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The use of supplementary foods by Australian magpies *Gymnorhina tibicen*: Implications for wildlife feeding in suburban environments

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Abstract The provision of foods to wild birds is an extremely common practice among householders through out the Western world. Nonetheless, concerns over potential impacts of the practice are currently being raised, including the possibility that some species may become reliant on human-provided food. We compared the foraging and breeding ecology of pairs of fed and unfed Australian magpies *Gymnorhina tibicen* living suburban environments in Brisbane, Queensland, Australia. Detailed behavioural observations of both foraging and chick provisioning were made for males and females of both groups throughout the breeding season.

Natural foods dominated the diets of both fed and unfed magpies, making up 76% and 92% of all items consumed respectively. During the morning, fed magpies obtained fewer food items during ground foraging than did unfed birds, apparently because they visited suburban feeding stations more often during the early part of the day. At other times, the amount of food items obtained during foraging was similar for both fed and unfed birds.

Magpies utilising suburban feeding stations started all breeding activities significantly earlier than unfed magpies, except during the fledgling phase. Both fed and unfed magpie parents provisioned their chicks predominantly with natural food. Magpies were not reliant or dependent on supplementary food provided by wildlife feeders at any time during the breeding season. Although many magpies did utilise suburban feeding stations extensively, they continued to forage for and provision their chicks with natural food.

INTRODUCTION

Attracting wildlife, especially birds, to suburban houseyards by the provision of foods ('wildlife feeding') is an extremely common practice throughout the Western world. Numerous studies indicate that 25% to 75% of householders surveyed in suburban areas regularly provided food specifically for visiting wildlife, with the highest rates occurring during the winter in temperate regions (Cowie & Hinsley 1987, 1988; Brittingham & Temple 1988). Approximately 63-80 million Americans feed birds during the winter (Brittingham & Temple 1992; Wilson 2001), distributing around 450 million kilograms of seed every year (Brittingham 1991). Throughout Europe, bird feeding is also ubiquitous, especially in the United Kingdom (Cannon 1999, 2000).

In Australia, wildlife feeding is similarly popular with recent studies finding participation rates of 25-57 % of households in several large cities (Woodall 1995; Thomas 2000; McLees 2001; Rollinson *et al.* 2003). There are, however, some important differences in the practice of bird feeding in Australia compared to the Northern Hemisphere. Australian bird feeders, for example, attract relatively few smaller granivorous passerines (Jones 2003); more likely are larger insectivorous or carnivorous species such as the Australian magpie *Gymnorhina tibicen* and the laughing kookaburra *Dacelo novaeguineae* (McLees 2001; Rollinson *et al.* 2003). These species are typically attracted by meats, although bread and food scraps are also widely used (Rollinson *et al.* 2003). Furthermore, Australian wildlife feeders tend to provide food year-round (Thomas 2000), rather than primarily during winter, as is the case the Northern Hemisphere (Cowie & Hinsley 1988; Brittingham 1991).

The feeding of wildlife is openly promoted throughout the Northern Hemisphere as being of positive benefit to the recipient animals, as a means of increasing community interest in nature, and as having an important role in conserving wildlife, especially in urban areas (e.g. see Cannon 1999). Prominent organisations such as the British Trust for Ornithology (BTO), the Royal Society for the Protection of Birds (RSPB) and Cornell Laboratory of Ornithology (CLO), among others, actively encourage the feeding of birds, and provide details on how to attract birds and minimise associated problems (Dunn & Tessaglia-Hynes 1990; Grubb & Cimprich 1990; RSPB 2002; BTO 2003).

That the benefits of feeding, for both the people involved and the birds themselves, outweigh any possible negative effects, is widely assumed, although remarkably little specific research has been conducted on these issues anywhere in the world (Brittingham 1991). Several recent assessments (Brittingham 1991; Anderson *et al.* 1997; Green & Higginbottom 2000; Orams 2002) of the possible negative and positive impacts of wildlife feeding in general were significantly constrained by the dearth of reliable information. Nonetheless, numerous studies have demonstrated benefits of supplementary feeding in enhancing populations of several endangered species (e.g. Wilbur *et al.* 1974), the winter survival rate and health of certain non-migratory species (Grubb & Cimprich 1990). Other benefits include enhanced physical condition and reproduction rates, greater resilience to disease, parasites and predation (Brittingham 1991).

