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COMPARISON OF TIME-BUDGETS FOR MAINLAND AND OUTER CHETWODE ISLAND POPULATIONS OF ADULT MALE SOUTH ISLAND ROBINS

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SUMMARY: Mainland robins forage less and spend less time in interspecific interactions than do Outer Chetwode Island birds, but devote more time than the latter to vocalising, body maintenance and partner-interactions. Outer Chetwode Island males forage for a similar proportion of time throughout the day, but mainland birds forage less, and spend more time on vocalising and partner-interactions, in early and mid-morning than at other times.

From the comparison it seems that the first priority of a robin is to find enough food to meet maintenance needs. When more time has to be spent finding food, that devoted to several other activities declines. Once sufficient food for metabolism is found, "spare" time is devoted to body-maintenance. The activities of least importance to robins in April, May and June are those related to reproduction, such as vocalising and partner-interactions. The birds' diurnal patterns of activities are such that most reproductive behaviour occurs in the early morning, a time of day when foraging efficiency is probably low, so that these activities take place when they have least effect on time required for foraging.

INTRODUCTION

The way birds allocate time to the activities associated with self-maintenance (the needs of metabolism, thermoregulation and the procurement and processing of food) is of vital importance to their survival. The amount of time they devote to a particular activity depends mainly on their life style (Pearson, 1954; Orians, 1961), body size (Gibb, 1954), food availability (Pennycuick and Bartholomew, 1973; Gibson, 1978) and the ambient temperature (Verbeek, 1964). The most important activity of an animal is foraging for food to accumulate sufficient energy to meet metabolic needs. Only after these basic needs have been met can other activities requiring extra energy and time, such as reproduction and moulting, be performed.

Flack (l975a, 1976b, pers. comrn.) found that South Island robins *(Petroica australis australis)* on Outer Chetwode Island differed from those on the mainland (Kowhai Bush) in having a delayed breeding season and lower productivity (Table 1). However, when the birds from the island were released onto a similar nearby island they bred in the manner of the Kowhai Bush population, having an August to December laying season, laying mainly 3-egg clutches and becoming triple brooded (Flack, 1975b, 1978). Thus, their delayed breeding and reduced productivity on Outer Chetwode Island seemed to be caused by environmental factors rather than being genetically controlled. The island population had a smaller mean territory size (Table 1), which may limit the food supply of each pair. I hypothesised, therefore, that when not breeding the Outer Chetwode Island birds would spend more time in maintenance behaviour than would the mainland birds; that foraging would be of prime importance to the robins; and that activities associated with reproduction would be of least importance. By comparing their allocation of time to various activities I hoped to test these hypotheses.

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STUDY AREAS

Kowhai Bush (l74°05'E, 40º54'S) is in coastal north-eastern South Island, 7 km inland (Fig. 1). It is a narrow strip of forest of 240 ha on the north-eastern side of the Kowhai River, 60-150 m a.s.l. The low forest consists of a flood-induced series of successional stages of varying age, structure and species composition often dominated by kanuka *(Leptospermum ericoides)*. Hunt and Gill (1979) described in detail the physical aspects of Kowhai Bush. During the present study, from April to June 1978, a population of 40-50 individually colour-banded robins of known age was present.

Outer Chetwode Island (l73°38'E, 42°25'S) lies at the head of Pelorus Sound, in northern South Island. From its highest point of 174 m, the land slopes steeply to the sea, usually ending in cliffs. A variety of vegetation types is present, probably

TABLE 1. *Comparison of some population features for mainland (Kowhai Bush) and Outer Chetwode Island populations of South Island robins. Information from Flack (1976b, pers. comm.).*

Feature	Kowhai Bush	Outer Chetwode Island
Main egg-laying months:	August Ö December	September - October
Modal clutch size:	3	2
Number of broods per season:	3[a]	<1[b]
Mean number of juveniles fledged per pair:	3.00	0.14-1.10
Territory size range per pair (ha)	1-5	0.2-0.6

Notes: [a] If no losses occurred that forced renesting
[b] Not all birds bred .

reflecting the various stages of regeneration since farming ceased, as well as soil depth and the degree of exposure to the weather. Although robins inhabited other areas they were observed mainly in valleys because there the forest has a high canopy and little undergrowth, ideal habitat for observing robin behaviour. Forest in valleys consists of pure stands of manuka *(Leptospermum scoparium)* with little or no undergrowth, or an association of manuka, *Pseudopanax arboreus, Dodonaea viscosa, Melicytus ramiflorus, Olearia paniculata* and *Dysoxylum spectabile*. The island has a population of about 120 robins (Flack and Lloyd, 1978), about half of which were individually colour-banded.

