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FOOD PREFERENCE OF LONG-BILLED CORELLAS *Cacatua tenuirostris* IN AVIARY EXPERIMENTS

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The long-billed corella causes extensive damage to crops in western Victoria. In an attempt to deter birds from vulnerable crops an appropriate bait is being sought for use in field trials of a chemical deterrent. Food preference was examined in captivity to determine bait acceptability in free-choice and no-choice trials. Corellas (n = 10) were offered 4 feeds simultaneously in free-choice trials; whole and hulled oats and whole and hulled sunflower seeds. A significant difference was found in daily consumption between feeds ($F = 88.24$, df = 319, $P < 0.001$). Although hulled oats were consumed in significantly higher amounts than all other feeds, there was some individual variation in food preference. Overall, mean daily diet comprised 62 per cent hulled oats, 17 per cent whole oats, 12 per cent hulled sunflower and 9 per cent whole sunflower. A no-choice experiment offering either hulled oats or hulled sunflower seeds found daily consumption of hulled oats was significantly higher than that of hulled sunflower seeds ($t = 6.01$, df = 98, $P < 0.001$), however daily energy intake in Mj was not significantly different. Hulled oats offer a suitable and practical bait for use in field trials as it is readily consumed by captive corellas, it is economical and widely available and may be an appropriate vehicle for chemical deterrents. Further studies are recommended to address non-target species issues and to test bait acceptance in the field.

INTRODUCTION

Several cockatoo species are considered serious pests by farmers of cereal and oil seed crops in western Victoria, namely the Long-billed Corella *Cacatua tenuirostris,* Sulphur Crested Cockatoo *Cacatua galerita* and Galah *Eolophus roseicapillus*. The Victorian Department of Natural Resources and Environment has attempted to manage this issue for a number of years (e.g. Walters 1981; Horsham Region Land Protection Advisory Committee 1986) and has investigated techniques to alleviate the problem, including means of capturing and euthanasing birds, use of chemical deterrents and increased education on crop management and bird deterring tactics (e.g. Venn 1986, 1992; Environment and Natural Resources Committee 1995). In addition, the State Government Environment and Natural Resources Committee produced a series of recommendations which included the need to conduct further research on potential avicides and chemical deterrents that have been used successfully in crop management worldwide (Environment and Natural Resources Committee 1995). The urgency of the situation has been further highlighted by an apparent increase in the incidences of illegal poisoning which may affect both target and non-target species and contribute to environmental contamination (Du Guesclin *et al.* 1983). While all three species can cause extensive damage to crops, the Long-billed Corella (hereafter referred to as 'corella') is often highlighted as the main culprit in western Victoria and is the focus of this study.

A variety of techniques have been used worldwide in attempts to reduce bird damage to cereal and oil seed crops including scare devices (Conover 1979, 1984), avicides (DeGrazio *et al.* 1971; Cyr 1977), habitat manipulation (St John 1994) and chemical repellents (Goodhue and Baumgartner 1965; Venn 1986; Crocker *et al.* 1993). However, all methods have limitations of cost, effectiveness and practicability and no single method has proven universally successful (Linz *et al.* 1995). The chemical 4-aminopyridine (hereafter referred to as '4AP'), registered as Avitrol© in the United States and Scatterbird© in Australia, was selected for further testing for several reasons. 4AP has been used successfully in the US to manage Blackbird *Agelaius phoeniceus* depredation of sweetcorn (De Grazio *et al.* 1971; Stickley *et al.* 1976; Conover 1984) and it is a registered chemical in Australia, an important factor given the urgency of the situation. Further, 4AP acts as a deterrent as well as an avicide. Birds ingesting the substance typically die; however, distress calls and behaviours produced during toxicosis deter the remaining flock from feeding areas (Goodhue and Baumgartner 1965; Woronecki *et al.* 1979). Thus 4AP is typically applied in a 1:100 ratio so that 1 per cent of a feeding flock is likely to ingest the chemical and 99 per cent will be frightened away by the response of the affected few, leading to a much lower mortality rate than expected with the use of a poison alone (De Grazio *et al.* 1971; Stickley *et al.* 1976; Conover 1984).