Despite the almost universal appeal and promotion of wildlife feeding, the potential for negative impacts are also beginning to be addressed (Brittingham 1991, 1992; Green & Higginbottom 2000; Orams 2002). Concern over, for example, the spread of disease, dietary deficiencies, increasing abundance of certain species, and potentially disadvantageous behavioural changes, has prompted some to question whether feeding should be regarded so favourably (Deis 1982; Anderson *et al.* 1997).

This attitude is especially pronounced in Australia. Many state-based wildlife agencies, having promoted feeding in the past, now actively discourage the practice of wildlife feeding (Skira & Smith 1991; Hunter 2001), although the context of interest is usually that of reserves and national parks. Concern over the impacts of feeding wildlife in suburban settings is rapidly growing, however. Cannon (1999: 288), for example, quoted an Australian correspondent as stating: "Generally, the more conservation-minded and knowledgeable individuals in Australia do not feed in their garden". Nonetheless, wildlife feeding, in Australia, as elsewhere, remains a very common practice (Rollinson *et al.* 2003; Howard & Jones 2004).

Prominent among the numerous potential impacts of wildlife feeding is that of dependency (see Brittingham 1991; Anderson *et al.* 1997; Green & Higginbottom 2002; Orams 2002). This suggestion proposes that animals that become used to receiving a predictable and regular supply of food may become entirely reliant upon this food source with possible short-term and long-term implications (Brittingham & Temple

1992). In the short-term, birds may be temporarily affected when a feeding station is moved or discontinued. Over longer periods these birds may be unable to fend for themselves, potentially resulting in starvation, as well as associated issues such as a diminished ability to find appropriate food, or reliance on unsuitable or nutritionally poor foods (Anderson *et al.* 1997). The impact of these dependency-related activities on chick welfare and survival is of particular concern (Brittingham 1991).

The potential for dependency is acknowledged by both proponents of wildlife feeding (see e.g. Dunn & Tessaglia-Hynes 1990; Grubb & Cimprich 1990; BTO 2003) and opponents (Green & Higginbottom 2002; Orams 2002), yet unequivocal findings remain virtually nonexistent (but see Brittingham & Temple 1988, 1992). Generally, the continuing debate is largely based on inference, opinion and anecdote (Deis 1982; Nattrass 2001; Jones & Howard 2001). To investigate this issue, it is imperative that birds being fed by humans are compared with birds in the same environment not being fed. It would be particularly instructive to investigate the food provisioning behaviour of fed birds during the high food-demand period prior to the fledging of chicks. Do such birds continue to obtain natural food sources or do they rely entirely on easily obtained supplementary foods?

The Australian magpie is an ideal candidate for such a study. Not only is it abundant in suburban environments throughout Australia (Jones 2002), it is among the most common species to utilise feeding stations (McLees 2001; Rollinson *et al.* 2003). Suburban wildlife feeders, while common, are often distributed patchily throughout the suburbs, providing a 'natural experiment' in which to investigate the reaction of magpies to the presence of different treatments of supplementary foods. In the present study we compared the foraging and chick provisioning behaviour of magpies resident in the suburbs of Brisbane, Australia. Two groups of magpies were studied: those using feeding stations ('fed') and those that did not ('unfed'). As all pairs were actively engaged in breeding, we predicted that fed magpies would obtain significantly less natural food for themselves and especially for their chicks than would unfed birds. For the purposes of this study, we regarded magpies as being dependant upon supplementary foods if they obtained most of their food from feeding stations even during low food-demand times.

METHODS

Study area and animals

The study was conducted during the 2001 magpie's breeding season (June to November) in suburban areas of Brisbane (153°03'E, 27°33'S), in south-east Queensland, Australia. The climate is typically sub-tropical without pronounced seasonality. During the study the rainfall recorded June-August (minimum 8.4 mm, maximum 27.6 mm) was less than the long-term average (57 mm), September and October were similar (34 mm and 92 mm), and November (192 mm) received higher than the average rainfall (98 mm) (Queensland Bureau of Meteorology 2003). The suburban environment consisted largely of a matrix of lots with single or two-storey private houses, interspersed with smaller areas of native woodland and parkland. Approximately 45-78% of the area consisted of well-managed lawns (the primarily foraging substrate of the species) in houseyards, sports fields, school grounds and parks (Jones 2002).