METHODS

Because of the cold, reduced invertebrate availability and shorter days, winter is the time of year when many birds spend more of the day meeting maintenance requirements (Gibb, 1954, 1956; Verbeek, 1972). Therefore, observations of the two populations of robins were made just before and during the month of shortest day length. Three one-week visits to observe the robins on Outer Chetwode Island were made from 6-13 April, 15-22 May and 6-12 June 1978. Between these visits, observations of robins in Kowhai Bush were undertaken.

The method of observing robins and recording the time they spent on each behaviour was the same at both study areas. Behaviour was timed using a stopwatch and the elapsed time for each activity noted. The duration of momentary activities (less than five seconds) was often estimated rather than timed. Each robin was watched for an hour at most so as not to over-emphasise the behaviour of any particular bird and so the behaviour of as many individuals as possible could be timed.

Throughout the period of study, robin behaviour was categorised into eight distinct activities. These were:

foraging - searching for, killing, dismembering and eating prey;

food-storing - carrying food in flight and depositing it in a store site (Powlesland, 1980);

body maintenance - stretching, body-shaking, head-scratching, beak-wiping, toe-nibbling, preening, bathing, anting and sunning;

vocalising - giving full song, sub-song, "down scales" and "chuck" calls when these vocalisations were not associated with a

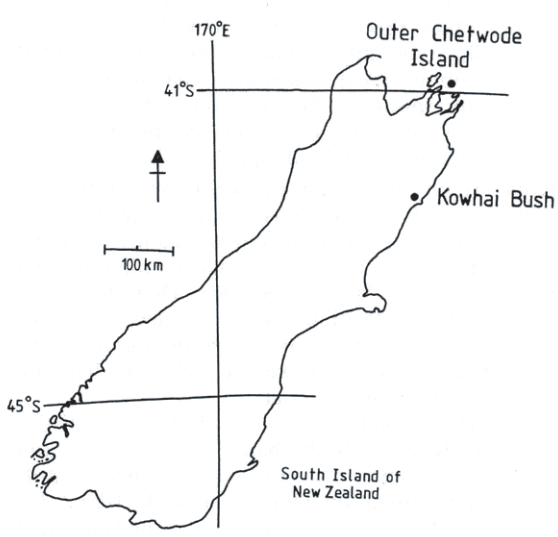

FIGURE 1. *Location of the study areas in the South Island of New Zealand.*

particular activity. For example, male robins gave "downscales" and short phrases of full song when engaged in boundary disputes. These vocalisations were not timed as such, but as territorial-defence activity;

resting - when the birds assumed the resting posture. The head was withdrawn onto the body, the contour feathers fluffed, the tail slightly depressed and the legs flexed. Occasionally, resting birds sat on a branch, otherwise they perched on one leg with the other tucked into their feathers. Sometimes they briefly closed their eyes while resting;

partner-interactions - interactions between members of a pair. Males invariably dominate females, so that much of the time robins spent in this activity involved the birds giving characteristic aggressive and appeasement displays (Flack, 1976a);

territorial defence - interactions between neighbouring robins, which mainly took place along the common boundary of their territories. These boundary disputes involved the birds moving along the boundary within a few centimetres of each other and displaying by wing lifting, elevating the crown feathers and under-tail coverts, puffing the cream-coloured breast feathers, and bill snapping (Flack, 1976a);

interspecific interactions - interactions between robins and other species of birds mainly, but occasionally mammals. Robins displayed their frontal spots before chasing and bill snapping at other species of birds (Flack, 1976a). As well, some interspecific interactions resulted in robins being vigorously chased by a few avian species. The reactions of robins to mammalian predators were to perch out of reach and give loud, quick calls.

