

Breeding biology of the South Island saddleback (*Philesturnus carunculatus carunculatus*, Callaeatidae)

SCOTT HOOSON

Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand.

IAN G. JAMIESON

Department of Zoology, University of Otago, P.O. Box 56, Dunedin, New Zealand.
ian.jamieson@stonebow.otago.ac.nz

Abstract This study provides a first description of breeding biology of the South Island saddleback (*Philesturnus carunculatus carunculatus*) and the first comparisons with North Island saddlebacks (*P.c. rufusater*), using data collected from Ulva (Stewart Island), Breaksea (Fiordland) and Motuara (Marlborough Sounds) Islands, New Zealand. We found courtship and copulation behaviour to be similar to that of North Island saddlebacks. So too were nest locations, heights and materials, with nest materials determined by their proximity to the nest site. On Motuara and Ulva Islands, most nests were located in natural cavities (54% and 80%, respectively), while on Breaksea Island, 67% of nests were in flax (*Phormium cookianum*). In the recently established Ulva Island population, saddlebacks had a median and maximum clutch size of two and laid a maximum of two clutches. This contrasts with translocated island populations of North Island saddlebacks where up to four-egg clutches and four clutches per season have been recorded for pairs breeding in the first few seasons post-release. Incubation and brooding behaviour was like that described for North Island saddleback. A small number of yearlings bred successfully on Ulva Island (0.18 birds/ha), but no yearlings bred on Motuara (0.42 birds/ha) and Breaksea (0.42 birds/ha) islands.

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INTRODUCTION

Obtaining accurate information on the breeding biology of endangered species is important for their conservation because productivity is usually a key determinant of endangerment, and reproductive parameters are essential for accurate population viability analyses. The South Island saddleback (*Philesturnus carunculatus carunculatus*) is an endangered, medium sized (c. 25 cm), forest-dwelling passerine endemic to New Zealand. It is a member of the New Zealand wattlebird family, Callaeatidae, and one of two subspecies of saddleback, although Holdaway *et al.* (2001) have recently argued the subspecies should be elevated to full species.

Saddlebacks were formerly widespread throughout North, South and Stewart Islands and also many small islands within 50 km of the New Zealand mainland, but declined rapidly due mainly to their inability to co-exist with introduced mammalian predators (Williams 1976; Roberts 1994; Lovegrove 1996a). Saddlebacks were virtually extinct in the North Island by 1890 and in the South Island by 1905 (Merton 1975; Williams 1976). The North Island saddleback survived only on Hen Island (484 ha) off the east coast of Northland, while the South Island saddleback became confined to Big South Cape Island (939 ha) and two adjacent islets, Pukeweka (2 ha) and Solomon (25 ha), situated south-west of Stewart Island (Merton 1975; Roberts 1994).

Although anecdotal accounts of the behaviour and ecology of North Island (Reischek 1887; Buller

1888; Moncrieff 1929) and South Island saddlebacks (Potts 1872; Guthrie-Smith 1925; Stead 1936; Wilson 1959) have been published, the species was not studied in detail until the 1960s, when the North Island saddleback's ecological niche was examined on Hen Island before the first island translocations were undertaken (e.g. Atkinson 1966; Atkinson & Campbell 1966; Blackburn 1966; Merton 1966). Several detailed investigations followed this early work (Jenkins 1978; O'Callaghan 1980; Lovegrove 1992). Despite intensive research on the North Island saddleback, there has been little study of the threatened South Island saddleback (Gaze 1994). Therefore gathering accurate information on the breeding biology of the South Island saddleback was seen as a necessary prerequisite to further management and recovery.

Before 1992, the lack of research on the South Island saddleback was largely due to the remoteness of, and restricted access to, the islands it inhabited. Recent translocations have established South Island saddlebacks on three more accessible islands: Ulva Island in Stewart Island's Patterson Inlet (2000), Breaksea Island in Fiordland (1992) and Motuara Island in Marlborough Sounds (1994) (Hoosen & Jamieson 2003). The only recent scientific study of South Island saddlebacks' ecology was undertaken by Pierre (1999, 2000, 2001) on Motuara Island. Pierre (1999) briefly described aspects of reproduction of the South Island saddleback, but not their breeding biology, which is normally assumed to be similar to that of the well-studied North Island subspecies (Roberts 1994; Heather & Robertson 1996).

In this paper we describe and compare information on timing of breeding, courtship and copulation behaviour, nesting materials, nest site characteristics, eggs and clutch sizes, incubation, brooding and rearing of nestlings and fledglings, and the age of breeding of South Island saddlebacks on Motuara, Breaksea and Ulva Islands during the 2001/2002 breeding season. We do not attempt to provide a comprehensive account of South Island saddleback breeding biology, but instead aim to present initial information to which future researchers might add. We also compare and contrast the breeding biology of the South Island saddleback with that of the North Island subspecies.