We selected twenty pairs of magpies with territories comprised predominantly of parks and sports fields; pairs with territories based mainly in suburban streets and house yards were avoided due to the difficulties of observing birds behind fences and other structures. All birds had previously been individually colour-ringed (Rollinson 2003) and sexes were easily distinguished through plumage differences (Jones 2002). Pairs were categorised into one of two groups: those regularly utilising suburban feeding stations ('fed') and those that were not fed by humans ('unfed'). Pairs were confirmed as belonging to either group through information obtained by observation and by a questionnaire survey of all households near or adjacent to known focal magpie territories (see Rollinson *et al.* 2003). Birds utilising one or more feeding stations were designated as 'fed' (total of 12 pairs). 'Unfed' (total of eight pairs) birds also visited some houseyard lawns during their normal foraging activities but did not encounter or use feeding stations. Some unfed magpies did consume food waste left unintentionally in parks and picnic areas but such foraging was irregular and opportunistic.

Information obtained separately on the practices of the wildlife feeders operating in the study area (O'Leary 2002; Rollinson *et al*. 2003) indicated that fed pairs had

access to one to four feeding stations situated in backyards, varandahs or patios offering meats and food scraps (mainly beef mince, sausage, steak, ham, bacon, bread and cheese. Approximately 78% of the supplementary food provided consisted of meat with the remainder including at least some bread. Wildlife feeders provided supplementary food on a regular basis, varying between one to ten times per day (mean 1.9 times per day)(O'Leary 2002).

Behavioural observations

Each magpie within all pairs was observed at least weekly for a total of 6-18 hours throughout the breeding season using binoculars (8x40 mm) and a zoom spotting scope (45x56 mm to 20x25 mm). Sampling was divided into three sessions per day: morning (dawn to 10:00); midday (10:00 to 14:00); and afternoon (14:00 to dusk). Each observation of an individual lasted 15 minutes, during which all foraging or chick-feeding actions were recorded per minute. Observation visits to pairs were randomised for time of day and location.

Foraging behaviour

Ground foraging activities was only recorded when the birds were on lawns or short grass, the preferred foraging substrate for magpies in the suburban environment (O'Leary & Jones 2002). During the observation session, foraging events were recorded for the minute in which they occurred; food items and amount were also identified where possible and counted. For different food types (natural or supplementary food), the foraging amount per minute was ascertained by counting the number of items consumed for a particular type of food item within a minute. Head tossing and swallowing (Veltman & Hickson 1989) distinguish the successful capture of prey, and most food items could be determined before being swallowed. Some small food items could not be identified and were categorised as 'unknown'. Foraging events only included food obtained from the lawns and not from feeding stations.

Chick provisioning

All pairs (both fed and unfed) were assessed weekly for breeding activity from June to November 2001 and chick-provisioning events were recorded during each session with the sex of the provisioner, amount of food and food source (natural or supplementary food) being recorded per minute. The breeding season was divided into the following phases: nest building; incubation; hatchlings (chicks not visible from the ground but being fed); medium chicks (approximately 7-14 days since hatching date); large chicks (chicks frequently visible from ground); and fledglings (chicks permanently away from nest for maximum of seven days). The starting date of each breeding phase for each pair was determined as the date on which either the male or female was first observed engaged in the particular phase.

For each pair, 15 minute observational periods of both male and female were combined per day. During the chick phases, both parents were usually observed foraging for food for the chicks. Food intended for the chicks was held in the parent's beak and once sufficient food had been obtained the parent bird returned to the nest to feed the chicks. The item and amount of each food item collected for the chicks was recorded while the parent bird was foraging prior to the parent provisioning the chicks. If the parent bird was not observed foraging before provisioning the chicks it was difficult to determine the quantity and type of food being provisioned. When this occurred, the amount and type of food was estimated if the bill was seen before the food was provisioned to the chicks; otherwise it was recorded as 'unknown'. All food provisioned to the chicks was recorded, including food obtained from feeding stations.

Statistical analysis

Analyses were performed using the SAS statistical analysis package (SAS System for Windows, SAS Institute, Cary, NC). Data lacking normality were logarithmically transformed, due to the factor effects being multiplicative rather than additive (Zar 1999). Means and standard errors are, however, presented as untransformed. The level of significance used was 5% unless otherwise stated.