Each robin was banded with an individual combination of a metal serial band (size B, butt-ended) and three or four colour bands (size C, butt-ended), as part of the National Banding Scheme controlled by the Wildlife Service, Department of Internal Affairs. Nestlings were banded at about 13 days of age, and adults which immigrated into the mainland study area were caught for banding using a clap-trap or mist net.

Although five categories of robins were distinguished at Kowhai Bush, based on their sex and age, the behaviour of only colour-banded adult males was recorded on Outer Chetwode Island for two reasons. Firstly, colour-banding of nestlings had not been carried out during the previous two breeding seasons, so unbanded birds could not be distinguished as immature or adult. Immature robins were those independent of parental care, a status attained about four weeks after leaving the nest. Their immature status terminated at the end of July when breeding began. Secondly, adult females lived in areas in which it was difficult to follow them, whereas males inhabited gullies which had forest with a high canopy and little lower under storey and groundstorey vegetation.

To test statistically the difference between the percentage of time the two populations of robins, or one population for two sample times, devoted to an activity, the method of "testing the equality of two percentages" (Sokal and Rohlf, 1969, p. 608) was used.

RESULTS

In all three months (Fig. 2) and in most day-periods (Fig. 3) the Outer Chetwode Island birds spent more time foraging than the Kowhai Bush population. The diurnal foraging pattern was quite different for the two populations. The island birds foraged for a similar proportion of time throughout the day (except for a significant reduction in the late morning), whereas the Kowhai Bush birds foraged less in early and mid-morning than during the rest of the day ($p<0.01$) (Fig. 3).

Adult males at Kowhai Bush spent more time vocalising and in partner-interactions than the Outer Chetwode Island birds ($p<0.01$) (Fig. 2). The former had a distinct diurnal pattern of involvement in these two activities, spending more time on them during the early and mid-morning, but the Outer Chetwode Island males had no such pattern. Thus, the Kowhai Bush birds foraged less and spent more time in singing and partner-interactions during the early morning than afterwards (Fig. 3).

The Kowhai Bush birds spent more time in body-maintenance than did the island birds. Furthermore, whereas the former did not have an obvious diurnal pattern for this activity, the latter consistently spent more time on body-maintenance during the late morning.

There was little difference between the populations in the percentage time per month spent in storing food, resting and territorial defence. Also, for neither population was a diurnal pattern of these activities evident, except for a significant increase in time devoted to territorial defence during the early afternoon for the mainland population.

The island birds spent more time in interspecific interactions in April and May than did the Kowhai Bush birds. Neither population showed an obvious diurnal pattern of interspecific interactions, although the island birds devoted more time than those of