For these reasons the potential use of 4AP as one part of a bird control scheme has been under investigation in Victoria. A number of issues important when contemplating broadcasting toxic substances have been addressed, including the effect of 4AP on the main target species (the corella), the potential for combining the avicide with an analgesic to address issues of humaneness during toxicosis and means of delivering the chemical to a low proportion of the bird population. In addition, further research into other means of deterring birds and crop management has been recommended as well as the need to determine the effect on non-target species and corella populations in the

wild. While these issues need to be addressed as part of a management plan for wildlife control, that is not the purpose of this paper. Rather, this paper focuses on the selection of an appropriate bait in preparation for field trials of such compounds. This is an important first step in the use of feeding deterrents such as 4AP. The efficacy of a bird deterrent depends on rapid consumption of the bait, thus enhancing its effectiveness and reducing risks to non-target species (Linz *et al.* 1995). When choosing a bait for field experiments several aspects must be taken into consideration, including known diet and food preference of the target species, availability and cost of the bait and ease of applying chemical compounds to the bait. The potential for bait uptake by non-target species is another important issue; baits should be palatable to the target animals and less so to non-target animals (Brunner and Browne 1979).

Several feed types were considered that might meet some of these objectives. The corella is a ground feeding bird, inhabiting grassy woodland areas in western Victoria, south-eastern South Australia and the Riverina area of New South Wales (Temby and Emison 1986; Emison *et al.* 1994). Although historically the corella fed on roots of tuberous plants (namely the native yam, *Microseris lanceolata*) and native grasses and seeds, the diet has changed as a result of decline in abundance and distribution of these plant species (Temby and Emison 1986). Currently the corella's diet is dominated by introduced species of both tuberous plants (namely onion grass, *Romulea* spp.) and cereal grains (Environment and Natural Resources Committee 1995). Among cereal grains, corellas have been reported to exhibit a preference for oats (Walters 1981) which may comprise up to 92.6 per cent of grains consumed (Temby and Emison 1986; Emison *et al.* 1994).

Sunflower seeds are another component in the corella diet and are considered to be a highly preferred feed for a number of bird species. Birds held in aviaries often selectively eat sunflower seeds before consuming other seeds in mixed seed diets (Shephard 1919; Ullrey *et al.* 1991) and corellas may feed selectively in sunflower seed crops when they are available (Walters 1981). Based on this information, food preference trials were conducted to determine whether corellas would demonstrate a preference between sunflower seeds and oats.

Corellas feed by husking grains and seeds, discarding the husk and consuming only the kernel. Thus the majority of any compound applied to the whole seed may not be consumed (Tighe 1959). This problem may be circumvented by vacuum impregnation with the chemical so that the chemical is applied to the kernel and not the outer husk; however, the use of a hulled grain may be a simpler and more cost-effective solution should the birds readily eat them. For this reason, it was decided to use both forms (whole and hulled) of each of the two experimental baits in food preference trials.

Free-choice food preference tests have commonly been used in the development of suitable baits for pest species by demonstrating a species' preference for a particular food item when a variety of food types are available (Ridsdale and Granett 1969; Sridhara and Srihari 1983; Asran 1993; Linz *et al.* 1995). No-choice experiments have been used to test palatability and repellency of feeds (Alenier and Combs 1981; Bennett and Prince 1981; Crocker *et al.* 1993; Dolbeer *et al.* 1998) and have been useful in determining variation in food intake depending on type and variety of food available.

The purpose of this study was to examine food preference of corellas in an aviary setting to determine a suitable bait for a chemical deterrent. Food preference experiments were conducted to determine if corellas exhibited a preference for oats or sunflower seeds in the whole or hulled form and to determine differences in daily intake relative to type of feed.

METHODS

Animals and facilities

Corellas were purchased from a licensed controller in July 1999 and transported to a holding facility at the Victorian Institute of Animal Science (VIAS), Werribee (37°55'S, 144°40'E). All birds had been captured from the wild in February 1999 and maintained in an aviary until their relocation to Werribee. The sex of individual birds was unknown and was not determined. Birds were housed in individual pens 2.9 m (length) × 1.2 m (width) × 2.2 m (height) along the south side of an open-sided shed (19.7 × 7.6 m). Pens were constructed of wire mesh on three sides (1.3 mm diameter wire, mesh size: 12 × 12 mm for the front and rear panels and 2.6 mm diameter wire, mesh size: 24 × 24 mm for the side panel) and aluminium siding walls on the fourth side so that each bird had visual and physical contact with one other bird through a mesh wall. Although the shed provided shelter, the upper half of the north and south facing walls were covered in mesh only, allowing natural light and breeze into the enclosure. Plastic sheeting and an aluminium sheet were attached to the upper half of the outward facing wall of each pen to form a sheltered windbreak area. Each pen contained a hanging and ground eucalyptus or cypress branch for perching and cement floor partially covered in wood shavings and sand grit. Birds were acclimatized to the cages for one week and were fed on a mixed seed diet of commercial parrot seed (Parrot Mix: Western Produce, Werribee). Fresh water was provided *ad libitum*. All birds were weighed at the beginning and end of each experiment.

