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COLOUR PREFERENCES IN NORTH ISLAND ROBINS (*PETROICA AUSTRALIS*): IMPLICATIONS FOR DETERRING BIRDS FROM POISONOUS BAITS

Summary: There is growing awareness and concern in New Zealand about native birds eating poisonous baits intended for pest species such as brushtail possums (*Trichosurus vulpecula*) and rats (*Rattus rattus, R. norvegicus, R. exulans*). We investigated the colour preferences of North Island robins (*Petroica australis)* a species known to be vulnerable to poisoning. The main aims were to determine if: (1) robins had colour preferences, (2) the preferences were consistent between two separate populations and 3) the preferences were similar to those found previously in weka (*Gallirallus australis*), another native species.

Robins in Pureora Forest Park and Te Urewera National Park were individually offered a choice between differently coloured versions of a novel food (red, yellow, brown, green, light blue and medium blue) daily, for six consecutive days. Robins showed food colour preferences pecking more at the red, yellow and green cake than the medium blue, light blue or brown cake. No difference was evident in the colour preferences of the two populations. The colour preferences of robins were similar to those reported previously with weka.

Dyeing poisonous baits may be sufficient to stop a proportion of robins from eating them. Further work is needed to determine how colour preferences vary across seasons, populations and species.

Keywords: Bird repellents; robin; non-target species.

Introduction

Poisons are used with increasing frequency in New Zealand in operations to kill introduced mammalian pests. The conservation benefits of these control operations have been documented. For example populations of North Island robins (*Petroica australis longipes* Garnot) (Powlesland, Knegtmans and Marshall, 1998), and North Island kokako (*Callaeas cinerea wilsoni* Bonaparte) (Innes *et al*., 1998) recover following the poisoning of pest species. However a wide range of native birds are known to die during poisoning operations (Harrison, 1978; Powlesland *et al*., 1998; Spurr, 1993; Empson and Miskelly, 1999) and there is considerable concern and pressure from the public to make poisonous baits safer for non-target species (Wright, 1995).

Overseas research on bird repellents has often focussed on repelling birds from crops and storage areas. The challenge in New Zealand is to produce a bait that will repel birds while remaining attractive to target species, generally brushtail possums (*Trichosurus vulpecula* Kerr) and rats (*Rattus rattus* L.*, R. norvegicus* Berkenhout, *R. exulans* Peale). Two possible approaches for accomplishing this goal are (1) incorporation of a bird-specific chemical repellent, into existing bait formulations and (2) identification of bait characteristics, such as colour, that may make baits less attractive to birds. Suitable colours, for example, could discourage birds from eating baits because they make the baits inconspicuous or because the baits no longer look like food. Unfortunately all repellents that have been effective against birds in New Zealand have also been found to adversely affect consumption by target species, notably rats (e.g., Spurr and Porter, 1998). Altering the colour of poisonous baits, however, had no adverse effect on bait consumption by brushtail possums (Day and Matthews, 1999).

Birds are currently discouraged from taking poisonous baits by size and colour. The Pesticides Act, 1979 requires all baits to be larger than 16 mm and dyed green. Work by Kalmbach and Welch (1946) showed that some North American birds avoided dyed food, particularly if it was green or yellow. In New Zealand in the 1950s Caithness and Williams (1971) conducted trials leading on from Kalmbach and Welch's work. These trials resulted in the recommendation that poisonous baits be dyed green. However, Caithness and Williams (1971) tested only introduced bird species. Once poisoning of brushtail possums started in forests and forest margins, many more native bird species were exposed to poisonous baits. In addition operations targeting rats on conservation land expose a wide

range of native birds to baits, but the colour preferences of these native New Zealand bird species have not been established.

We tested the colour preferences of the North Island robin. This species was chosen as robins are particularly vulnerable to poisoning (Brown, 1997; Powlesland *et al*., 1998; Empson and Miskelly, 1999). Two geographically isolated groups of robins were tested at the same time to see if different populations showed the same colour preferences. The methods used and colours offered followed those in a previous trial with weka (*Gallirallus australis* Sparrman) (Hartley *et al*, *in press*), an omnivorous, ground feeding, New Zealand rail (Heather and Robertson, 1996), allowing comparisons of colour preference and behaviour between these two species of native birds.

Methods

The North Island robin is a small, predominantly insectivorous passerine that generally feeds on or near the ground (Heather and Robertson, 1996). Two geographically isolated populations of robins were tested for colour preferences, one at Tahae, Pureora Forest Park, 38° 25' S, 35° 10' E, 600 m a.s.l., and the other at Otamatuna, Te Urewera National Park, 38° 20'S,177° 10'E, 500-700 m a.s.l. Both study sites were in mixed forest with emergent podocarps over a mainly tawa (*Beilschmiedia tawa* A.Cunn.) canopy. Seasons appeared synchronous between sites judging by general observation of fruiting and nesting (*pers. obs.*).