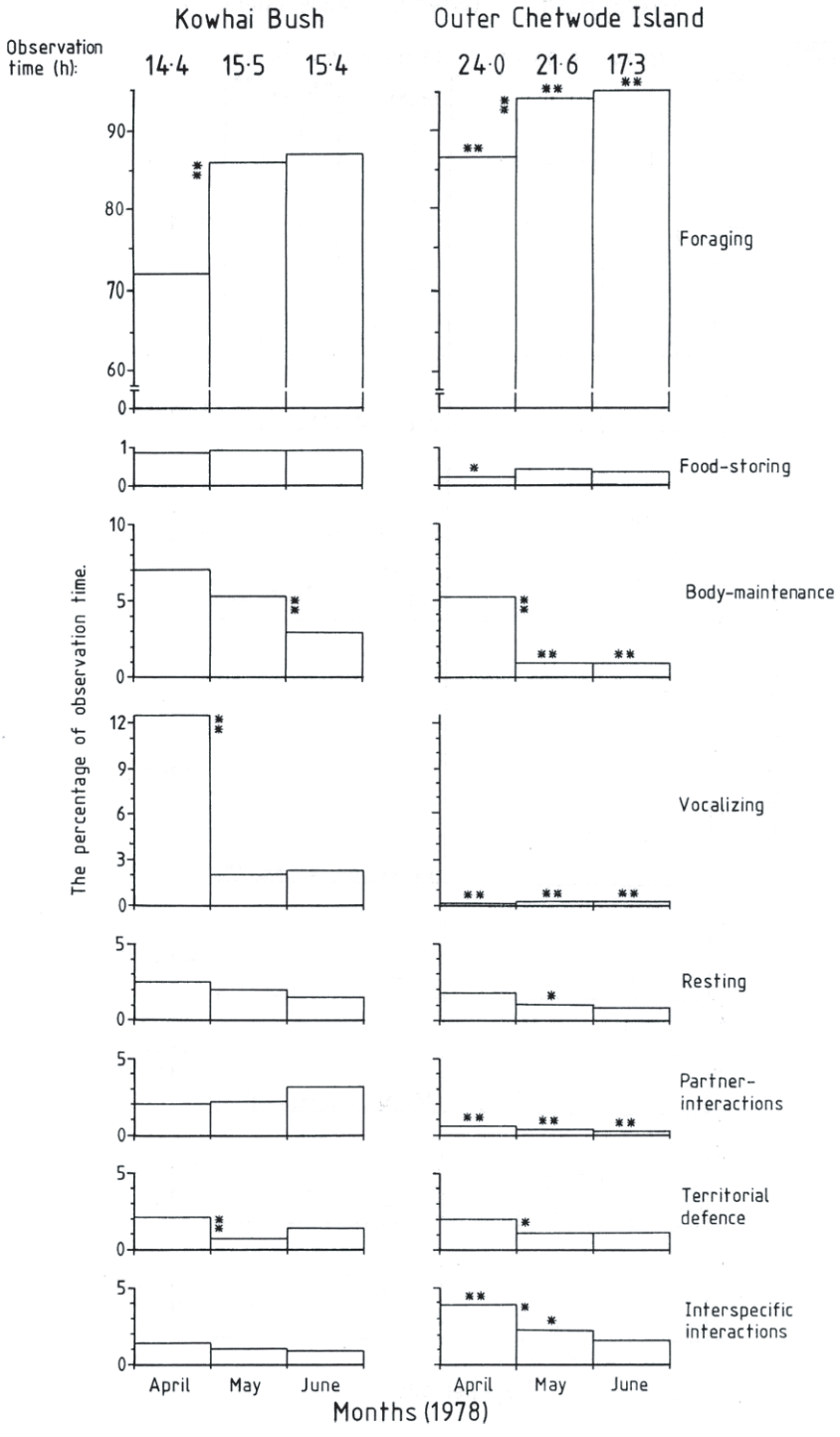

FIGURE 2. *The monthly time-budgets for adult male robins at Kowhai Bush and Outer Chetwode Island in April, May and June 1978.*
*The asterisks denote significance~ levels: *=p<0.05, **=p<0.01. Those placed next to the sides of columns indicate significant differences between adjacent monthly samples. Asterisks above the columns of the Outer Chetwode Island male time-budgets show significant differences between the proportion of time the island and Kowhai Bush males engaged in an activity for the same month.*

