Breeding biology of the North Island Tomtit *(Petroica macrocephala toitoi)* at Pureora Forest Park

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ABSTRACT

The breeding biology of the North Island Tomtit (*Petroica macrocephala toitoi*) was studied at two sites in Pureora Forest Park, central North Island, during the 1997/98 season, and compared with data from the Ornithological Society of New Zealand's Nest Record Scheme. The nesting season at Pureora was from 26 September 1997 to 15-17 February 1998, one pair fledging three broods. Of 11 Pureora nests and 32 of the Nest Record Scheme, 63.6% and 28.1% respectively were among dead hanging fronds of tree ferns, and 18.2% and 34.5% respectively were in holes in trees, rocks, banks, the ground or in nest boxes. The mean height of 11 nests at Pureora was 3.4 m, and that of 34 nests in the Nest Record Scheme was 2.8 m. Mean clutch size for the combined data was 4.15 eggs (n=13). On all occasions, except one, females were incubating, with males feeding their mates at regular intervals. Both parents fed the chicks but only the female brooded them. Mean brood size at Pureora was 4.0 (n=4), but for the Nest Record card data it was 3.1 (n=21). All 13 fledglings in four broods appeared to reach independence. Of 11 nesting attempts at Pureora, 72.7% were successful, compared with 45.4% of 11 attempts on Nest Record cards. This greater success at Pureora compared with other mainland areas was attributed to aerial 1080 possum control at Pureora reducing mammalian predator densities to low levels, and so reducing the incidence of predation.

KEYWORDS: *Petroica macrocephala toitoi*, Eopsaltriidae, nesting, Pureora, Nest Record Scheme, predation, 1080.

INTRODUCTION

The New Zealand Tomtit (*Petroica macrocephala*) is one of three endemic species of the family Eopsaltriidae, the Australasian robins. The North Island Tomtit *(P. m. toitoi)* is widespread through the North Island, and on a few of the larger offshore islands (Bull *et al.* 1985). North Island Tomtits inhabit a variety of habitat types, including mature native forest (hardwood-podocarp and beech), second growth manuka *(Leptospermum scoparium)*/kanuka *(Kunzea ericoides)* scrub, and older stands of exotic plantations (Heather & Robertson 1996). Tomtits are territorial all year, forage from ground level to the top of the canopy (Brockie 1992), and feed mainly on invertebrates, supplemented with small fruits in autumn and winter (Brockie 1992, Heather & Robertson 1996). Even though the North Island Tomtit is widespread and relatively common, just one study has been published on aspects of its breeding biology (Brown 1997).

Breeding success of the North Island Tomtit was measured as part of a study

into the costs and benefits of aerial 1080 (sodium monofluoroacetate) possum (*Trichosurus vulpecula*) poisoning operations (Powlesland *et al.* 1998). The costs include primary or secondary poisoning and/or increased predation as a result of prey switching by predators, and the benefits improved survival and breeding success. Nests were monitored to compare the nesting success of pairs in a study area exposed to such an operation a month before nesting started with that of pairs in a study area treated a year previously. In this paper we provide information on North Island Tomtit breeding biology in Pureora Forest Park, plus that obtained from Nest Record Scheme cards of the Ornithological Society of New Zealand.

STUDY AREAS

North Island Tomtits were studied during the 1997/98 breeding season in Pureora Forest Park, which is situated in the central North Island west of Lake Taupo (Figure 1). Observations were carried out in two study areas. The Tahae study area is unlogged forest within the Waipapa Ecological Area that is bordered by Fletcher's Road, the Waipapa River and a scrub/swamp area called Taparoa Clearing (Leathwick 1987). The study area is approximately 100 ha and is relatively flat at an altitude of 520-540 m a.s.l. The forest consists of scattered emergent podocarps, particularly rimu *(Dacrydium cupressinum)*, kahikatea *(Dacrycarpus dacrydioides)*, matai *(Prumnopitys taxifolia)* and miro *(Prumnopitys ferruginea)* over a mainly tawa *(Beilschmiedia tawa)* canopy. Other canopy and understorey species include hinau *(Elaeocarpus dentatus)*, kamahi *(Weinmannia racemosa)*, mahoe *(Melicytus ramiflorus)*, totara *(Podocarpus totara)*, maire species *(Nestegis* spp.), wheki *(Dicksonia squarrosa)*, soft tree fern *(Cyathea smithii)* and supplejack *(Ripogonum scandens)*. The eastern part of the study area has fewer emergents, and rewarewa *(Knightia excelsa)*, fivefinger *(Pseudopanax arboreus)* and tree-ferns occur more frequently in the canopy and understorey (Leathwick 1987). An aerial 1080 possum poisoning operation occurred over 37,500 ha, including the Tahae study area, in September 1996.