METHODS

Study sites

Ulva Island

Ulva Island (267 ha) lies inside Paterson Inlet, north-west Stewart Island (46° 55.9' S, 168° 07.7' E). The island's topography is low and undulating, rising to a maximum elevation of 72 m. Norway rats (*Rattus*

norvegicus) were eradicated from Ulva in 1996 but weka (*Gallirallus australis scotti*), a known native avian predator of South Island saddlebacks (A. Roberts pers. comm.), are common. Thirty saddlebacks were reintroduced from Big Island (south-west Stewart Island) in 2000, and the population was still growing when our study commenced in September 2001 with an estimated density of 0.18 birds/ha. Rimu (*Dacrydium cupressinum*), southern rata (*Metrosideros umbellata*) and kamahi (*Weinmannia racemosa*) dominate the forest along with miro (*Podocarpus ferrugineus*). There is a diverse understorey of broadleaf shrubs and ferns. The coastal scrub is dominated by *Senecio reinoldii*, leatherwood (*Olearia colensoi*) and inaka (*Dracophyllum longifolium*) (Meurk & Wilson 1989).

Breaksea Island

Breaksea Island (170 ha, max. elevation 350 m) lies c. 2 km off the coast of Fiordland (45° 35' S, 166° 38.5' E). The island is free of mammalian predators. Fifty-nine saddlebacks from Big and Kundy Islands (south-west Stewart Island) were re-introduced in 1992 (Rasch & McClelland 1993), and we estimated the density during the study at 0.42 birds/ha. Breaksea Island is steep, rugged and densely forested with a rich and complex flora. Above 250 m elevation the canopy is dominated by silver beech (*Nothofagus menziesii*) and mountain beech (*N. solandri* var. *cliffortioides*), with southern rata and kamahi important sub-canopy species. On sheltered mid-elevation eastern slopes, mountain beech forms an open canopy over a lower dense canopy of shrubs. Kamahi and southern rata dominate the forest elsewhere, with several smaller broadleaf tree and shrub species in the understorey. A thick scrub of inaka, mahoe, kiekie (*Freycinetia banksii*) and tree nettle (*Urtica ferox*) grows on windswept ridge crests and exposed seaward slopes. Mahoe (*Melicytus ramiflorus*), tree fuchsia (*Fuchsia excorticata*), and pate (*Schefflera digitata*) dominate shady lower slopes and sheltered gullies. Teteaweka (*Olearia oporina*), inaka, *Hebe elliptica* and flax (*Phormium cookianum*) are common near the coast, particularly along the lower sheltered area at the northeast end of the island (Allen *et al.* 1994).

Motuara Island

Motuara Island (59 ha, max elevation 128 m) lies in the outer-Queen Charlotte Sound (41° 05.5' S, 174° 16.5' E) 1.8 km from the mainland. The island is free of introduced mammalian predators (Cash & Gaze 2000). Twenty-six saddlebacks from North and Jacky Lee Islands (northern Stewart Island) were released in 1994 (Lovegrove 1996b). In 2001/02 their density was estimated to be 0.42 birds/ha. Although extensively modified for

farming until designated a Scenic Reserve in 1926, the vegetation of Motuara is regenerating vigorously and the island is now predominantly forested (Cash & Gaze 2000). A low 3–8 m broadleaf forest dominated by five-finger (*Pseudopanax arboreus*) and mahoe, grows on the lower slopes and in the gullies. On the main ridge and upper slopes emergent kanuka (*Kunzea ericoides*) dominates the canopy, with a sparse, mixed-broadleaf understorey. In moister eastern parts of the island large remnants of kohekohe (*Dysoxylum spectabile*) forests have persisted. The coastal fringe is dense and scrubby and includes areas of flax (Cash & Gaze 2000).

Nest location and monitoring

We monitored pairs on Ulva Island at all stages of the nesting cycle, between early-September 2001 and 16 February 2002; on Breaksea Island at all stages of the breeding cycle between 30 October and 22 November and 11 and 13 December 2001; and on Motuara Island between 1 and 26 October 2001, during courting and nest-building, and then again between 15 and 20 December 2001 and 14 and 15 January 2002, when the birds were incubating, brooding and caring for dependent fledglings.

Maps of approximate territory boundaries were drawn, based on observations of the range of foraging pairs and boundary interactions with adjacent pairs. Nests were located by following nest building, incubating or brooding females, listening for the calls of females returning to nests and following flight paths of adults feeding nestlings. In the field, we determined sexes by observing the behaviour of pairs and from sexually dimorphic calls. If a paired male was observed for 90 min continuously and not seen to return to a nest to feed an incubating or brooding female or chicks, we concluded that the pair did not have a nest. If a female foraged continuously for 30 min, we concluded she did not have a nest (observation times were based on published accounts of North Island saddleback nest attendance (Blackburn 1966; Lovegrove 1980), and our own observations of nesting South Island saddleback).