The test of proportions (Zar 1999) was used to compare the proportion of six categories of foods consumed by the adult fed versus unfed magpies. These categories consisted on four natural food types: (1) insect larvae/worms (LarvWm); (2) flying

insects (including all Coleoptera, Lepidoptera and Hymenoptera other than non-flying ants)(FlyIns); (3) all other insects (mainly ants, Blattodeae, Phasmodeae, Araneae, Orthoptera and Diplopoda)(OthIns); and (4) other natural (all other living items including plant material)(OthNat); and two human-derived food types: (5) meat items (Meat); and (6) non-meat (primarily non-meat items such as bread)(Nmeat). For each category, a test of proportions was used to assess whether there was an equal chance of fed and unfed magpies consuming a particular food category.

Similarly, a test of proportions was performed on the proportion of natural and supplementary food provisioned by fed and unfed magpies to the chicks. Breeding dates were converted into numerals, starting at 1 for the first day of June and ending at 153 for 31st October. Student's *t*-test was used to test between fed and unfed magpies for each breeding event date.

A factorial analysis of variance was performed on the amount of food foraged by the adults and the amount of food provisioned to the chicks. Outliers identified during exploratory data analysis were examined to assess whether or not they could be explained. If an outlier could not be explained it was removed to avoid possible violations of normality and variance equality assumptions (Zar 1999). As the data (foraging amount and amount of food provisioned) had unequal sample sizes, the analysis of variance was carried out using the general linear models least squares method (Zar 1999). Analyses of the data were conducted using a split-plot model, with magpie pairs being split into males and females. A *t*-test using the least-squares means was used to test for differences between the means when an effect was identified as significant in the analysis of variance.

RESULTS

Foraging

Both fed and unfed magpies foraged on a wide variety of foods in suburban areas of Brisbane. Natural food clearly dominated the diets of both groups of magpies; approximately 76% and 92% of total items consumed by fed and unfed birds respectively were naturally occurring invertebrates. There were no differences in the

proportions of each of natural food types consumed by fed and unfed magpies (Fig. 1). Fed magpies, however, consumed a significantly larger proportion of both meat (test of proportions: $z = 40.06$, d.f. = 1, $P < 0.001$) and non-meat items ($z = 6.85$, d.f. = 1, $P < 0.01$) than unfed birds.

FIG 1

The mean number of natural food items ingested per minute by foraging adults was compared for feedtype (fed or unfed), sex and time of day (Table 1, Fig. 2). Fed magpies consumed similar numbers of items while foraging throughout the day. In contrast, unfed magpies fed at a significantly higher rate during the morning, with the feeding rate declining to a similar rate of fed birds by midday (Table 1, Fig.2). Thus, an obvious effect of magpies utilising feeding stations was to substantially reduce their rate of foraging during the morning; both fed and unfed birds foraged at similar rates at all other times.

TABLE 1

FIG 2

Reproductive activities

Fed magpies initiated each phase of breeding significantly earlier than unfed magpies, except during the fledgling phase (Fig. 3). The initiation of nest building (the first discernible event denoting the commencement of breeding) for fed magpies was on average 12.73 days earlier than that of unfed birds (Student's t-test: $t = 2.47$, d.f. = 16, $P = 0.031$), clutch initiation was 14.95 days earlier ($t = 2.39$, d.f. = 16, $P = 0.030$) and date of first hatch was 15.26 days earlier ($t = 2.45$, d.f. = 15, $P = 0.034$). Although fed birds first day of fledging was 8.17 days earlier than unfed birds, this was not significant.

FIG 3

A clear majority of the types of food provided to chicks by both fed and unfed magpies was natural, although the proportions were significantly different: 0.68 of the items provided by fed magpies were natural compared to 0.97 for unfed magpies (test of proportions: $z = 49.6$, d.f. = 1, $P = 0.001$). This is further emphasised by comparing the total amounts of natural versus supplementary food provided to chicks by their fed and unfed parents (Fig. 4).

FIG 4

The total amount of food provisioned to chicks was also compared for feedtype (fed or unfed), sex of provisioner and food source (natural or supplementary) (Table 2). There was a significant difference among pairs within feedtype, although the overall feedtype effect on the mean total amount food provisioned to the chicks was not significant. The interaction between feedtype and food source was significant (Table 2), however, with both fed and unfed magpies clearly preferring to provision their chicks with natural food (Fig. 4).