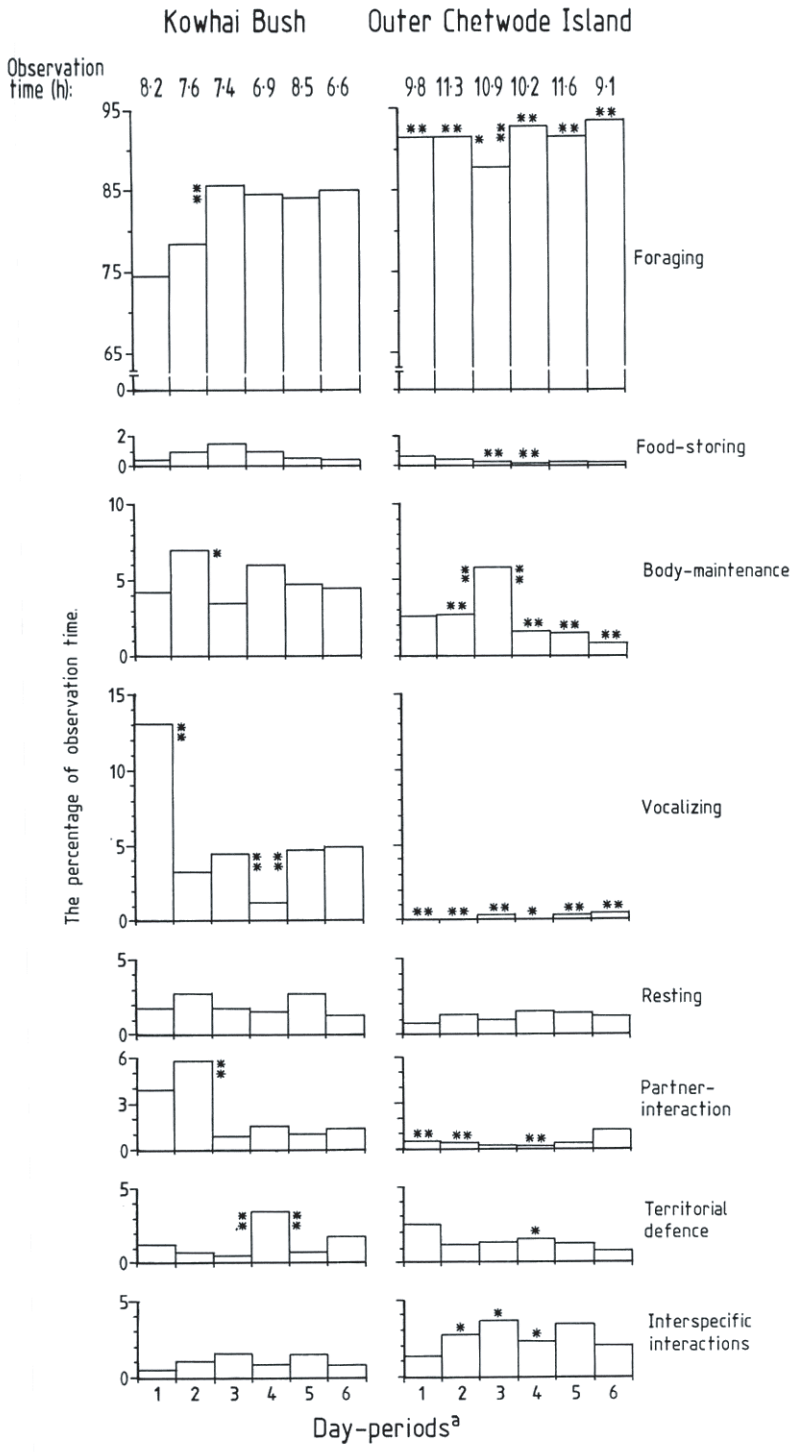

FIGURE 3. *The diurnal patterns of activities for adult male robins at Kowhai Bush and Outer Chetwode Island during April. May and June 1978.*
The asterisks indicate significance levels as in Figure 2.
[a]The division of the daylight hours into six day-periods of equal length.

the mainland to this activity from mid-morning to mid-afternoon.

DISCUSSION

From this comparison of the time-budgets for the two robin populations it can be concluded that foraging to find sufficient food to meet the metabolic needs for an individual's survival is a robin's most important activity. Only when foraging provides an excess of food can time be spent on non-maintenance activities. There are two possible explanations for the observation that adult males on Outer Chetwode Island foraged more than did the Kowhai Bush birds. Either the island birds had to spend more time foraging to find enough food to meet their metabolic requirements, or they spent their time foraging because there was no need to spend it on other activities. Other studies show that under mild temperatures, or when food is readily available, insectivorous species tend to devote less time to feeding in the morning than in the afternoon (Verner, 1965). However, during periods of environmental stress, when small passerines increase their rate of food intake or spend longer finding the same amount, they often increase the time spent foraging in the morning (Lees, 1948; Morton, 1967). The diurnal pattern of predominantly afternoon foraging of the Kowhai Bush birds indicates that they found sufficient food in less than the whole day to satisfy their maintenance needs. This contrasts with the Outer Chetwode Island robins, where the increased time spent feeding in the morning resulted in a lack of diurnal rhythm, indicating that for self-maintenance they had to forage for such a large proportion of their time. It is not clear what factors caused the increased foraging. Possibly a lower food availability and/ or smaller territory size resulted in these birds having to feed longer than the Kowhai Bush birds. That food availability to the island birds was restricted by small territory size is supported by the response of these robins when shifted to uncrowded environments (Flack, 1974, 1976b).