After a nest had been located, its contents were checked only while the adults were away and subsequently visited once a week to minimise disturbance. The development stage of any eggs was estimated by candling and ages of nestlings were estimated by their size and plumage development. Egg lengths and widths were measured to the nearest 0.01 mm with slide callipers. We also recorded nest materials, maximum height and width of the cavity opening (to the nearest mm), orientation of the

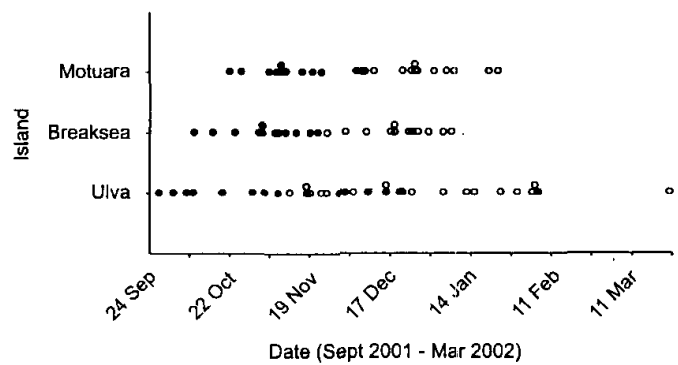


Fig. 1 Duration of the South Island saddleback breeding season on Motuara, Breaksea and Ulva Islands, 2001/2002. Solid circles = laying dates, hollow circles = fledging dates. Where necessary, laying and fledging dates were calculated from nestling development and weight, assuming a 20 day incubation period and 26 day nestling period. Nests that failed, or nests that were still in progress at the end of monitoring, were included only if laying and fledging dates could be calculated. (Motuara, $n = 12$; Breaksea, $n = 12$; Ulva, $n = 17$).

opening and the height of the nest rim from the ground (to the nearest cm). Where necessary, egg laying and fledging dates were estimated from embryo development, hatching dates and nestling development, assuming a 20 day incubation period and 26 day nestling period.

Statistical analysis

We checked for normality by constructing scatterplots of residuals against fits and histograms of the residuals. Where appropriate, normality was improved by log transformation ($X+1$) (Zar 1999). We tested for differences between islands for various measures with ANOVAs or Kruskal-Wallis tests. All analyses were carried out using Minitab (1991).

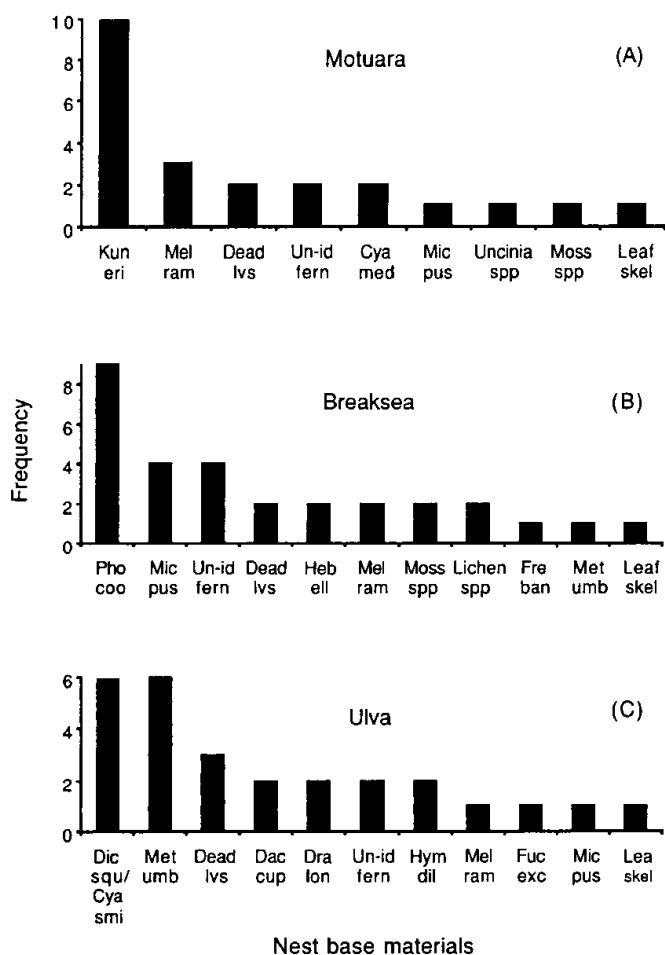
RESULTS

Breeding season

On Ulva Island, breeding was recorded between late September and late March, with the first clutch laid approximately 27 September (Fig. 1). On Breaksea and Motuara Islands, we estimated first eggs were laid on 10 and 22 October respectively, and most nests contained eggs or nestlings between the third week in October and the first week in January (Fig. 1). It was not possible to monitor breeding beyond December 2001 on Breaksea Island and January 2002 on Motuara Island. Comparison of the laying and fledging dates on the three islands shows that breeding may have been delayed on Motuara Island, possibly because of dry weather before the breeding season (W. Cash pers. comm.).