The Waimanoa study area is bordered by Waimanoa, Link and Swamp Roads (Figure 1). The forest block is about 300 ha, but only about 100 ha were visited for the field work. The topography consists of rolling country at 700 to 740 m a.s.l. The vegetation is similar to that at Tahae, but lacks the supplejack thickets and, due to logging in the 1970s, this forest block has fewer emergent podocarps. Toetoe *(Cortaderia fulvida)* and wineberry *(Aristotelia serrata)* are common on old logging tracks and skid sites. An aerial 1080 possum poisoning operation was carried out in September 1997 over 8,577 ha, which incorporated the Waimanoa study area.

METHODS

Tomtit capture, marking and monitoring

North Island Tomtits were fed mealworm (*Tenebrio molitor*) larvae in

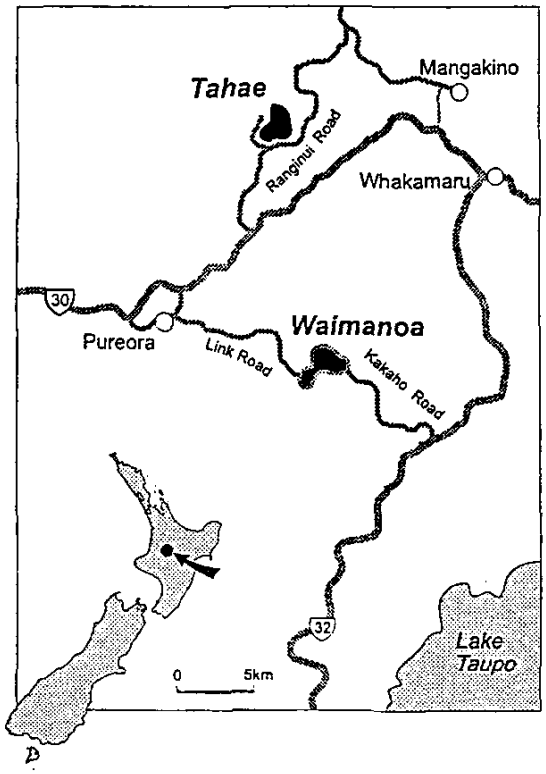

FIGURE 1 - Location of Tahae and Waimanoa study areas, Pureora Forest Park, North Island, New Zealand.

conjunction with tapping the lid against the mealworm container. Eventually the tomtits associated the tapping sound with receiving mealworms, and would approach us to be fed. Once individuals appeared readily to the tapping sound they were fed near a mist-net and startled into it for capture and banding. Each tomtit was banded with an individual colour combination, including a numbered metal leg band (size A, butt bands).

Nine pairs were monitored throughout the breeding season (four at Waimanoa and five at Tahae), of which six males and three females were banded. Each trained tomtit was attracted and fed 1-3 mealworms at least once a week during the nesting season. To find nests and monitor breeding success, we followed the female back to the nest or the male to the nest vicinity where he fed the mealworms to his mate (or nestlings), which we then followed back to the nest. The nest's location was marked with tape on a nearby tree. If possible, each nest was inspected every third day to determine the number of eggs and chicks, and chicks were banded when about 10 days old. If the eggs or chicks were preyed upon, the nest and nearby area were inspected for clues to the identity of the predator (Brown *et al.* 1998).

The Nest Record Scheme of the Ornithological Society of New Zealand was initiated in 1950 to collect standardised information on the breeding of New Zealand birds (Robertson 1990). Thirty-six cards on North Island Tomtit nesting for 1923-91 were available with varying amounts of information for analyses.

RESULTS

Nests

Not all nests of pairs we monitored were found, even when it was evident that a pair was nesting. In the main, this was because some banded males were paired with mates that were not trained to accept mealworms. Although the approximate location was known, four nests were not found due to thick vegetation cover and the female's secretiveness.

