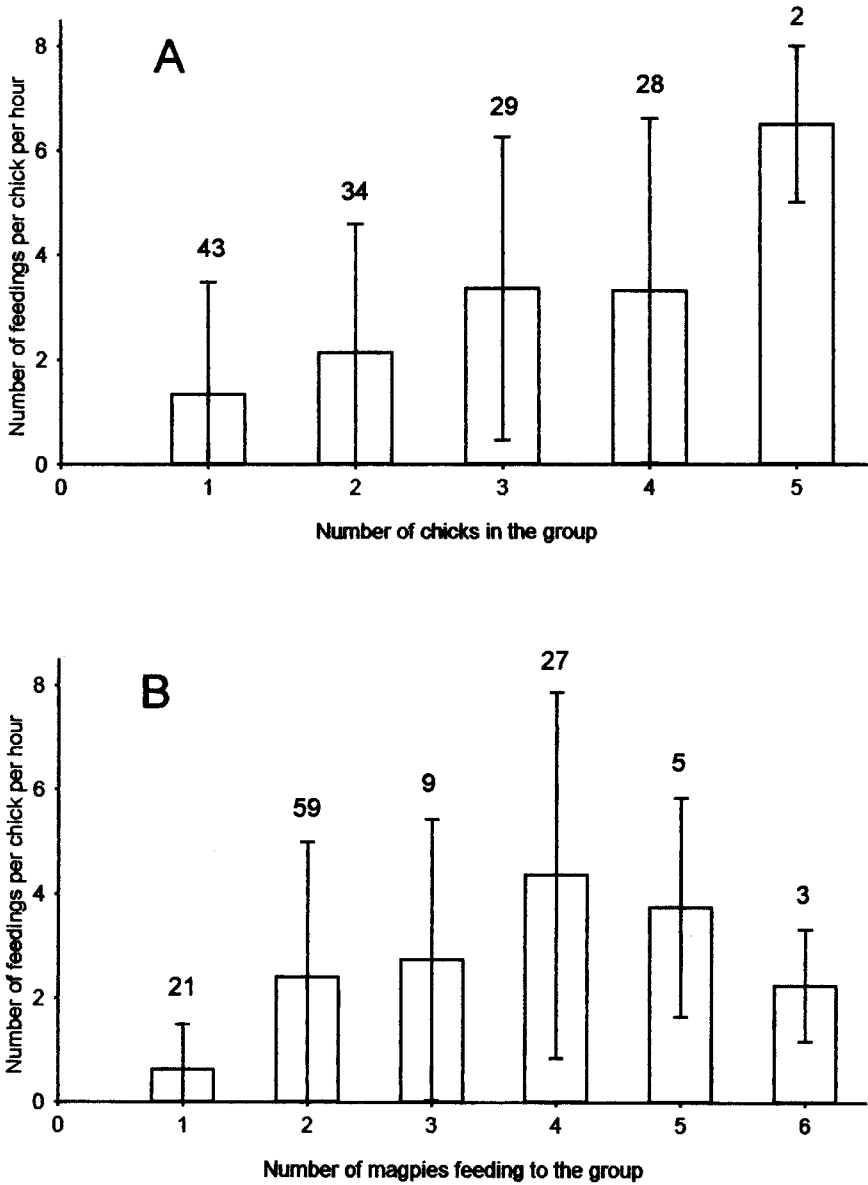


FIGURE 1. Feeding rate per capita of fledgling cuckoos (number of feedings per chick per hour) according to number of cuckoo chicks in the group (A) and number of magpies feeding cuckoos in the group (B). Vertical bars indicate \pm SD. Figures above bars denote sample sizes.

oos were not associated with areas near water or good foraging habitats for magpies like rubbish dump.

FEEDING RATE

The feeding rate of each fledgling cuckoo increased both as the number of cuckoos per group increased (mean $r = 0.53$, $H_0: r = 0$, $t = 4.02$, P

$= 0.007$) and as the number of adult magpies attending and feeding the group increased (mean $r = 0.46$, $H_0: r = 0$, $t = 2.75$, $P = 0.03$) (Fig. 1). In the latter case, however, the feeding rate peaked with four magpies attending the group, but was lower with smaller and larger groups (Fig. 1) (Polynomial Regression Multiple $R = 0.43$, $P < 0.0001$; $y = -0.95 + 1.02x - 0.66x^2$).