Activities of least importance to robins in April, May and June were those associated with reproduction. Throughout the island visits full song was never heard, although the robins there spent similar proportions of time giving the other types of vocalisations compared with the Kowhai Bush birds (Powlesland, unpubl.). Most full song heard at Kowhai Bush was given by bachelors, presumably to attract a mate. Bachelors were always present among the population of about 30-90 robins at Kowhai Bush from 1976 to 1979, and probably were also present in the island population of about 120. It seems that the island bachelors did not sing because foraging was of higher priority. Attracting a mate is an early stage towards reproduction, an activity possible only after self-maintenance requirements have been met (Verner, 1965).

The partner-interactions of the island adult males included no activities resulting in pair formation, in contrast to those of the Kowhai Bush males. The island robins were very aggressive towards their mates, chasing them whenever they came near. As a result the members of a pair were rarely seen together, keeping to different parts of their joint territory. Although males also dominated their mates at Kowhai Bush, they were more tolerant, so that members of a pair often fed near each other. In addition, the Kowhai Bush pairs participated in sexual chases, an interaction that seemed to be involved in pair formation and the reinforcement of the pair-bond between members of established pairs. Thus, the greater proportion of time spent in partner-interactions by the mainland adult males was of a reproductive nature, whereas the interactions between members of the island pairs separated them. The separation of the robin pair-members on Outer Chetwode Island may have been a response to low food availability. By achieving territorial exclusion, perhaps each partner maximised his or her harvest from an area, reducing, the likelihood of interference caused by the partner taking prey from a particular area of the territory before the recovery of the prey populations (see Krebs, 1978). The members of a pair in Kowhai Bush did not separate, presumably because food was readily available so that there was little, if any. competition between them for it.

Not only did the Kowhai Bush adult males spend time during winter in reproductive activities, unlike the island robins, but the former carried out these activities in the early morning. This, implies that the Kowhai Bush males began the day with energy reserves either in the body or as hoarded food after the night fast. "If more food ,can be obtained at one time of the day than another, selection should favour those individuals that forage at the better time since an equivalent amount of food could be acquired in less time, leaving more time for other activities" (Verner, 1965). For an insectivorous species. such as the robin, food species would be less active, hence less conspicuous, at lower temperatures during the early morning. Also, it is likely that prey would be harder to see in the dull light of the early morning. Consequently, the best time for robins to carry out non-foraging activities would be just after sunrise, as found by Kacelnik (1979) for great tits *(Parus major)*. From Figure 3 it is apparent that Kowhai

Bush males engaged in reproductive behaviour (vocalising and partner-interactions) in the early morning, as did male long-billed marsh wrens *(Telmatodytes palustris)* in the breeding season (Verner, 1965).

The activity of intermediate priority for robins, between foraging and those associated with reproduction, was body maintenance. When robins that spent little or no time on activities associated with reproduction had to devote more to finding food, they spent less time on body maintenance. During May and June, the robins on Outer Chetwode Island spent less time in body maintenance than did their counterparts at Kowhai Bush ($p<0.01$). The island birds used comfort movements (scratching, beak-wiping and preening) to remove bits of soil or prey, but they rarely interrupted foraging to preen extensive areas of plumage as did the Kowhai Bush robins. The significant rise in time spent by the island males on body maintenance during the late morning was largely a consequence of the data from two birds that took several minutes to bathe and dry themselves, compared with a few seconds for most other body maintenance activities.

Besides foraging, interspecific interaction was the only activity to which the island robins devoted more time than the Kowhai Bush robins. Several factors contributed to this result. Firstly, as well as the robins, other avian species seemed to be present at higher densities on Outer Chetwode Island than they were at Kowhai Bush, resulting in the island robins interacting- more often with other species. Secondly, the island robins were very aggressive towards species they were able to dominate that ventured near their stored food. Presumably, the island robins could watch their caches more closely as a result of their smaller territory sizes than could the mainland robins. Having expended time and energy on storing the food and since prey capture was unpredictable during the course of the day there was probably a strong selection pressure for the storer to ensure it retrieved its stored prey. Lastly, immature and female bellbirds *(Anthornis melanura),* which dominated robins at Kowhai Bush, were chased by adult male robins on Outer Chetwode Island.