Courtship feeding was first observed on 10 September 1997. The earliest date that a female was seen gathering nest material was 26 September 1997. The earliest record of a North Island Tomtit nest in the Nest Record Scheme is one found on 20 September 1957 in the Aniwaniwa Valley, Hawke's Bay, on which date the first egg was laid. Although two nests were seen being built at Pureora, the number of days taken to construct an entire nest was not determined.

Eleven nests were found at Pureora: five at Waimanoa and six at Tahae. Most of these nests were situated against the trunk and amongst the dead fronds hanging below the crowns of tree ferns (63.6 %) (Table 1). By comparison, 28.1% of 32 North Island Tomtit nests in the Nest Record Scheme were against the trunks amongst bark fibre or dead tree fern fronds (Table 1). The next most favoured nest site for both sets of data was in holes. At Pureora, 18.2% of nests were in holes in tree trunks, and 34.5% of nests in the Nest Record Scheme were in holes in trees, rock, banks, the ground, and in nest boxes.

Of the 11 Pureora nests, nine were in the upper understorey (shaded plant crowns below the canopy and above two metres high: Atkinson 1966) and two in the lower understorey (plants 0.3-2.0 m high). Heights of the Pureora nests ranged from 1.9 to 4.5 m, with a mean of 3.4 m (s.d.=0.82). This compares with a mean of 5.2 m (s.d.=1.23, range=3.0-7.5) for the height of the nest trees, and a mean of 7.2 m (s.d.=2.36, range=5.0-13.0) for the canopy height immediately above the nests. Of the 34 nests of the Nest Record Scheme for which nest heights were given, the mean was 2.8 m (s.d.=1.66, range=0.7-8.0 m). Omitting seven of these nests that were in nest boxes at 1.8 to 2.4 m, the mean height of the remainder is 3.0 m (s.d.=1.82).

Incubation

Our observations were too infrequent to determine the interval between the completion of the nest and the first egg being laid. However, one nest record card noted that the female was building on 13 November, the next day the nest was apparently complete, and the first egg was present on 15 November. Four records from the cards indicate that eggs were laid at daily intervals, three being for the successive eggs of one clutch.

The clutch size was determined for two nests at Pureora; four and five eggs. The mean clutch size at 11 nests of the Nest Record Scheme was 4.1: three nests of

TABLE 1 - Types of nest sites used by North Island Tomtits at Pureora in 1997/98, and as indicated on cards of the Nest Record Scheme, Ornithological Society Of New Zealand.

Nest Sites	Pureora nests Number	%	Nest record card nests Number	%
Holes in trees	2	18.2	2	6.3
Ledges in trees	1	9.1	3	9.4
Forks in trees	-	-	5	15.6
Tree trunks (bark fibre or tree-fern fronds)	7	63.6	9	28.1
Tree vegetation	-	-	1	3.1
Fallen twig thicket	-	-	1	3.1
Holes in rock, ground or banks	-	-	2	6.3
Ledges in rock, ground or banks	-	-	1	3.1
Nest box	-	-	7	21.9
Building	-	-	1	3.1
Old robin nest located in trunk fork	1	9.1	-	-
Total	11	100	32	100

three eggs, five of four eggs, two of five eggs and one of six eggs. Only females incubated. Of the 21 occasions that the sex of tomtits leaving from or going on to nests during the incubation stage at Pureora was noted, it was always a female. However, of the 38 occasions that the same information was noted on cards of the Nest Record Scheme, once a male was "seen sitting on the nest for more than three minutes", but was then replaced by the female (G.A. Taylor pers. comm.). At Pureora, males regularly fed their partners during incubation. Each male signalled that he had food and was approaching the nest by giving short bursts of full song. If the female did not leave the nest to accept the food, he would get to within about five metres of the nest and then move from perch to perch singing and giving aggitated twittering calls. After accepting the food the female usually preened and/or foraged before returning to incubate. Nest checks were too infrequent to determine the duration of the incubation stage at Pureora. However, from information available on two nest record cards, and assuming that incubation started on the day the last egg was laid (Kearton 1979), this stage was calculated to have lasted 14 and 16 days.