DISCUSSION

WHY DO CUCKOO FLEDGLINGS FORM GROUPS?

Flocking was advantageous for the cuckoos because each fledgling in larger groups received more food (Fig. 1). Fledgling cuckoos chose the areas with higher tree density, surely because these offer the greatest safety allowing cuckoos to remain well hidden in the tree canopy. Cases of flocking behaviour has also been reported for other brood parasites: in the European Cuckoo, three fledged birds close together were fed, apparently indiscriminately, by a variety of passerine species (Cramp 1985), and in the Brown-headed Cowbird, Woodward (1983) observed three cases in which fledglings from two different nests became intermingled, fed and protected not only by the foster parents, but also by a pair of conspecific hosts that had not raised the chicks.

WHY DO ADULT MAGPIES JOIN IN GROUPS?

Magpies may have joined groups because this flocking is advantageous or the cuckoos induced magpies to join. If joining flocks is advantageous to magpies when they are rearing cuckoos, flocking should also be advantageous when they are rearing conspecific fledglings. Husby and Slagsvold (1992) reported that magpie fledglings remained generally within, or near their natal territories until day 50, and even when about 80 days old, many young were observed still relatively close to their respective birthplaces. However, Buitron (1988) noted that "within 9 to 29 days of fledging, families began moving more widely, and groups of two to eight families joined together in sheltered areas near water and good foraging." This behavior is similar to that of cuckoo fledglings, but with two differences: (1) According to Buitron (1988), parents fed only their own offspring, although young indiscriminately begged from all adults, whereas cuckoo fledglings were fed by all magpies in a group. (2) The groups of fledgling cuckoos were not associated with areas near water and good foraging habitats (Table 2). Furthermore, in our study area we monitored the post-fledgling behavior of four non-parasitized magpie broods, and these remained very close to the adult territories, and groups consisting of several families were not observed (Soler et al. 1994). Therefore, cuckoo-joining behaviour may in fact induce flocking

behavior in magpies; evidently not only foster parents join these groups (Table 1).

WHY ARE GROUPS ATTENDED BY MAGPIES THAT DID NOT REAR NESTLINGS?

Feeding of fledgling parasites by more than two individuals of the foster species has been reported (Jubb 1966, Woodward 1983) and for more than one host species (Lack 1968, Klein and Rosenberg 1986, Hatton 1989, Smith 1989). In the case of the well-studied European cuckoo, fledglings were not uncommonly fed by birds other than foster parents (Cramp 1985). The adoption of a fledgling parasite besides the Great Spotted Cuckoo (Zuñiga and Redondo 1992, this study) has also been recorded in the Brown-headed Cowbird (Woodward 1983).

The birds other than the actual host pair feed a begging fledgling parasite can be explained in the following three ways. (1) The parasite chick possesses some supernormal stimulus that passerines cannot resist (Dawkins and Krebs 1979, Wyllie 1981, Zuñiga and Redondo 1992). (2) The parasite chick only effectively exploits the feeding response of parents to their young (Woodward 1983). (3) The parasite fledglings only effectively exploit the possibility of provisioning behavior of birds being provoked by the proper stimulus (Eisner 1960, Jamieson et al. 1987)

Cases of interspecific alloparental care and adoptions are frequent in non-parasitic species (i.e., Rohwer 1986, Pierotti and Murphy 1987, Bustamante and Hiraldo 1990, Donazar and Ceballos 1990, Shy 1990), mainly when individuals replace the maternal or paternal parents that have disappeared (20 of 26 spp.: Rohwer 1986). It does not seem that fledgling parasites need provide a supernormal stimulus to their hosts, at least no more effective than the stimulus provided by non-parasitic fledglings. Hypothesis (2) does not explain the case of the Great Spotted Cuckoo fledglings where magpies other than the foster parents care for the fledglings. In such case, only hypotheses (1) and (3) provide a logical explanation.

In conclusion, Great Spotted Cuckoo fledglings, after leaving the nest, often joined with other fledgling cuckoos to form groups that were attended by several magpies, some of which had not been involved in nestling rearing.

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