AUSTRALIAN FIELD ORNITHOLOGY 2006, **23**, 36–41

Is Learning Involved in Predator Recognition? A Preliminary Study of the Australian Magpie *Gymnorhina tibicen*

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Summary

Four groups of Australian Magpies *Gymnorhina tibicen* were presented with two model snakes (one naturalistic and the other conspicuous in colouring). The Magpies' responses were scored, and the responses of the adults and juveniles were compared. Each group was also presented with a model Magpie to test whether territorial 'intrusions' of a familiar stimulus resulted in similar responses or whether a model of a potential predator was treated differently. The responses of the Magpies to the model Magpie were distinctly different from those to the model snakes: there was little change in the number of foraging events during the presentation of the model Magpie but foraging ceased almost completely when the snake stimuli were presented. The results also showed that responses to the snake stimuli differed between adults and juveniles: adults were more likely to retreat whereas juveniles tended to approach the stimuli, which suggests that learning may be involved in anti-predator responses to snakes.

Introduction

Prey species may employ a number of strategies in response to a potential predator. They may attempt to avoid detection by the predator (Harvey & Greenwood 1978). If this strategy is unsuccessful, the prey animal may attempt to flee (Ellard & Byers 2005). Another strategy is to mob the predator (Curio 1978). Australian Magpies *Gymnorhina tibicen* are known to use mobbing as a response to predators (Olsen 1995; Kaplan 2004). In fact several avian species, including Magpies, attack a predator to drive it away (Kaplan 2004).

Magpies are ground-feeders (Kaplan & Rogers 2001), so snakes are one class of predator that may pose a threat. It is not known, however, whether responses to snakes (i.e. to a writhing stimulus on the ground) or to any other predator are innate or whether response to a signal stimulus (e.g. a particular colour, such as red) may invoke fear or aggression. Based on observation of responses by a juvenile Magpie to a snake model, Brockie & Sorenson (1998) suggested that fear of snakes may be innate. We conducted a pilot study to test whether this claim could be upheld. Four Magpie groups with permanent territories were exposed to realistic model snakes and their responses were recorded. A model Magpie was also presented to each group to differentiate responses to predator stimuli and to a model of a conspecific.

The age of the Magpies (juveniles or adults) was recorded since previous developmental studies of predator recognition have shown differences between adults and juveniles (Seyfarth *et al.* 1980; Marler & Evans 1996; Kelley & Magurran 2003). If anti-predator responses of Magpies do not depend on experience, one would expect to see similar, rather stereotyped, responses by both adults and juveniles. Nevertheless, the extended period of dependence of juveniles on adults suggests that anti-predator responses involve learning.

Methods

All experiments were conducted in the field within the city of Armidale, New South Wales (30°32′S, 151°40′E), between 14 May and 17 June 2003. Four groups of Magpies with permanent territories were studied. Group size varied between four and eight Magpies (Table 1). Groups 1–3 were located in the grounds of the University of New England, and Group 4 at Kathy Oval, in the centre of Armidale. Magpies were subdivided into two age groups (juvenile and adult) on the basis of their plumage (juvenile mottled, adult black and white: Pizzey & Knight 1997).

A 2-hour period was allocated for each experiment. Magpies were tested at four different times: early morning (0600–0800 h), late morning (0900–1100 h), afternoon (1400–1600 h) and early evening (1700–1900 h). A 48-hour interval between experiments at any location was used to minimise habituation. Each group was tested with the stimuli presented in random order and each group was exposed to each stimulus twice. Each experiment had a duration of 15 minutes consisting of three separate phases: a 5-minute pre-test (to determine the behaviour of the Magpies before exposure to the stimulus), a 5-minute test (exposure to the stimulus), and a 5-minute post-test (to determine whether the effects of the stimulus continued despite its absence).