TABLE 2

DISCUSSION

The possibility that animals utilising suburban wildlife feeding stations may become dependent on this source of supplementary food remains a prominent concern for both opponents and advocates of this extremely popular practice (Deis 1982; Anderson *et al.* 1997). The present study was designed to assess one aspect of this complex behavioural phenomenon by investigating the extent to which breeding Australian magpies utilised supplementary rather than naturally occurring foods when foraging for themselves and when provisioning their chicks. We predicted that magpies with continual access to feeding stations would feed from and provision chicks primarily with supplementary foods rather than natural foods. In contrast, unfed magpies, without this ready source of food would obtain all food items, for themselves and their chicks, via ground foraging.

Foraging

Contrary to our predictions, we found that the diets of suburban magpies, both fed and unfed, were dominated by natural foods with fed magpies consuming a similar proportion of each natural food category as unfed magpies. An earlier study from the same location (O'Leary & Jones 2002), conducted during a prolonged drought when ground-derived invertebrates were presumably difficult to obtain, found a similar result, with approximately 82% of the diet of magpies being natural rather supplementary. This strongly suggests that despite there being an abundance of supplementary food

available (Rollinson *et al.* 2003), fed magpies did not rely on this food for their daily energy requirements. Other ground-foraging birds in suburban environments, such as the common starling *Sturnus vulgaris*, also forage on a broad range of natural foods, even where feeding stations were readily available (Mennechez & Clergeau 2001).

The observed diet of unfed magpies was different to that of fed magpies with respect to incidental supplementary food obtained while foraging on the ground away from feeding stations. Unfed magpies were rarely observed consuming food scraps, whereas 24% of the diet of fed magpies consisted of food wastes and other discarded items. O'Leary & Jones (2002) also found that magpies regularly obtained food scraps, with approximately 18% of all items consumed consisting of this food. This difference between fed and unfed birds may have been due to a greater availability of incidental foods in the territories of fed magpies, although this was not investigated at the time. Certainly, all of the territories surveyed in this study contained picnic grounds or public parks where human foods were often discarded.

In general all birds need to replenish their energy levels early in the morning after the enforced 'fast' of night roosting; for species reliant on protein-rich foods such as insects feeding rates are typically fastest during the early morning (Sutherland 1996). Observations of foraging patterns (Fig. 2) provided some evidence that fed magpies were able to satisfy their early-morning nutritional requirements more rapidly than unfed birds. During the morning, fed magpies consumed significantly less food per minute than unfed magpies, suggesting that fed magpies obtained most of their morning food from feeding stations. (This suggestion is corroborated by an independent study of visits by magpies to feeding stations (Rollinson 2003).) At all other times of the day, fed magpies consumed a similar amount of food per minute as unfed magpies.

Reproductive activities

Timing of breeding

Magpies utilising feeding stations commenced nest building almost two weeks earlier than unfed birds resident in the same environment. Similarly, in a separate study of magpies breeding in the same region, Rollinson & Jones (2002) found suburban magpies breeding on average 17.55 days earlier than birds in nearby rural areas, a

difference attributed primarily to the greater food availability of the suburban environment. In addition to the regular supply of supplementary food at the many feeding stations (Rollinson *et al.* 2003), suburban lawns typically contain a greater abundance of invertebrates than grasslands in rural areas and bushland (Rollinson 2003). An advancement in laying date by two to 25 days (mean 8.84 days) is a consistent finding of experimental supplementary feeding studies of a wide variety of species (Boutin 1990; Soler & Soler 1996), results which clearly demonstrate the fundamental influence of food availability on reproduction in birds (Martin 1987). These experimental results are consistent with numerous studies (Dhont *et al.* 1984; Boal & Mannan 1999) comparing reproductive parameters of urban versus rural or wildlife species; urban populations invariably commenced breeding earlier, a finding attributed to the greater availability of supplementary foods.

Although fed magpies started their breeding much earlier than unfed birds, this difference was statistically insignificant by the fledgling phase. This result may have resulted from small sample sizes in the fledgling phase, as many pairs of both fed (about 40%) and unfed (about 50%) magpies did not successfully fledge their brood. It is also possible that a dietary difference between fed and unfed magpies may have caused the chicks of fed magpie to grow more slowly and therefore fledge at a similar date as that of unfed magpie chicks (see below).