Table 1 Comparison of mean size (\pm SE) (n) [range] of various nest and egg parameters of South Island saddlebacks on Motuara, Breaksea and Ulva Islands, 2001/2002 breeding season.

Island	Nest height (m)	Cavity opening height (mm)	Cavity opening width (mm)	Egg length (mm)	Egg width (mm)
Motuara	1.63 \pm 0.59 (13) [0 – 7.55]	157 \pm 19 (9) [102 – 280]	133 \pm 17 (9) [65 – 230]	32.58 \pm 0.36 (12) [30.28 – 34.42]	22.45 \pm 0.09 (12) [22.06 – 23.02]
Breaksea	1.02 \pm 0.19 (14) [0 – 2.66]	105 \pm 35 (2) [70 – 140]	230 \pm 60 (2) [170 – 240]	32.54 \pm 0.25 (24) [30.26 – 34.78]	22.09 \pm 0.36 (24) [21.12 – 23.12]
Ulva	2.02 \pm 0.26 (10) [1.18 – 3.60]	301 \pm 87 (8) [100 – 880]	211 \pm 72 (8) [60 – 660]	31.39 \pm 0.46 (7) [30.20 – 33.38]	21.93 \pm 0.14 (7) [21.54 – 22.56]
Overall	1.50 \pm 0.24 (37) [0 – 7.55]	212 \pm 40 (19) [70 – 880]	176 \pm 32 (19) [60 – 660]	32.36 \pm 0.20 (43) [30.20 – 34.78]	22.16 \pm 0.07 (43) [21.12 – 23.12]

**Fig. 2** Frequency of use of various nest materials in the base of South Island saddleback nests on A) Motuara, B) Breaksea and C) Ulva Islands during the 2001/2002 breeding season. Kun eri = kanuka, Mel ram = mahoe, Dead lvs = dead leaves, Un-id fern = unidentified fern species, Cya med = mamaku, Mic pus = hounds tongue fern (*Microsorium pustulatus*), Leaf skel. = leaf skeletons, Pho coo = flax, Heb ell = *Hebe elliptica*, Fre ban = kiekie, Met umb = southern rata, Dic squ/Cya smi = tree fern species, Dac cup = rimu, Dra lon = inaka, Hym dil = filmy fern, Fuc exc = tree fuchsia.

Courtship and copulation

A close pair-bond is maintained by courtship feeding, 'bow-fan-warble' and 'archangel' displays, soft whistles and pips identical to those of the North Island saddleback (Lovegrove 1980). Three pairs were observed copulating. Before copulation, both members of a pair perched side by side, the female vibrating her wings and peeping softly as the intensity of her wing vibrations increased. She bowed her head as the male moved towards her. The male vibrated his wings in the same manner and, calling softly, climbed on her back and flapped his wings rapidly to make cloacal contact.

Nest materials and site characteristics

The female builds the nest alone. No continuous observations of nest building were made, but nest building activity appeared to be most intense between 0630 h and 0900 h (standard time), and was not observed after 1130 h. On all three islands, many different materials selected from around the nest site were used (Figs 2A – C). The base (outer portion) of the nest was loosely constructed of twigs, bark, rootlets, and ferns. The cup was lined with finer materials such as inner bark fibres, *Uncinia* spp., grasses and tree-fern (*Dicksonia squarrosa* and *Cyathea smithii*) scales. The predominant material in nest bases was kanuka on Motuara Island (present in 77% of nests, $n = 13$; Fig. 2A), flax on Breaksea Island (64%, $n = 14$; Fig. 2B) and tree-ferns and southern rata on Ulva Island (60%, $n = 10$; Fig. 2C). The materials most frequently selected for nest lining were the inner bark fibres of kanuka on Motuara Island (77%, $n = 13$; Fig. 3A), flax and tree-fern scales on Breaksea Island (both 57%, $n = 14$; Fig. 3B), and grass and *Uncinia* spp. leaf blades on Ulva Island (80% and 50% respectively, $n = 10$; Fig. 3C).