This comparison of time-budgets of two populations of adult male robins illustrates the plasticity of behaviour in passerines. Not only did the adult males of the two populations have very different time-budgets for the same months, but some activities were not exhibited by both populations. Island males were neither heard to give full song nor seen in sexual chases during my visits, but chased immature and adult female bellbirds - just the reverse of male behaviour at Kowhai Bush. This shows that the formulation of theories and models on bird behaviour should not be attempted on the basis of the study of just one population.

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REFERENCES

FLACK, J. A. D. 1974. Chatham Island black robin. *Wildlife - a Review* 5: 25-31.

FLACK, J. A. D. 1975a. The Chatham Island black robin, extinction or survival? *Bulletin of the International Council for Bird Protection* 12: 146-50.

FLACK, J. A. D. 1975b. Aspects of the ecology of the New Zealand robin. *Emu* 74 (supplement): 286.

FLACK, J. A. D. 1976a. The use of frontal spot and crown feathers in inter- and intraspecific display by the South Island robin, *Petroica australis australis*. *Notornis* 23: 90-105.

FLACK, J. A. D. 1976b. New Zealand robins. *Wildlife a Review* 7: 15-9.

FLACK, J. A. D. 1978. Interisland transfers of New Zealand black robins. *In:* Temple, S. A. (Editor) *Endangered Birds: Management Techniques for Preserving Threatened Species*. pp 365-72. University of Wisconsin Press, Madison.

FLACK, J. A. D.; LLOYD, B. D. 1978. The effect of rodents on the breeding success of the South Island robin. *III:* Dingwall, P. R.; Atkinson, I. A. E.; Hay, C. (Editors) *The Ecology and Control of Rodents in New Zealand Nature Reserves*. New Zealand Department of Lands and Survey Information Series 4, Wellington. 237 pp.

GIDD, J. A. 1954. Feeding ecology of tits, with notes on treecreeper and goldcrest. *Ibis* 96: 513-43.

GIBD, J. A. 1956. Food, feeding habits and territory of the rock pipit *(Anthus spinoletta)*. *Ibis* 98: 506-30.

GIBSON, F. 1978. Ecological aspects of the time budget of the American avocet. *American Midland Naturalist* 99: 66-82.

HUNT, D. M.; GILL, B. J. (Editors) 1979. Ecology of Kowhai Bush, Kaikoura. *Mauri Ora Special Publication* 2. University of Canterbury Biological Society, Christchurch, 54 pp.

KACELNIK, A. 1979. The foraging efficiency of great tits *(Parus major L.)* in relation to light intensity. *Animal Behaviour* 27: 237-41.

KREBS, J. R. 1978. Optimal foraging: decision rules for predators. *In:* Krebs, J. R.; Davies, N. B. (Editors) *Behavioural Ecology: An Evolutionary Approach*. pp. 23-63. Sinauer Association, Massachusetts.

LEES, J. 1948. Winter feeding hours of robins, blackbirds and blue tits. *British Birds* 41: 71-6.

MORTON, M. L. 1967. Diurnal feeding patterns in white crowned sparrows, *Zonotrichia leucophrys gambelii*. *Condor* 69: 491-512.

ORIANS, G. H. 1961. The ecology of blackbird *(Agelaius)* social systems. *Ecological Monographs* 31: 285-312.

PEARSON, O. P. 1954. The daily energy requirements of a wild anna hummingbird. *Condor* 56: 317-22.

PENNYCUICK. C. J.; BARTHOLOMEW, G. A. 1973. Energy budget of the lesser flamingo *(Phoeniconaias minor* Goeffroy). *East African Wildlife Journal* II: 199-207.

POWLESLAND. R. G. 1980. Food-storage behaviour of the South Island robin. *Mauri Ora* 8: 11-20.

SOKAL, R. R.; ROHLF, F. J. 1969. *Biometry: The Principles and Practise of Statistics in Biological Research*. W. H. Freeman and Company, San Francisco. 776 pp.

VERBEEK, N. A. M. 1964. A time and energy budget study of the brewer blackbird. Condor 66: 70-4.

VERBEEK, N. A. M. 1972. Daily and annual time budget of the yellow-billed magpie. *Auk* 89: 567-82.

VERNER, J. 1965. Time budget of the male long-billed marsh wren during the breeding season. *Condor* 67: 125-39.