Chick provisioning

Although a regular and abundant supply of supplementary food (mainly intentional) was available, fed magpies continued to provision their chicks primarily with natural food. Unexpectedly, the proportion of natural food provisioned to the chicks was similar for both fed and unfed magpies. Furthermore, the rate at which natural food was provisioned per minute was significantly greater than supplementary food for both groups. These results were the opposite to that predicted; given the ease with which food could be gathered from feeding stations, and its generally high-protein levels, we expected that fed magpies would feed their chicks mainly with supplementary food. Those opposed to wildlife feeding often claim that birds utilising supplemental food abandon natural foraging, and come to rely entirely on food provided by humans for themselves and their chicks, with a range of negative implications likely (Anderson *et*

al. 1997; Orams 2002). Our results demonstrate that, for adult Australian magpies at least, these concerns are unfounded. Nonetheless, we are also aware of numerous situations where large numbers of juvenile un-paired magpies appear to remain close to particular suburban feeding stations throughout the day and for extended periods of time (D. Jones, unpublished data, 2003). Although the foraging behaviour of these birds has yet to be investigated, some degree of reliance upon anthropogenic foods could be expected.

Other studies on the diets of chicks raised in suburban areas were all conducted in the Northern Hemisphere. In southern Wales, Cowie & Hinsley (1988) found that approximately 15% of the diets of blue tits *Parus caeruleus* and great tits *Parus major* chicks consisted of peanuts, bread and fat obtained from suburban feeding stations. A similar result was found among common starlings, with 11-20% of items consumed by nestlings consisting of supplementary foods (fruits and human refuse) in France (Mennechez & Clergeau 2001), and 35% in Warsaw, Russia (Gromadzka & Luniak 1978). In the present study, about one third of the food provided to the chicks of fed magpies consisted of supplementary food, compared to only 2% for unfed birds. In none of these studies did the proportion of supplemental food in the diet of chicks exceed more than about 40%.

In their investigation of suburban starlings in France, Mennechez & Clergeau (2001) found that the proportion of supplementary food provided to chicks peaked during the later stages of chick development, when nestling feeding demands were at a maximum. These authors suggest that starling parents actively avoided supplementary foods for as long as possible, sacrificing food quality for more readily obtained foods only when satisfying chick hunger was most difficult. The supplementary foods available to these birds consisted mainly of human food wastes such as bread and meat scraps, food generally regarded as being of low energetic content or poor nutritional value (Pierotti & Annett 2001). The human-provided foods used by suburban Australian magpies, however, were more often high-quality, protein-rich meats, although poorer quality foods were also provided (Rollinson *et al.* 2003). Given that virtually nothing is currently known of the nutritional quality of commonly used anthropogenic foods we strongly advocate this issue as a priority issue for future research.

This observational study found that the suburban magpies studied were not dependent on supplementary food (both intentional and incidental) as both fed and unfed magpies foraged mainly on a wide variety of natural items and provisioned their chicks primarily with natural foods. Magpies may be regarded as opportunists in the suburban environment as they utilise a wide variety of both natural and supplementary foods. However, further study is needed to determine whether the commonest types of supplementary foods that the magpies are consuming have a detrimental effect on adults, and in particular, the health and survival of chicks.

Given the popularity of wildlife feeding throughout the world, and the many benefits to human participants, it is unlikely that assertions of potential negative impacts are likely to curb public enthusiasm for the practice, especially when little factual information exists. Nonetheless, the considerable literature on experimental supplementary feeding studies (Boutin 1990) indicates clearly that the addition of food resources almost always influences many parameters of the population ecology of the species involved. Although suburban wildlife feeding represents a supplementary feeding experiment on a truly global scale, it has received remarkably little attention by researchers. As interest in the opportunities for ecological research in urban areas grows (Collins *et al.* 2000), we suggest that further studies into the phenomenon of suburban wildlife feeding may be particularly important.

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Table 1. Analysis of variance (least squares general linear model) of foraging rate for natural food (number of items per minute) for feedtype (fed and nonfed magpies), sex and time of day (morning, midday and afternoon). Pairs within feedtype were used as the error for feedtype. *Significant variable or interaction.