Saddlebacks built nests in six types of sites (Fig 4): in natural cavities, in flax bushes, on the ground, under debris caught in vegetation, in crowns of mamaku (*Cyathea medullaris*) or other tree-fern species (*Dicksonia squarrosa* and *Cyathea smithii*), and in nest boxes (only available on Motuara Island). On Motuara and Ulva Islands saddleback nests were most commonly located in natural cavities (54%, $n = 13$ and 80%, $n = 10$, respectively). On Breaksea Island only four pairs nested in natural cavities (27%, $n = 15$); 67% were in the bases of flax bushes. Most nests in natural cavities were in mahoe trees on Motuara Island (50%) and southern rata on Ulva Island (50%, $n = 10$). There was no significant difference between the mean maximum height (Kruskal-Wallis, $H = 5.61$, 2 df, $P = 0.06$) or mean maximum width ($H = 1.90$, 2 df, $P = 0.39$) of nest cavity openings measured on the three islands (Table 1). No nest sites were re-used within a season.

On Breaksea Island all nest openings faced from north-east through east to south-west, whereas the direction of nest openings on Ulva and Motuara Islands were more randomly distributed (Fig. 5). There was no significant difference in mean nest heights between islands (ANOVA, $F = 2.53$, 2 df, $P = 0.094$), with an overall mean across the three islands of 1.50 m, (range 0-7.55 m, $n = 37$) (Table 1).

Egg dimensions, clutch size and clutch number

South Island saddleback eggs are pale grey or white with pale brown, purple brown and violet blotches and speckles, especially at the larger end. The overall mean length and width of eggs on all three islands was 32.36×22.16 mm ($n = 43$) (Table 1). There was no significant difference in egg lengths between islands ($F = 2.62$, 2 df, $P = 0.086$) but there was for egg widths ($F = 3.39$, 2 df, $P = 0.044$), although the islands with the largest difference in means [Motuara and Ulva Islands (Table 1)] were not significantly different (Tukey's pairwise comparison, $q = 3.45$, $P > 0.05$).

Data from only those nests that were inspected at least twice during incubation were included in calculations for clutch size. The median and maximum clutch size was two ($n = 35$) with single eggs in two nests only. The number of clutches per pair was significantly higher on Ulva Island than on Motuara or Breaksea Islands ($F = 11.17$, 2 df, $P < 0.001$). Six of 12 pairs on Ulva Island double-clutched compared with one of 14, and none of 15 pairs on Motuara and Breaksea Islands respectively, although three of the six second-clutches on Ulva Island followed nest failures.

Incubation, brooding and care of nestlings

The female incubated and brooded the nestlings.

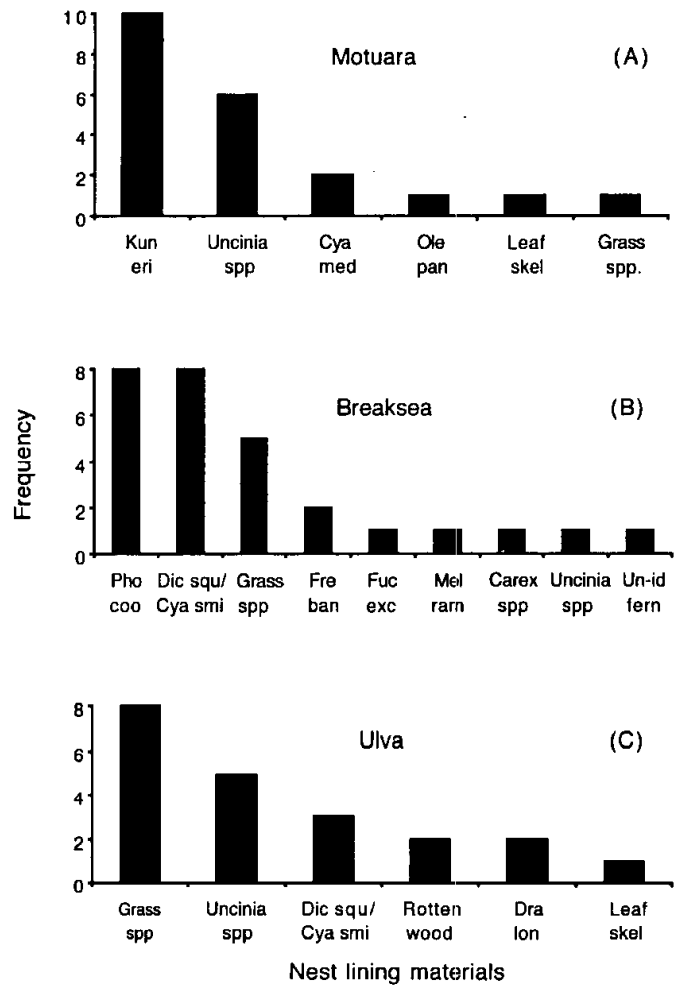


Fig. 3 Frequency of use of various nest materials in the linings of South Island saddleback nests on A) Motuara, B) Breaksea and C) Ulva Islands during the 2001/2002 breeding season. Ole pan = *Olearia paniculata*. See Fig. 2 caption for other six letter plant code definitions.