Feed trays were designed so that discarded seed and husks could be collected and weighed to measure actual food intake. A 600 ml bowl was bolted to a wire mesh grill (34 × 34 cm) which was then set into a 34 × 34 cm metal tray. Feed trays were placed on the floor of each cage balanced on two bricks in an area swept clean of wood shavings and grit. This method proved successful in catching spilled seed and debris and in deterring rodents. Feed trays were placed in approximately the same location in each cage.

Experiment 1 — Free-choice bait selection

Ten adult corellas (sex unknown) with a mean weight of 512 ± 12.6 g were used in a free-choice preference test to determine whether corellas would exhibit a preference when offered a choice of four feed types. Feeds used in the experiment were whole oats ('oats'), hulled oats ('H oats'), whole sunflower seeds ('SF') and hulled sunflower seeds ('H SF'). For three days prior to the beginning of the experiment all birds were fed an *ad libitum* diet of an equal mix of the four feeds so that no food was novel. During the experiment 30 g (an amount in excess of daily requirements) of each feed type was placed in a separate feed tray in each corella pen. Feed trays were placed in each pen between 0800 and 0830 hrs and collected between 1700 and 1730 hrs daily. Tray position in each pen was randomized daily across four positions so that each feed type was in each position the same number of times during the study. Remaining feed, spilled seed and debris were weighed after tray collection each day and actual intake of each feed recorded for each individual. A control container of each feed was also weighed daily to determine if there were any changes in moisture content. The variation in moisture content over the experiment was negligible and food intake was not adjusted for these changes. This feeding regime continued for eight consecutive days. At the end of the experiment birds were returned to the maintenance diet for two days before beginning experiment 2.

Experiment 2 — No-choice bait selection

In this experiment a no-choice format was used to determine if corella daily food intake would vary when only a highly preferred feed (H oats) or a less preferred feed (H SF) (as determined in experiment 1) was available.

The same study subjects from experiment 1, maintained in their individual pens, were used. Birds (n = 10) were randomly allocated to two groups (A and B) and each offered a single feed diet over a three week period according to Table 1. A single tray was placed in each pen between 0800 and 0830 hrs and collected between 1700 and 1730 hrs and residual feed and debris weighed and recorded daily. A sample of each of the feeds used in this experiment was sent to the Pig and Poultry Production Institute Nutrition Research Laboratory, South Australia for analysis of energy content.

TABLE 1

Daily feeding regime for corellas during Experiment 2. This feeding regime was administered Monday to Friday (5 days) during each treatment week. Birds received the maintenance diet on weekends.

	Daily Feeding Regime		
Group	Week 1	Week 2	Week 3
A	40 g H oats	Maintenance diet	40 g H SF
B	40 g H SF	Maintenance diet	40 g H oats

Statistical analysis

Mean daily food intake was determined for all birds during experiment 1 and by treatment in experiment 2. Per cent of the total daily intake contributed by each feed type was also calculated for each bird in experiment 1. Two-way analyses of variance ('ANOVA') (Genstat version 5.1, Lawes Agricultural Trust, Rothamsted, UK) were conducted to determine if there were any interactions between daily food intake and day and between daily food intake and position of feed tray. No interactions were detected and the null hypothesis that all feed types were consumed equally was tested with a one-way ANOVA on average intake per bird. Specific contrasts were made using Fishers Least Significant Difference (LSD) at the 5 per cent level.

Data in Experiment 2 were compared with a paired t-test to determine if there was a significant difference between average daily intake of H oat and H SF. A two-way ANOVA was used to determine if there was any interaction between mean daily food intake and treatment week. A one tailed Student's t-test was used to compare weekly minimum and maximum temperatures over the duration of the experiments. Daily energy intake was calculated for each bird by multiplying daily intake (kg) by energy content (Mj/kg) as determined by the energy content analysis. A paired t-test was used to compare mean daily energy intake between the two treatments.

RESULTS

Experiment 1

Mean total daily food intake over the eight day experiment for all birds was 23.47 ± 6.8 g (SD), range (11.5–31 g). Mean daily food intake of each food type is given in Table 2. No interaction or significant differences were found in daily food intake over time or by position of feed tray. A significant difference was found between preference for feeds ($F = 88.24$, $df = 319$, $p < 0.001$). Based on the calculated LSD of 1.7, daily intake of H oats was significantly greater than that for all other feeds. There was also a significant difference between the intake of oats and SF, however, differences between oats and H SF and between SF and H SF were not significant (Table 2). Although the overall preference was very striking, not all individuals conformed to this pattern (Fig. 1). While H oat was the preferred feed for most birds

TABLE 2

Mean daily intake (g) and standard deviation (SD) for each of the four feeds for all birds overall in a free-choice food preference experiment. Mean daily intake of feed types sharing the same letter notation are not significantly different, while significant differences at the 5 per cent level ($LSD_{(P = 0.05)} = 1.7$) were found between those with different letter notations. (SF = whole sunflower seeds, H SF = hulled sunflower seeds, Oat = whole oats and H oat = hulled oats).