Brood rearing

From observations at Pureora and information on the nest record cards, both adults feed the chicks, but the female alone broods them. The modal brood size in four Pureora nests was four (range=3-5). By comparison, the modal brood size at 21 nests reported to the Nest Record Scheme was three (range=1-5). No information is available from either source to indicate the number of days that chicks remained in the nest.

Fledglings

The earliest chicks to leave the nest at Pureora did so on 19 November

1997. The last of the monitored broods left the nest during 15-17 February 1998. This compares with a record in the Nest Record Scheme of a brood in Kaingaroa Forest, central North Island, that appeared close to fledging when found on 21 February 1968. Thirteen fledglings in four broods were regularly observed during the period they were dependent on their parents for food and all appeared to survive to independence. Our observations were too brief to determine whether females began nest building while their partners attended the fledglings.

Nesting success

Of the 11 Pureora nesting attempts monitored for which nests were found, eight (72.7%) were successful. A further four nesting attempts were evident, but the nests not located, of which three were successful. For the combined data, nesting success was 73.3%. One pair reared three broods during the season. One three-egg clutch failed during laying or early incubation when it was abandoned for no apparent reason, and two broods were preyed upon. From sign at the nest, one brood was probably killed by a rat (*Rattus* sp.): a partly-eaten chick and rat droppings were found on the nest edge and the nest lining had been disturbed (Brown *et al.* 1998). After the failure of the other nest that had contained chicks, no evidence of the chicks remained, the nest-cup lining was undisturbed, but part of the edge had been pulled out slightly. Of the nine banded adults, one (11.1%), a male, disappeared during the nesting season.

Of the six nests found in the Tahae study area where an aerial 1080 operation occurred in September 1996, four (67%) were successful, one was abandoned and the other failed due to predation. By comparison, four (80%) of the five nests found in the Waimanoa study area where an aerial 1080 operation occurred in September 1997, were successful. The unsuccessful nest at Waimanoa failed due to an unidentified predator. The difference in nesting success between the two study areas is not significant (Fisher exact test, $P=1.00$).

Of 11 nesting attempts in the Nest Record Scheme for which their fates were recorded, five (45.4%) were successful. Four failed during the egg stage; one deserted during windy, wet weather, one nest that was found tipped slightly had been abandoned, and two clutches were preyed upon, one by a rat and the other by an unknown predator. One of the failed broods was preyed upon by a rat, and insufficient information was supplied to determine whether the other brood had been abandoned or preyed upon.

DISCUSSION

Nesting season

Tomtits and robins at Pureora started breeding later than at most other places in New Zealand. Our earliest record of courtship feeding by tomtits (10 September 1997) was three weeks later than Kearton's (1979) earliest record for the South

Island Tomtit (*P. m. macrocephala*) at Mount Fitzgerald Scenic Reserve, Banks Peninsula (20 August 1978). The South Island subspecies has been observed courtship feeding as early as the first week of August in Southland (Philpott 1919). Similarly, New Zealand Robins (*P. australis*) at Pureora during 1995-98 started nesting in late August-early September (RGP & JWK unpubl. data), but those at Kaikoura in the 1970s did so a month earlier in late July-early August (Flack 1979, Powlesland 1983). The later start of tomtit and robin nesting at Pureora may be related to the area's altitude (520-740 m a.s.l.) because tomtits at Kaingaroa Forest (c. 600 m a.s.l.), central North Island, started egg laying in late September during 1958/59 (Gibb 1961), while nesting started a month earlier at a lower altitude in the vicinity of Rangatira Point, Kapiti Island (0-200 m a.s.l.)(Wilkinson & Wilkinson 1952). However, the timing of nesting is related not just to altitude: earlier nesting occurred at Mt Fitzgerald Scenic Reserve which is at a similar altitude (500-700 m a.s.l.) to the Pureora study site but is not far inland.