The male, when provisioning the female called loudly "cheet ta-chet ta-chet ta-chet" from a distance of 10-20 m. The female left quietly to be fed by the male within 1-3 m of the nest. When the female returned to the nest, she emitted a sharp "cheee cheee cheee" repeated at regular intervals at the nest entrance. Females were also observed calling from the nest three times in response to a call from the male nearby. Twice when the male was absent, incubating females were observed leaving the nest to drive off bellbirds (*Anthornis melanura*) and another saddleback. Females left their nests unattended for up to 14 min every hour, or less frequently during rain or colder temperatures, to forage with and/or be fed by their male. The male also provisioned the female while she brooded younger nestlings. Both male and female fed the late-stage nestlings and fledglings; foods consisted of small insects,

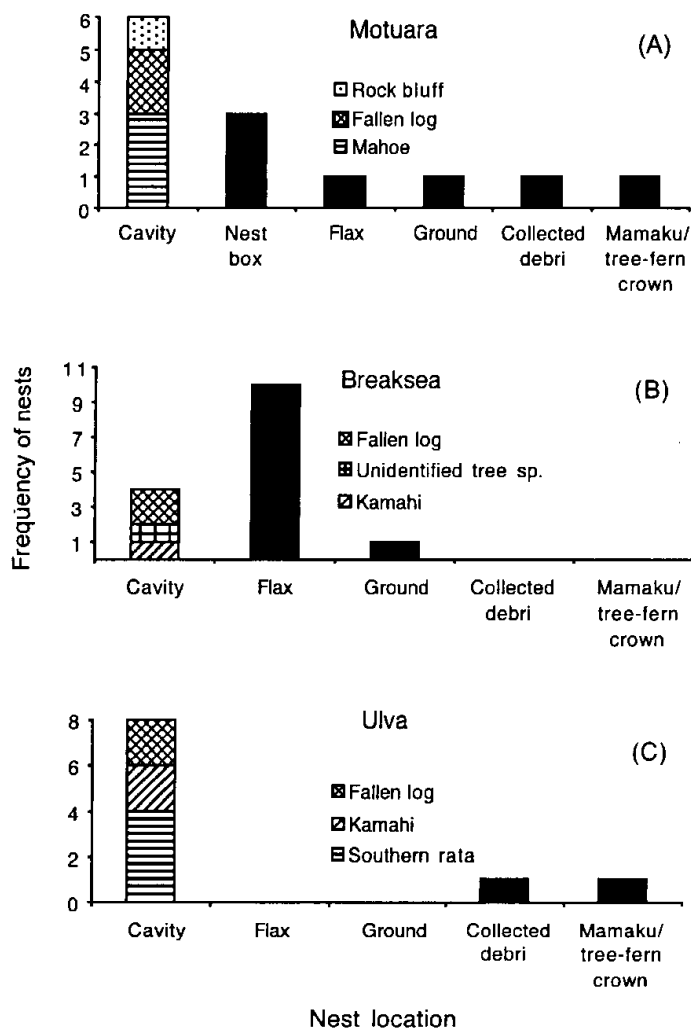


Fig. 4 Frequency of use of various nest site locations for South Island saddleback on A) Motuara, B) Breaksea and C) Ulva Islands during the 2001/2002 breeding season.

caterpillars and white grubs but were often macerated and unidentifiable. Twice a female saddleback was observed incubating a second clutch, while fledglings of the first clutch remained dependent on the male for food.

Breeding age

South Island saddlebacks usually do not breed until their second year. However, on Ulva Island, where the population density is much lower (0.18 birds/ha) than on Motuara and Breaksea Islands (0.42 birds/ha on both), yearling males bred with adult females on five occasions; although their overall numbers were unknown, no female yearlings were observed attempting to nest. There was no significant difference between the number of young fledged by yearling-adult pairs (mean = 1.3, SE = 0.67, $n = 5$) and adult-adult pairs (mean = 1.8, SE = 0.48, $n = 6$) (Mann-Whitney test, $W = 31$, $P = 0.92$) on Ulva, but sample sizes were small. On

Motuara and Breaksea Islands, no pairings involving yearlings were confirmed but an adult male was observed attempting to copulate with a yearling female on Motuara Island.

DISCUSSION

There are few previous accounts of the breeding biology of South Island saddlebacks. Before their extermination on the mainland, Potts (1872) described three saddleback nests on the West Coast, South Island. Guthrie-Smith (1925) observed five nests on Solomon Island, and although both Stead (1936) and Wilson (1959) commented briefly on breeding biology, they concentrated on clarifying the confusion surrounding differences in the juvenile plumage of the North and South Island subspecies. Blackburn (1965) briefly described an empty nest located on Big (Stage) Island (south-west Stewart Island).