Robins were presented individually with a choice of six colours offered simultaneously, for six consecutive days. The colours were red, yellow, green, medium blue, light blue, and brown in the form of dyed, non-toxic cake (Edmonds pre-mixed Madeira cake) soaked in lard. Non-toxic powdered dyes (Bush Boake Allen, New Zealand Ltd) were used to colour the cake and care was taken to ensure that the colours offered were the same as those in the previous trial with weka (calibrated using spectral reflectance measures, *unpubl. data*). Cake was a completely novel food for the robins which were wild birds.

Test areas, consisting of an area 1.0 m x 0.5 m scraped clear of leaf litter, were set up in the central areas of 18 robin territories at both Pureora and Te Urewera. Most territories were occupied by a pair of robins, although a few were occupied by lone males. The robins were offered a teaspoon of finely chopped cake of each colour laid out in a line of piles each 10 cm apart. The position of the colours in the line was changed between birds and between days using a Latin square design to ensure that each colour appeared next to each of the other colours twice, and only twice, in each area. All test areas were positioned in shade.

The robins had been trained to approach researchers for mealworms (pale brown in colour, *Tenebrio* sp., Powlesland *et al.,* 1998). Once present, robins showed a lot of interest in the test areas as clearing the leaf litter exposed insects that the birds foraged for. The tests lasted 30 min each day and a video camera was used to record the behaviour of each bird. Tests were completed in blocks of six territories alternating between the two study sites so both populations were tested during the same time period (7 July - 18 November 1997, austral winter - spring).

Robin interest in the colours was measured by the number of pecks directed at cake of each colour. The resulting numbers were analysed as a Poisson variate using the Generalised Linear Mixed Model (GLMM) in the Genstat 5.4 statistical package (Breslow and Clayton, 1993). GLMM combines residual maximum likelihood analysis (Patterson and Thompson, 1974) for multiple area strata with log-linear modelling for response variates which are not normally distributed. Thus underlying effects are modelled as additive on the log scale and, consequently, are multiplicative as observed counts. Fixed effects comprised colour, location, run number (i.e., 1st, 2nd, etc. occasion on which a bird responded), plus their interactions. Terms were retained when the related Wald statistic in GLMM gave a chi-square value corresponding to $P < 0.05$. Sources of variation considered for the random model comprised test-day, test-area and bird (within area), their interactions with colour, and the interaction of area and bird with test-day.

Means resulting from the GLMM analysis were compared using the Least Significant Ratio (LSR). If the ratio of the larger to the smaller mean is greater than the LSR, then the means are different at the 5% level using Fisher's LSD test.

Results

Six of the 71 robins that visited the test areas (one from Pureora and five from Te Urewera) were present on the sites for less than 5 min. The data for these individuals were excluded from the analysis. The remaining robins foraged for mealworms and natural food on and around the test areas. Of the foragers, 24 did not peck at any coloured cake (Pureora 35%, Te Urewera 39%, Table 1). Only data from those robins that pecked at cake (Pureora n = 22, Te Urewera n = 19) were used in the statistical

Table 1: *Percentage of robin eating novel cake of each of six colours including those that ate natural food off the test area but did not eat the cake (Pureora n=34, Te Urewera n=31).*

	None	Any colour	Yellow	Red	Green	Medium blue	Light blue	Brown
Pureora	35	65	47	29	29	6	9	21
Te Urewera	39	61	45	29	42	39	23	19

analysis of colour preference. Over 40% of these robins pecked at yellow and green cake and a decreased percentage pecked at either of the blue or the brown cakes (Table 1). An average of only 2-3 colours were sampled by each robin (Fig. 1) and only two individuals pecked at all the colours.

There was variation in response to colour evident between birds and, to a lesser extent, between test-days. Despite this variation, significant overall food colour preferences were found. Robins pecked at yellow and green cake more than at medium blue, light blue or brown cake. Red cake was pecked at less than yellow cake but more frequently than light blue or brown cake ($\chi^2 = 29.4$, d.f. = 5, $P < 0.001$) (Table 2). There was no evidence that the amount of pecking or colour preferences differed between populations ($\chi^2 = 2.9$, d.f. = 1, $P = 0.09$, and $\chi^2 = 8.9$, d.f. = 5, $P = 0.11$, respectively).

Table 2: *Scaled means (± S.E.) resulting from the GLMM analysis for number of pecks directed at coloured novel food per test for each of the six colours offered to robins. The Least Significant Ratio is 3.5. Means not sharing any letter are significantly different at P < 0.05.*

	Scaled mean	S.E.
Yellow	5.76^{a}	2.7
Green	2.58^{ab}	1.1
Red	1.57^{bc}	0.8
Medium blue	0.64^{cd}	0.4
Light blue	0.50^{cd}	0.3
Brown	0.38^{d}	0.2

There was no evidence to suggest that individuals within a single territory influenced one another's colour preferences although only a pronounced effect could have been detected with the