Three stimuli were used: a naturalistic snake, a colourful snake and a model Magpie. The two model snakes were 130 cm in length and 6 cm in circumference (taken 5 cm from the tip of the mouth). The naturalistic snake was dull in colour (dark green), whereas the other was colourful, with red and yellow stripes extending down its body. The colourful snake was an attempt to mimic the appearance of the snake used by Brockie & Sorensen (1998), who had observed a juvenile Magpie responding to a confectionery snake with anti-predator responses (alarm calls and flight response). Both snakes had fishing line sewn into the mouth and attached to a reel so that they could be reeled in from a distance of 15 m from the Magpie group, thus realistically imitating the movement of a snake. The fabric-model Magpie, only marginally larger than an adult male, was placed as a stationary stimulus ~15 m from the group.

Continuous sampling was used to score five types of behaviour: vocalisations, flying events, scanning, foraging and approach behaviour. All behaviours were scored by direct observations.

Vocalisations were scored as the number of vocalisations recorded during each phase of the experiment, irrespective of vocalisation type. Each vocalisation was scored as one event, regardless of duration. Vocalisations were recorded by a Sony Electret condenser stereo microphone (ECM-MS907) on a Sony Mini-disc Player (Sony MD, MZ-R701).

Flying was recorded as the number of events of flying observed. The individual was recorded as flying when it lifted off a substrate (e.g. branch or ground), and the event ended when the bird landed on a substrate or continued flying until out of sight.

Scanning was recorded when the bird adopted an alert posture with feathers sleeked and with horizontal or tilting head movements.

Foraging was recorded when the Magpie looked directly at the ground or when it probed with its beak. The locomotion associated with foraging was either standing still, walking or occasionally running. During the testing phase, foraging events were recorded only when the Magpies were no farther than 30 m from the stimulus.

Approach behaviour was recorded when a bird (or birds) approached the stimulus to within 1 m.

The data were analysed using the statistical package Minitab 13 with stimulus (dull snake, colourful snake and model Magpie) and testing phase (pre-test, test, and post-test) as the variables.

Table 1: Number of Magpies, adult and juvenile, per group in the study

Group no.	*No. adults*	*No. juveniles*	*Total*
1	2	2	4
2	2	2	4
3	6	2	8
4	4	2	6

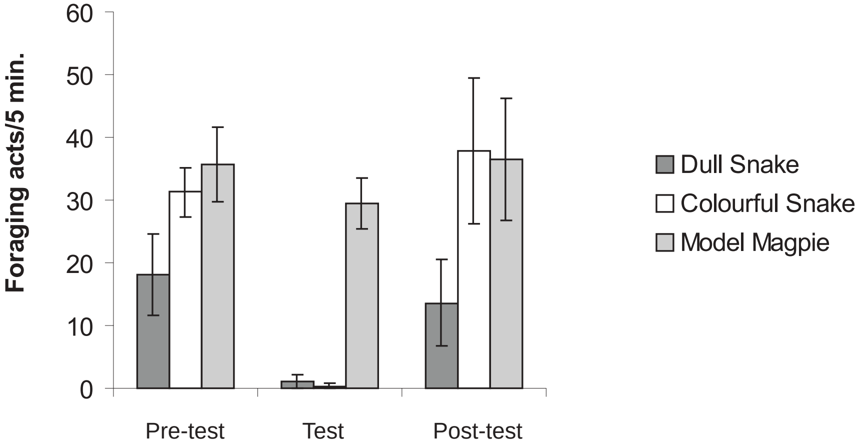

Figure 1. **Variation in foraging behaviour of Magpies in response to different experimental stimuli: number of foraging acts/5 min. (mean ± standard error) for each stimulus; four experiments/stimulus. Note significant decrease in foraging during presentation of model snakes but not model Magpie.**