Feed Type	Mean daily intake (g)
H oat	14.6 (± 7.8)
Oat	3.9 (± 4.7)
H SF	2.9 (± 5.5)
SF	2.2 (± 3.9)

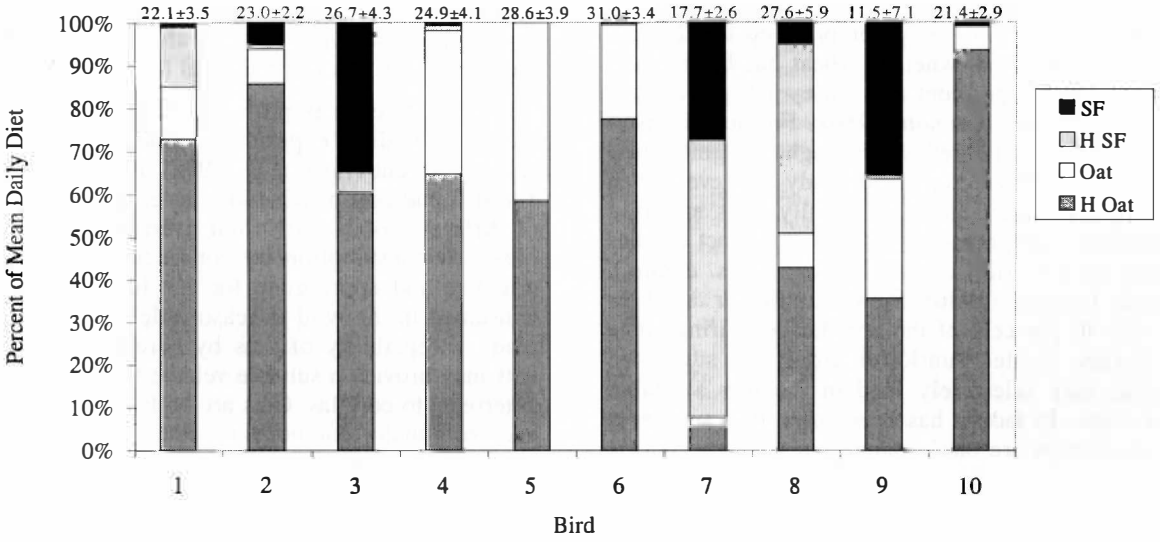

Figure 1. *Percentage of the daily diet attributed to each of 4 feed types for 10 individual corellas in a free-choice food preference experiment. Individual mean total daily intake and SD are noted above each column (SF = whole sunflower seeds, H SF = hulled sunflower seeds, oat = whole oats and H oat = hulled oats).*

and comprised more than 50 per cent of the daily diet, one individual (Bird 7) consumed more H SF (65%) than H oat (5.7%), and two others (Birds 8 and 9) had an equal preference for SF and H oat.

Experiment 2

When the 10 birds were offered a no-choice diet they consumed significantly more H oat (19.4 ± 5.2 g) than H SF (12.1 ± 6.9 g) per day ($t = 6.01$, $df = 98$, $p < 0.001$). A significant difference was also found in average daily food intake between weeks of treatment ($t = 3.8$, $df = 49$, $p < 0.001$). During week 1 daily food intake was 17.8 ± 6.6 g and during week 3, it was 13.8 ± 7.1 g. Although mean daily food intake varied between weeks 1 and 3, the same trend was apparent in both weeks, i.e. H oats were consumed in greater quantities than H SF. Temperature ranged between an average minimum of 9.3°C and a maximum of 14.2°C in week 1 and a minimum of 6.8°C and maximum of 13.7° in week 3, but these differences were not significant ($p > 0.05$).