Source	**d.f.**	**Mean Square**	***F*-Value**	***P*-Value**
Feedtype	1	1.855	8.93	0.008*
Pairs:Feedtype	18	0.208	0.93	0.538
Sex	1	0.023	0.10	0.747
Feedtype X Sex	1	0.769	3.46	0.064
Time of day	2	0.414	1.86	0.158
Feedtype X Time of day	2	0.791	3.56	0.030*
Sex X Time of day	2	0.223	1.01	0.368
Feedtype X Sex XTime of day	2	0.252	1.13	0.324
Residual	222	0.222		

Table 2. Analysis of variance (least squares general linear model) of the total number of items of food provisioned per 30 min for feedtype (fed and nonfed magpies), sex of provisioner and food source (natural and supplementary). Pairs within feedtype were used as the error for feedtype. *Significant variable or interaction.

Source	d.f.	Mean Square	*F*-Value	*P*-Value
Feedtype	1	2.538	1.2400	0.2825
Pairs:Feedtype	16	2.052	2.5000	0.0083*
Food Source	1	42.047	51.2600	0.0001*
Feedtype X Food Source	1	11.975	14.6000	0.0004*
Sex	1	0.800	0.9700	0.3289
Feedtype X Sex	1	1.189	1.4500	0.2351
Food Source X Sex	1	0.662	0.8100	0.3739
Feedtype X Food Source X Sex	1	0.108	0.1300	0.7181
Residual	44	0.820		

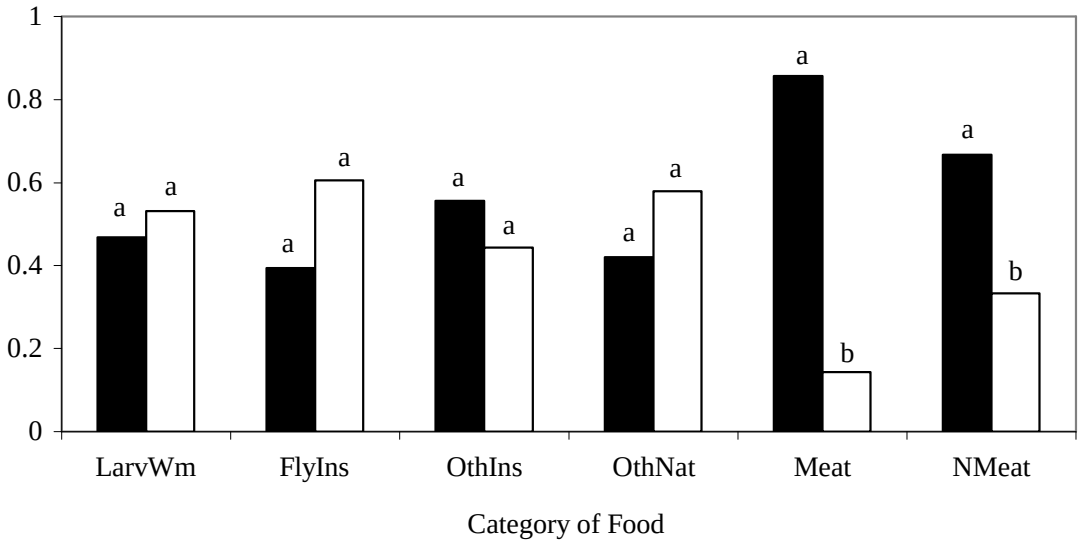
Figure Legends

Fig. 1. Total proportion of natural and supplementary food categories ingested by fed (solid bars) and unfed magpies (open bars) (LarvWm = insect larvae/worms, FlyIns = flying insects, OthIns = all other insects, OthNat = other natural food, Meat = all meats, NMeat = supplementary non-meat items.)(Total number of items detected: 1736 for fed, 2409 for unfed.) Proportions with the same letter not significantly different.

Fig. 2. Mean (± SE) (least squares) number of items ingested per minute during foraging for fed (•) and unfed (o) magpies. Means with the same letter not significantly different.

Fig. 3. Mean (± SE) dates (1 = 1st June) for start of phases of breeding for fed (•) and unfed (o) magpies. Means with the same letter not significantly different.