Results

No significant results were obtained for the scores of vocalisations: there were no significant differences for this measure according to stimulus presentation ($F_{2,63}$ = 1.27, P = 0.32) or phase of testing ($F_{2,63}$ = 1.15. P = 0.33) and there was no significant interaction between testing phase and stimulus presentation ($F_{4,36}$ = 1.15, P = 0.34). However, significant results were obtained for the number of flying events. There was a significant interaction between stimulus and testing phase ($F_{4,63}$= 2.68, P = 0.04). Number of flying events was elevated in the post-test phase following presentation of the dull snake compared with all other testing sessions for the other stimuli. Scanning events varied significantly according to testing phase ($F_{2,63}$ = 4.48, P = 0.02) but did not differ according to stimulus (stimulus: $F_{2,63}$ = 2.42, P = 0.09 and interaction: ($F_{4,36}$= 0.59, P = 0.67). The number of scanning events decreased by a third during presentation of the stimuli, since the birds fixated on the stimulus and reduced general scanning.

The number of foraging events did show significant differences. There was a significant main effect ($F_{2,63}$ = 6.35, P = 0.00; Tukey comparison: pre-test × test: P = 0.01, pre-test × post-test: P = 1.00, test × post-test: P = 0.01) between the number of foraging events during the testing phases (pre-test, test and post-test). However, there was no significant main effect of stimulus ($F_{2,63}$ = 2.64, P = 0.08). There was no significant interaction between the stimulus and testing phase ($F_{4,63}$ = 0.72, P = 0.58). Figure 1 illustrates the decrease of foraging events during the testing phase compared with the pre-test and the post-test of the snake models and the model Magpie.

No approaches towards the model Magpie were observed, but individual Magpies, mostly juveniles, were recorded approaching the snake stimuli (to within 30 cm) and often foraged and preened whilst near the model snake. Although the

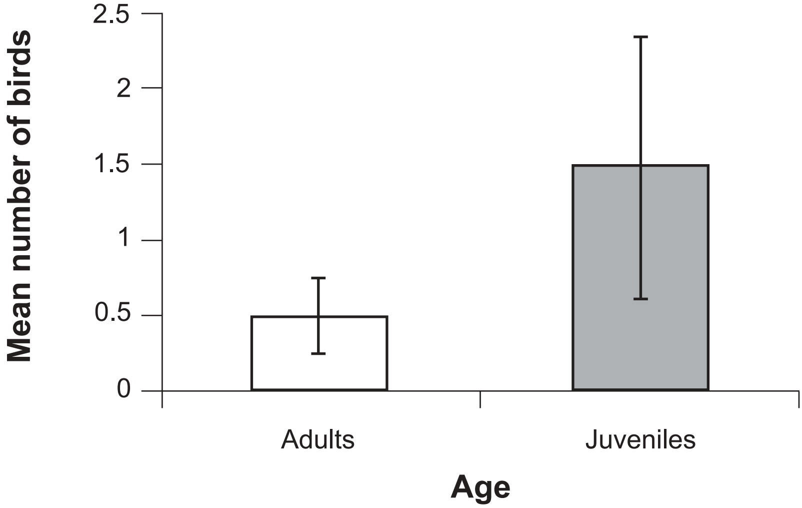

Figure 2. Variation in response to model snakes by Magpies of different ages: mean number (± standard error) of Magpies (adult vs juvenile) that approached within 1 m of snake stimuli; four experiments/age group.

differences between adult and juvenile behaviour in approaching the snake stimuli yielded no significant results (unpaired *t*-test, $t = -1.00$, df = 3, $P = 0.391$), there appeared to be a tendency for the juveniles to approach the snake more often than adults did (Figure 2).

Discussion

The significant decline in foraging events during the presentation of the model snakes, as well as the significant difference in behaviour towards the different snake stimuli, indicate clearly that the model snakes elicited visual attention. The significant differences found between the testing phases for scanning behaviour support this claim. Although recent research has shown that a bird's brain is capable of processing foraging and predator-detection information simultaneously, e.g. in detecting a predator overhead whilst the bird is foraging on the ground (Rogers & Kaplan 2005), such foraging (lowering the head) may make it impossible for the bird to trace the movements of a snake, especially in high grass, unless foraging stops and the bird's posture is erect to provide a better visual field of its nearest surroundings.