Tomtit density may influence breeding effort, that is the number of broods reared per pair and the duration of the breeding season. One pair of tomtits nested successfully three times during the season at Pureora, as did a pair on Banks Peninsula (Kearton 1979). Nest building lasts about four days, the prelay period one to seven days depending on time of year, incubation about 16 days and brood rearing about 18 days (Kearton 1979, Heather & Robertson 1996). Therefore, the Pureora pair would have begun nesting during the first week of October, and their last brood probably became independent in early March. Thus their nesting season lasted five months. Similarly, Kearton (1979) noted that the nesting season of tomtits on Banks Peninsula lasted about 5.5 months. In contrast, the nesting season of the high density Snares Island Tomtit (*P. m. dannefaerdi*) population lasted about four months and only one brood was reared per pair each season (McLean & Miskelly 1988). The influence of tomtit density on breeding effort could be tested at "mainland island" sites (Saunders 1990, Clout & Saunders 1996) where tomtit density should increase through time in response to sustained and intensive control of mammalian predators.

Nest site

Information from this study and on the Ornithological Society of New Zealand's Nest Record cards for both North Island and South Island Tomtits supports the conclusion that tomtits prefer nest sites that provide excellent camouflage and protection from extremes of weather for the nest and its occupants (Kearton 1979). At ten of the 11 Pureora nests both the incubating female and the nest were completely hidden by vegetation. Similarly, most nests of North Island Tomtits (Table 1, Brown 1994) and South Island Tomtits reported on Nest Record cards and by Kearton (1979) were in holes (including nest boxes and buildings) or within the dead and hanging fronds of tree-ferns. Likewise, most Snares Island Tomtit nests were well protected from weather (and crash-landing petrels) by being sited in banks, stumps, trunks or among the roots of fallen logs (McLean & Miskelly 1988).

This propensity of the tomtit to nest in holes helps to explain why it has the nested in boxes, even though to a limited degree. In Kaingaroa Forest, which was dominated by *Pinus* spp., eight nestings occurred during two seasons in 100 boxes (Gibb 1961). In the Orongorongo Valley, Wellington, one nest in each of 1967, 1971 and 1972, and four in 1968 were built in about 40 boxes (A.H. Whitaker pers. comm.). However, none of 61 boxes of the same design as those used in the Orongorongo Valley and erected in Mount Fitzgerald Scenic Reserve was occupied during the 1977/78 and 1978/79 seasons (Kearton 1979). Kearton (1979) considered that the tomtits failed to use the nest boxes in his study area because there was an abundance of natural sites in the forest consisting of mainly regenerating mixed hardwood species with some podocarps.

The use of holes as nest sites could make females more vulnerable to predation, or offer greater protection, depending on the size of the predator relative to the hole! Brown (1997) reported the loss of four female tomtits compared with one male during one breeding season. However, this use of relatively enclosed nest sites does not seem to result in greater losses of female tomtits than robins during the nesting season, the latter nesting at more open sites in trunk forks and trunk-branch forks (Powlesland 1983). Brown (1997) found that a similar proportion of female robins disappeared (41.7% of 12) as female tomtits (33.3% of 12) at Kaharoa during the 1993/94 season. However, further information is required on how various nest characteristics influence the predation of female tomtits.

Nests of North Island Tomtits at Pureora and in the Nest Record Scheme were situated in the upper and lower understorey at a mean height of about three metres. Similarly, Kearton (1979) found that 16 South Island Tomtit nests in Mount Fitzgerald Scenic Reserve were built between 1.8 and 8.0 m (mean=4.1 m) and below the canopy. Data for this subspecies in the Nest Record Scheme to 1978 (Kearton 1979) showed nest height ranged from ground level to 18.2 m (mean=5.3 m, n=42), with most nests having been found in beech (*Nothofagus* spp.) forest. Given the species' preference for nesting in holes and sites that provide thick cover for concealing the nest, such situations are most readily available below the canopy and in large trees, whether alive or dead (Elliott *et al.* 1996). While there may be a bias towards finding low tomtit nests, we suspect that this is slight because there are few suitable sites in the canopy and above it in emergents. Finding nests by following tomtits to them provided an independent measure that supports this.

Egg laying, clutch size and incubation behaviour

Modal clutch size of four eggs was the same for both North Island (s.d.=0.84, range=3-6, n=11) and South Island Tomtits (s.d.=0.64, range=3-5, n=18)(Kearton 1979), as evident from data in the Nest Record Scheme of the Ornithological Society of New Zealand. Similarly, Brown (1994) found that the modal clutch size at 13 nests at Kaharoa was four eggs (s.d.=0.38, range=3-4), as did Gibb (1961) for six clutches laid in nest boxes in Kaingaroa Forest (s.d.=0.82, range=2-4). Hadden (1988) reported a brood of six chicks in a South Island Tomtit nest.