Fig. 4. Least squares Mean (± s.e.) number of items of natural and supplemental foods provisioned per 30 minutes to chicks by fed (•) and nonfed (o) magpies. Means with the same letter not significantly different.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LarvWm
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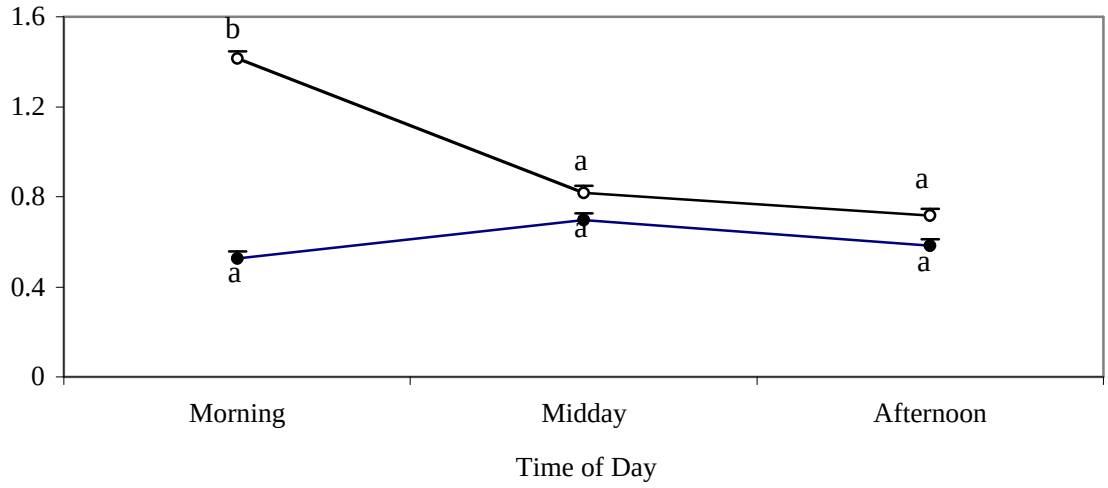
Category of Food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Afternoon
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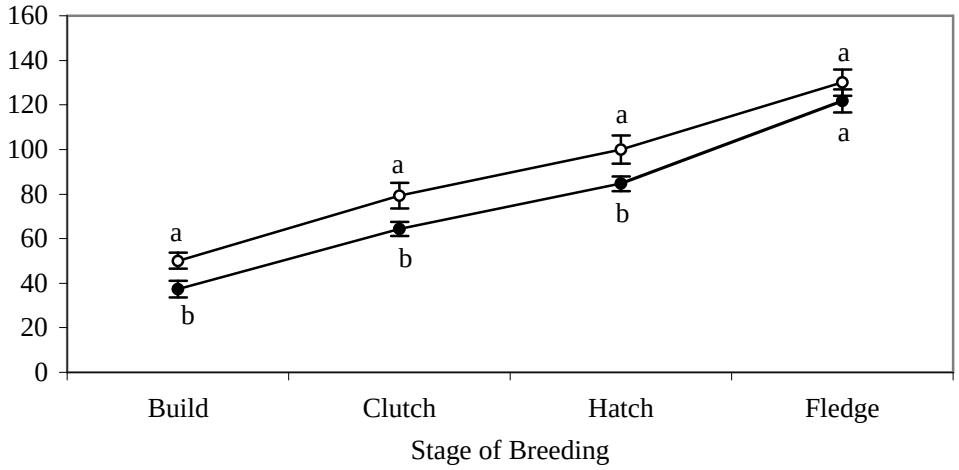
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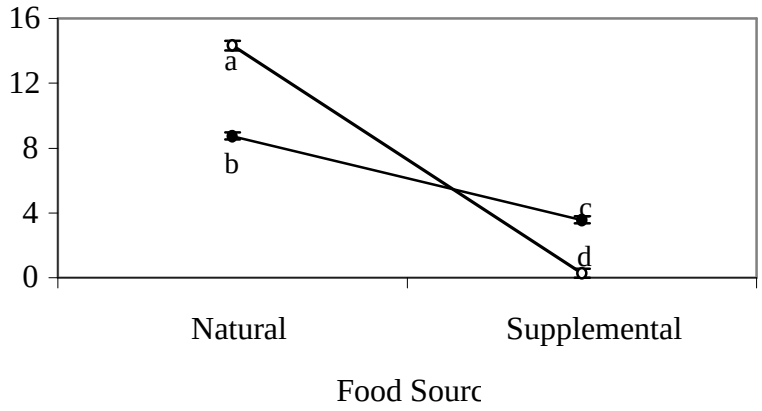
Stage of Breeding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