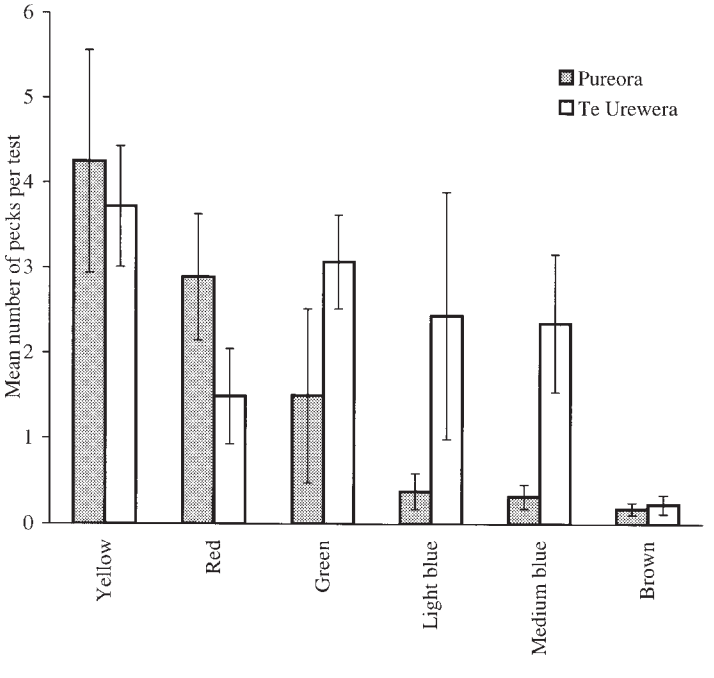

Figure 1: *Mean number of pecks (± S.E.) directed at coloured cake per test by two separate populations of robins, Pureora (n=22) and Te Urewera (n=19).*

number of pairs tested. The number of pecks directed at cake during each 30 min test did not change systematically from test to test ($\chi^2 = 2.9$, d.f. = 5, $P < 0.07$).

Discussion

Robins showed differing preferences for the novel food offered depending on the colour of the food. There was some variability in colour preference between individual robins. We did not use the same green dye in this study as that currently specified for poisonous baits in New Zealand. As the spectral reflectance of poisonous baits have not been measured we can only say that the baits appeared similar in colour to those currently used. It is of concern that such a high proportion of robins (38%) pecked at the green cake (Pureora 29%, Te Urewera 42%). Judging from our tests, green is not the optimum colour for preventing bird deaths. Further studies are needed to determine whether the shade of a colour affects robin preference for that colour.

Robins showed the least interest in pecking the two blue and brown cakes (Table 1), suggesting that these colours may be better deterrents for birds. Not only did robins, overall, direct less pecks at blue and brown cake, but the cakes were pecked at by fewer individual robins (Table 1). Preference trials, such as this study however, do not tell us what the robins would have done if confronted by a single colour rather than a choice of colours. Brown was the colour that was closest to the colour of the background soil, at least for human viewers, suggesting contrast may be a factor worth investigating in food colour studies with birds.

No significant differences in colour preferences were detected between the two populations studied. This raises the possibility that the colour preferences recorded may be general among robins. Care was taken in this study to test robins in very similar habitats, over the same time period. Further studies are needed to determine whether colour preference for a novel food varies with season or site.

A previous study tested preferences in a group of 14 wild-caught weka for the same colours offered in this study (Hartley *et al*, *in press*). The robin preferences differed from those found on day 1 only in that the robins ranked green among their most preferred colours while weka ranked it among their least preferred.

Robins tried an average of only 2 - 3 colours with very few robins trying all six colours. This behaviour contrasted with that of weka where all but one tried every colour (n = 14). Robins also showed no tendency to increase the number of pecks directed at coloured cake over time whereas weka consumption built up rapidly. By the end of the trial weka were eating over 70% of the food of every colour. These differences in behaviour toward coloured novel food suggest that robins, unlike weka, may avoid eating baits dyed some colours for the duration of a poisoning operation.

Robins became familiar with the test arrangements very quickly and spent long periods of time foraging on the test areas. Despite this 37% of the robins did not try the coloured novel food, eating only natural food items within the test area. This pattern of behaviour differs markedly from that observed in weka (Hartley *et al*, *in press*) where all the birds that explored the test area ate the coloured food. A parallel exists between interest in the novel food in the trials and the mortalities observed in the field during poisoning operations: a much lower proportion of robins die in such operations than weka. Robin mortalities of 43 - 55% have been recorded following poisoning operations with carrot 1080 baits (Powlesland *et al.*, 1998) and 30 - 64% with Talon baits (Empson and Miskelly, 1999; Brown, 1997). Weka mortalities were 80 - 100% with Talon baits (Eason and Spurr, 1995).

In conclusion, robins were found to have colour preferences and these preferences did last for the duration of the trial suggesting colour may work as a deterrent for this species. Preference was found to differ between individual robins making it unlikely any colour will deter all individuals from baits. The similarities in colour preferences between robins and weka, two very different species with different food sources, raises the possibility that preferences may be similar in other native bird species as well.

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