This result also showed that foraging ceased only when the snake stimulus began to move (was reeled in by the experimenter). It is possible that the writhing motion on the ground was in itself a stimulus, although the difference in response between the colourful and the dull snake was also significant, suggesting finer discrimination by the Magpies. The dull snake may have resembled a real snake (such as a young Brown Snake *Demansia textilis*, a Copperhead *Austrelaps superbus* or even a small Tiger Snake *Notechus scutatus*) found in the territories of the focal Magpies. The colourful snake, despite the conspicuous warning colours, elicited fewer responses, suggesting that colour was not an innate warning stimulus but that experience with snakes in the area might have elicited the difference in behaviour to the two snake stimuli.

The presentation of the model Magpie, by contrast, evoked few measurable responses. Magpies continued to forage and seemingly went about their usual routines but with some vigilance behaviour, albeit covert. During the test, adults reduced the foraging distance in relation to the stimulus, and by the end of the test had formed a semicircle around the model Magpie and tended to proceed around it in a clockwise direction. Hence, although the motionless model seemed not to represent an immediate threat and was not treated as a strange and intruding Magpie might have been (immediate alarm calling and mobbing, for instance: Kaplan 2004), the Magpies' behaviour suggested some vigilance.

The results also suggest that adults and juveniles may have different responses to a ground-predator. Adults tended to increase their distance from the model snakes whereas juveniles tended to approach and also often remained quite near the moving snake. Indeed, some juveniles even pursued the snake and followed it throughout the testing phase without any sign of alarm. These differences in behaviour did not show up as statistically significant possibly because of the small sample size and also because the duration of approach behaviour was not separately scored. This would be worth investigating further in a larger sample. Adult Magpies approached the snake stimuli but only briefly. Hence, duration of approach rather than number of approaches would have been a better measure, or at least an important additional measure, to compare adults and juveniles.

The difference between the behaviour of adult and juvenile Magpies towards the model snakes prompts the question of whether anti-predator responses by Magpies are learned or innate. Brockie & Sorensen (1998) suggested that fear of snakes may be innate but the present, albeit preliminary, results suggest that this may not be the case. Differences between experienced and naïve animals have been discovered in the Domestic Chicken *Gallus gallus*, where inexperienced chicks exhibited none of the anti-predator responses of adults (Marler & Evans 1996). The difference between the responses of adult and juvenile Magpies likewise suggests that learning is required before Magpies adopt an avoidance response to a snake.

It would seem an evolutionary disadvantage for any juvenile to approach a snake or unfamiliar stimulus. Approach by a predator often results in mobbing of the predator (Curio 1978; Maklakov 2002; Nijman 2004; Griesser & Ekman 2005), with stereotyped flight, loud broad-frequency vocalisations, and often also the attraction of conspecifics and heterospecifics (Curio 1978). Model snakes did not elicit such a response in the present study; juvenile Magpies approaching a snake model rarely vocalised and showed no sign of attacking. Moreover, their actions did not attract more Magpies to the site, as would be expected in mobbing; the adults actually left the area. The fact that the juveniles approached and looked at the model predator, sometimes for as long as 4 minutes, is an example of behaviour that has rarely been described in birds (Black-headed Gulls *Larus ridibundus*: Kruuk 1976) but regularly in fish (Pitcher 1992). Such predator-inspection behaviour may explain the actions of the juvenile Magpies. One explanation is that juveniles may need to learn about a predator and thus first have to inspect it, as has been argued in the case of guppies *Poecilia reticulata* (Kelley & Magurran 2003). Although in field experiments one cannot determine the previous experience of a bird, further experiments are now being conducted to clarify the differences observed here in the responses by the Magpies according to age.

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Received 15 January 2005 ■