Breeding season

Anecdotal observations from the Big South Cape Islands suggested the South Island saddleback's breeding season extends from late October to late December or early January (Guthrie-Smith 1925; Stead 1936). North Island saddlebacks breed between October and January in high-density populations (Falla *et al.* 1993), and between August and May in low density populations, following translocation (Craig 1994).

We did not monitor nests on Motuara and Breaksea Islands for the entire breeding season, so could not determine the length of the nesting period on these islands. The extended breeding season on Ulva Island (late September to mid-March) probably reflected the low density of this population following their recent release. A decrease in per capita reproductive output is expected with increasing population density, as seen in translocated North Island saddlebacks (Craig 1994; D. Armstrong unpubl. data).

Courtship and copulation

Our description of South Island saddleback courtship is similar to that of Guthrie-Smith's (1925) and there were no obvious differences to those described for North Island saddleback (Lovegrove 1980). Our description of copulation is, as far as we are aware, the first for saddlebacks. Lovegrove (1980) found that courtship feeding increased in intensity towards the initiation of egg laying. Twice we noted that South Island saddlebacks performed the ritualised 'archangel' nest invitation display within 1-2 m of nests in the early stages of construction.

Nest materials and site characteristics

Nest building is carried out by the females of both

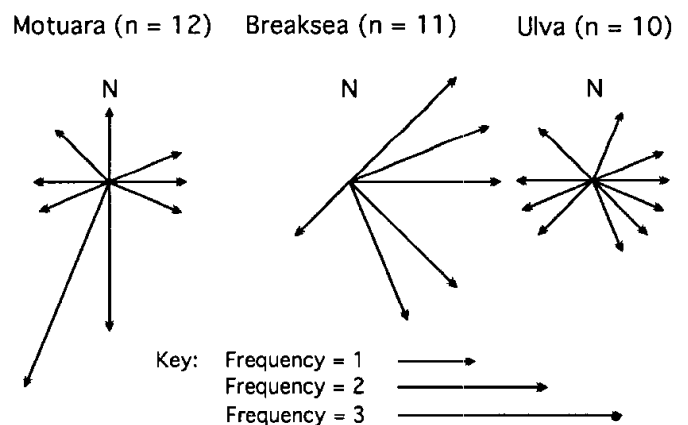
Table 2 Comparison of mean egg lengths and widths (mm) of North and South Island saddlebacks at various locations.

Location	Egg length (mm)	Egg width (mm)	Number of nests	Source
North Island saddleback				
Cuvier Island	29.33	22.43	4	Lovegrove (1980)
Hen Island	29.56	22.45	5	Oliver (1955)
Little Barrier Island	29.2	22.9	3	Hutton (1870)
Overall	29.4	22.5	12	
South Island saddleback				
Breaksea	32.54	22.09	24	this study
Motuara	32.58	22.45	12	this study
Solomon	30.25	21.28	4	Oliver (1955)
South Island	32.0	23.5	?	Oliver (1955)
Ulva	31.39	21.93	7	this study
Westland	30.5	21.6	?	Oliver (1955)
Overall	31.9	22.3	47+	

subspecies, which in this study was never observed after 1130 h. Similarly, Blackburn (1966) noted that North Island saddlebacks were never seen building after 1300 h. The material used in nest construction appears to be determined by what is available close to the nest site and differences between islands were attributed to differences in local vegetation types and abundances. Completed nests were similar in composition and form to those described for the North Island subspecies (Lovegrove 1980; Falla *et al.* 1993). Before this study there were only two other published accounts of nest materials used by South Island saddlebacks (Guthrie-Smith 1925; Blackburn 1965).

Both subspecies nest in a range of natural locations, including tree cavities, rock fissures, ground cavities, tree-fern crowns, dense epiphytes, and beneath clumps of ferns, and most nests are within 2 m of the ground (Guthrie-Smith 1925; Blackburn 1966; Lovegrove 1996a). However, the mean height of North Island saddleback nests on Cuvier Island was 3.4 m (range = 0.5–10 m) (Lovegrove 1980), and nests on Hen Island were c. 2 m or more above the ground (Falla *et al.* 1993). South Island saddleback nest heights measured during this study were much lower. This may reflect differences in the height of suitable nesting cavities on northern and southern islands as determined by vegetation age, species composition and structure. Variation in vegetation structure and composition between the islands could also explain the subtle variation in mean nest heights between Motuara, Breaksea and Ulva Islands. For example, the lower mean height of nests on Breaksea Island is a consequence of the high proportion of nests located in flax.