The general description of behaviour of male (regularly feeding female near nest) and female (sole charge of incubating, spending some time off the nest to accept food from her mate and to forage) tomtits during incubation at Pureora is much the same as that described elsewhere in the literature for the South Island Tomtit (Fleming 1950, Anglesey 1957, Soper 1976, Kearton 1979) and Snares Island Tomtit (McLean & Miskelly 1988). Few records exist for the duration of the incubation period of *Petroica macrocephala*; however, our two records of 14 and 16 days are much the same as that of 15-18 days given by Potts (1883), Anglesey (1957), Soper (1976) and McLean & Miskelly (1988). In contrast, the Snares Island subspecies has an incubation period of 18-20 days (Best 1975, McLean & Miskelly 1988).

Fledglings

Although the sample sizes are small, the mean number of 3.3 fledglings per brood (n=4) at Pureora is less than that found by Kearton (1979) of 4.0 (range=3-5, n=14) for South Island Tomtits at Mount Fitzgerald Scenic Reserve, Banks Peninsula. Like us, he considered that survival of fledglings from leaving the nest to independence was nearly 100%. This seems to be substantiated from Kearton's results since mean brood size of fledglings is the same as mean clutch size, but he does not state at what fledgling age he recorded brood size.

Nesting success

The nesting success of tomtits at both study areas at Pureora in 1997/98 (Tahae: 67%, n=6; Waimanoa: 80%, n=5) was much greater than has been reported for two other mainland sites. At Kaharoa, central North Island, Brown (1997) found that of 26 nests seen to contain at least one egg, only two (7.7%) were successful. Of 16 nesting attempts that Kearton (1979) monitored on Banks Peninsula in 1977/78 and 1978/79, five (31.3%) were successful. The true nesting success of tomtits at Pureora and Banks Peninsula was probably slightly less than that stated above because nesting attempts that failed during egg-laying and early incubation would have probably gone undetected. These results are in contrast to the apparently high nesting success of the Snares Island Tomtit, with most nestings resulting in at least one nestling being fledged (Best 1975, McLean & Miskelly 1988).

As at Pureora, the main cause of nesting failures at Kaharoa was predation. At least 92% of the 24 failed attempts at Kaharoa were the result of predation, particularly by ship rats (*Rattus rattus*)(66.7% of 24 failed nests)(Brown 1997). The greater nesting success of tomtits at Pureora, than at Kaharoa and Banks Peninsula, likely resulted from aerial 1080 possum poisoning operations at Tahae a year before this study and at Waimanoa about a month before tomtit nesting started in 1997. Even a year after the 1996 poison operation in the Tahae block, possum indices were still low (0.8 captures/100 trap-nights) and ship rat indices were moderate (58% in August 1997 compared with 94% in June 1996 (Powlesland *et al.* 1999)). The slow recovery of the rat population at Tahae differs from the findings of Innes *et al.* (1995) for several central North Island sites where recovery to pre-poison

levels occurred within 4-5 months. Because of the poisoning operations at Pureora, possum, rat and mustelid densities were much lower than usual, especially at Waimanoa (Murphy *et al.* 1999, Powlesland *et al.* 1999). Similarly, following the poisoning operation at Tahae in 1996, robin nesting success was much greater there during the 1996/97 season (72%, n=18 nests) than at Waimanoa (11%, n=35) during the same season (Powlesland *et al.* 1998).

Even though the tomtit is relatively widespread and common on the North and South Islands and on a few of the larger offshore islands (Bull *et al.* 1985), there is still little detailed information available on its breeding biology and nesting success. We have demonstrated that tomtits can be trained to approach observers for food, which facilitates colour banding, finding nests and monitoring individual survival. Video monitoring can also be used to obtain detailed breeding data at nests (Brown *et al.* 1998). Therefore, future studies could more efficiently fill remaining gaps in our knowledge of tomtit breeding biology. Also, the increasing numbers of mammal-free islands and mainland sites where introduced mammalian predators are maintained at very low densities provide opportunities to study tomtit nesting behaviour without the problems associated with a high proportion of nesting attempts failing due to predation.

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