Gross energy content for samples of the H oats and H SF used in this study were 18.05 Mj/kg and 29.19 Mj/kg respectively. Thus, birds consumed on average 0.351 ± 0.093 Mj per day when fed H oat and 0.354 ± 0.200 Mj per day when fed H SF, which was not significantly different ($p > 0.5$)

DISCUSSION

As most birds prefer some food items and partially or totally reject others (Ullrey *et al.* 1991) it has been assumed that adult corellas in the wild would be selective of feed and exhibit preferences. Corella diet has been investigated by analysis of bird crop and stomach contents (Temby and Emison 1986) and by recording the number of birds and amount of time spent feeding at various sites (Emison *et al.* 1994). These studies have both found cereal grains to be an important part of the corella diet, comprising 49 per cent overall. Grain is consumed throughout the year at different growth stages including germinating seeds, mature seed heads and spilled grain left in stubble fields. Oats may comprise up to 92.6 per cent of grains consumed, whereas wheat has been found to comprise only 5.6 per cent and barley 1.8 per cent of the diet (Temby and Emison 1986). Further, Emison *et al.* (1994) found that corellas were sighted significantly more often feeding in oat crops at all study sites even when wheat fields were available. Additionally, oats are used more often than other grains as feed trails to attract corellas for trapping in western Victoria (D. Venn, pers. comm.). Temby and Emison (1986) found sunflower seed to comprise 15–40 per cent of the corella diet during some months, despite limited sunflower crops and suggested that corellas may selectively feed in the few available sunflower crops. In fact, it has been noted that sunflower and safflower crops are rarely planted in western Victoria because damage by corellas has made these crops uneconomic (Walters 1981; Venn 1986).

Based on the reported preference displayed by birds in aviaries for sunflower seeds and reports of corella damage to sunflower crops (I. Temby, pers. comm.) and, despite the limited number of farming areas growing such crops, it was expected that sunflower seeds might be a highly preferred feed of corellas. Oats were included in food preference trials because they offered an alternative food item regularly consumed in the field in preference to other available grains.

However, our study found that when offered a choice of sunflower seeds and oats, corellas typically consumed more oats, often to the exclusion of other available feed. When only hulled oats were offered, daily consumption was consistently high. In contrast, neither form of sunflower seed constituted a significant portion of the daily food intake for most corellas when a choice was available. When only H SF was offered it was consumed readily, though intake did not match that of H oat. Average daily energy intake was similar regardless of feed, while daily food intake by weight varied between sunflower seeds and oats. Sunflower seeds have a much higher energy content than oats, thus corellas would need to consume larger quantities of oats to meet daily energetic requirements.

Although overall patterns of food preference were very marked, not all individuals showed the same preference. Novelty of certain food items or previous experiences may have influenced food preference by individual birds in this study. There is some evidence that food preferences in birds may be based on early experiences and that non-recognition of food items based on lack of familiarity may lead to rejection (Neff and Meanly 1957; Rabinowitch 1968). Rowley *et al.* (1989) found that individual preference may be related to experience, genetics and food availability. Thus some corellas might experience a lack of familiarity with sunflower as it is not a common crop in Victoria. While all birds had experience of sunflower seeds in their diet while in captivity (in the commercial parrot mix diet and in the pre-trial diet comprised of equal parts of the four experimental feed types), familiarity with oats and early experience in the wild may have had an influence in ultimate diet selection. Conversely, the individuals that preferred sunflower seeds may have had early experiences with this food. All corellas in this study did consume sunflower seeds in the no-choice experiments, showing at least acceptance of this type of feed even if it was not preferred by most.

Food preference is probably dependent on a variety of factors including experience, food item size, taste and caloric content (Linz *et al.* 1995). Further, (Rowley *et al.* 1989) found that distribution, accessibility and abundance of different foods will often override preference as will observed consumption by conspecifics. For a bait to be effective and appropriate for use in the field it must be consumed in the wild in reasonable quantities. Due to the ready acceptability of oats by corellas in the laboratory, oats may provide a suitable vehicle for delivering chemical deterrents to corellas. Oats are widely available in Victoria and are a major component in the diet of corellas. Hulled oats should be tested in the field where a wider choice of dietary items occurs. As corellas consume more oats than SF in a given day, it may be possible to apply chemical deterrents in smaller quantities to each grain of bait. This may have important implications for non-target species as the risk that non-target animals face during a baiting

programme is dependent on the number of baits they encounter and consume and the concentration of the poison within those baits (McIlroy 1993).

CONCLUSION

This study demonstrated that hulled oats could be an appropriate bait on which to deliver chemical deterrents to corellas. Hulled oats are a highly preferred feed item during laboratory trials, they are consumed in a larger quantity than other seeds, are inexpensive and widely available and are accepted in the hulled form which may best ensure uptake of chemical compounds. Further studies are needed to determine the potential uptake of hulled oats in the field and impact on non-target species. Prior to field trials, issues including the poisoning of native wildlife and the possibility of alternative means of deterring birds from crops without causing mortality need to be addressed.

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