Cavities in southern rata trees were commonly used by South Island saddlebacks on Ulva Island,

**Fig. 5** Orientation of cavity openings of South Island saddleback nests on Motuara, Breaksea and Ulva Islands during the 2001/2002 breeding season.

while a close relative, the pohutukawa (*Metrosideros excelsa*) is a preferred species of the North Island saddleback on Hen and Cuvier Islands (Lovegrove 1980). Although North Island saddlebacks have been recorded nesting in epiphytes (*Collospermum hastatum*) (Blackburn 1966; Lovegrove 1980) there are no previous records of saddlebacks nesting in flax. Flax nectar seemed to form a large proportion of the diet of nesting South Island saddlebacks on Breaksea Island's exposed coastal plateau, where many of these nests were located, and where suitable alternative nest sites, such as cavities in trees and fallen logs, appeared to be scarce.

Compared with Motuara and Ulva Islands, Breaksea Island is exposed, with a windy, wet climate and a mean annual rainfall of 4200 mm. Eighty-seven percent of the nests located on Breaksea Island were on the north-eastern end and sited near the coast in exposed locations in flax or

low scrub. Here nest cavity openings were orientated away from the prevailing weather. On Motuara and Ulva Islands, where the climate is less severe and nests were located in less exposed sites, nest cavity opening orientations were randomly distributed. There was a strong tendency for North Island saddlebacks on Tiritiri Matangi Island to use artificial nest boxes with northerly facing entrances, although the significance of this is unclear (Stamp *et al.* 2002).

Like North Island saddlebacks (Lovegrove 1992; Stamp *et al.* 2002), South Island saddlebacks will use nest boxes and other artificial sites. Three pairs used nest boxes on Motuara Island during the 2001/2002 breeding season and old nest material was found in others, while Pierre (1999) observed nest boxes being used in previous years. Guthrie-Smith (1925) found and photographed a South Island saddleback nesting in a flax kit suspended from a nail in a mutton-bird's hut, and saddlebacks are reported to nest in mutton-bird's buildings on Big and Kundy Islands (M. Bragg, A. Roberts pers. comm.). On Cuvier Island, North Island saddleback nests have been found inside the walls of derelict buildings (T. Lovegrove pers. comm.).

Eggs, clutch size and clutch number

The eggs of North and South Island saddlebacks appear similar (Stead 1936), but mean length is c. 2.5 mm longer for South Island saddleback eggs (Table 2). Mean egg sizes also vary even among South Island saddleback populations (Tables 1 & 2). This study found that South Island saddlebacks almost invariably lay a clutch of two eggs, which is consistent with the observations of Guthrie-Smith (1925) and Wilson (1959). On Ulva Island up to two clutches were laid. Four egg-clutches and up to four clutches per pair have occasionally been recorded in low density populations of North Island saddlebacks (Craig 1994), but a single clutch of two, and occasionally three, eggs seems to be the norm in established populations.

Incubation, brooding and care of nestlings

Guthrie-Smith (1925) noted that incubation began immediately after the second egg had been laid and ascertained the incubation period for South Island saddlebacks to be 20-21 days, two to three days longer than that for North Island saddlebacks (Heather & Robertson 1996). There are no known records of South Island saddleback fledging periods, but judging from known laying dates and the weights and developmental stages of nestlings recorded during this study, it appears to correspond to the 25-27 day period of North Island saddlebacks (T. Lovegrove pers. comm.).

In both the North and South Island subspecies, the female incubates and broods the nestlings without assistance from the male (Merton 1975;

Lovegrove 1980; this study), despite statements to the contrary by Reischek (1887) and Robertson (1985). Guthrie-Smith (1925) found eggs buried in nest material when females were absent from the nest, and questioned whether the eggs are deliberately hidden. We found no evidence for egg concealment in this study.

Age of sexual maturity

Reischek (1887) found the reproductive organs of both male and female South Island saddlebacks in juvenile plumage well developed, and both Stead (1936) and Pierre (1999) observed yearling South Island saddlebacks paired or breeding with adults (in the latter case in the first season after release, although both pairs deserted their nests). Similarly, North Island saddlebacks will breed as one-year-olds in low density populations (Craig 1994; Armstrong & Craig 1995). We confirmed that South Island saddlebacks will breed as yearlings in low density populations, most likely the result of reduced competition for territories. Armstrong & Craig (1995) reported that North Island saddleback pairs including yearlings fledged significantly fewer young than exclusively adult pairings. No such difference was found in this study, although sample sizes were small.

In conclusion, the information presented here will help to improve parameter estimates used in population viability models of South Island saddleback, particularly in view of planned mainland translocations (e.g., Davidson & Armstrong 2002). It will also aid future field workers in determining breeding activity and nest locations, and in establishing field protocols to limit nest disturbance.

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